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Training Manual on:

CORRECTIVE MEASURES FOR RESIDENCES INSULATED WITH UREA FORMALDEHYDE FOAM INSULATION (UFFI)

Revised UFFI Centre Specification 82-03R2

October 1984

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Canada

TRAINING MANUAL ON CORRECTIVE MEASURES FOR RESIDENCES INSULATED WITH UREA FORMALDEHYDE FOAM INSULATION (U.F.F.I.)

(321 pages)

UFFI CENTRE
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PREFACE

1.0 INTRODUCTION

Corrective Measures for Residences Insulated with Urea Formaldehyde Foam Insulation (UFFI) is the second edition of a revised training manual.

In addition to providing background information about the UFFI issue and the federal Assistance Program for UFFI Homeowners, this manual provides information required to understand corrective measures and describes, according to currently accepted methods and specifications, measures that can be taken to correct problems in a UFFI house.

On the basis of a nation-wide test of 2,400 randomly selected homes, it was concluded that approximately 8,000 Canadian dwellings have levels of formaldehyde which exceed the 0.1 parts per million (ppm) level set by Health and Welfare Canada as being acceptable for the living environment. This level is considerably lower than the accepted level for the industrial working environment.

Despite the 0.1 ppm standard, in a number of homes where the concentration of formaldehyde was found to be well below the accepted level, people suffered from ailments attributed to UFFI gas. Additionally, the reduced resale value of UFFI homes is a continuing concern.

In recognition of this situation, the government of Canada established the Assistance Program for UFFI Homeowners whereby costs of corrective measures undertaken by registered contractors and/or homeowners may be paid in full or in part by the government.

This manual is designed to be used by contractors as a training aid and as basic reference material for courses given by Consumer and Corporate Affairs Canada (CCAC) to contractors as well as do-it-yourself homeowners who wish to become qualified to carry out recommended corrective measures under the UFFI Program.

The information contained herein reflect the present "state of the art".

Much of the content has been drawn from the work of the National Research Council and that of other research funded by the government of Canada. The content also reflects the experience of registered contractors, the insights of instructors and the responses from the representatives of UFFI homeowners.

The Appendices provide additional information on related subjects.

1.1 DIVISIONS OF THE MANUAL

This revised manual is divided into two main categories so that Chapters 1 to 4 give background information necessary to understand and apply corrective measures and Chapters 5 to 8 give concise, but detailed descriptions of corrective measures currently accepted. The Appendices deal with related background information and procedures.

1.2 **Chapter 1** outlines basic information about UFFI: its physical characteristics, composition, manufacture, proper and improper uses, and the effects of the latter.

The first chapter also deals with UFFI and human health, and with the UFFI Program, which was established as a consequence of these health implications.

Chapter 2 provides an overview of tests and testing: types of tests, passive and active testing in the living environment and in wall cavities, visual verifications and laboratory testing.

Chapter 3 outlines house construction types: platform frame, balloon frame, post and beam, plank frame, and solid and cavity load-bearing masonry, and special attention is given to the manner in which different construction types determine the scope of work associated with the implementation of corrective measures.

Chapter 4 outlines basic principles of air flow dynamics related to house construction, principles of ventilation, air leaks visible and hidden, and gas generation related to moisture dynamics, all of which are integral to an understanding of UFFI contamination and the principles of corrective measures.

Chapter 5 outlines methods to keep cavities dry.

Chapter 6 outlines the required equipment and procedures for sealing invisible and hidden air leaks on the inside of the living environment. This measure reduces UFFI gas emissions into the living environment and the exfiltration of warm moist air into wall cavities.

Chapter 7 outlines measures for diluting the concentration of UFFI gas in the living environment by reducing the infiltration of UFFI gas and by diluting the concentration of gas that does enter.

Chapter 8 outlines procedures for UFFI removal, treatment of cavities, and disposal of UFFI and other contaminated material. While safe working practices are highlighted throughout the manual, Chapter 8 deals specifically with safety procedures to be followed by workers engaged in this corrective measure.

Appendices deal with a variety of related subjects on up-to-date procedures, equipment, materials, and new techniques.

Abbreviations for organizations referred to in this manual are listed and explained below:

ACGIH	-	American Conference of Governmental Industrial Hygienists
ANSI	-	American National Standards Institute
ASHRAE	-	American Society of Heating, Refrigeration, and Air Conditioning Engineers
CCA	-	Consumer and Corporate Affairs Canada
CGA	-	Canadian Gas Association
CGSB	-	Canadian General Standards Board
CMHC	-	Canada Mortgage and Housing Corporation
CSA	-	Canadian Standards Association
EMR	-	Energy, Mines and Resources Canada
HRAI	-	Heating, Refrigeration and Air Conditioning Institute of Canada
HWC	-	Health and Welfare Canada
MESA	-	Mining Enforcement Safety Administration
NIOSH	-	National Institute of Occupational Safety and Health
NRC	-	National Research Council
OSHA	-	Occupational Safety and Health Association

The revised training manual was prepared by the UFFI Centre, Consumer and Corporate Affairs Canada, and includes technical input to the previous editions by:

Consumer and Corporate Affairs Canada
DIDAK Corporation
National Research Council of Canada
Canada Mortgage and Housing Corporation
Associated Kellog Limited
Ontario Research Foundation
Saskatchewan Research Council
Scanada Consultants

Chapter 1

UREA FORMALDEHYDE FOAM INSULATION (UFFI), HEALTH, AND THE ASSISTANCE PROGRAM

Contents

SECTION A: UREA FORMALDEHYDE FOAM INSULATION (UFFI)

1.0 INTRODUCTION: WHAT IS UFFI?

Urea formaldehyde foam insulation (UFFI) is a low-density foam prepared at the installation site from a mixture of urea formaldehyde resin, an acidic hardening agent solution, and a propellant, usually compressed air. The mixture was pumped through a tube into the cavities of a wall where it hardened. At the time it was pumped in, the material looked and felt like shaving cream. It was usually white or cream coloured, although occasionally blue. UFFI was used mainly in the retrofit of older homes to insulate cavities.

1.1 APPEARANCE AND CURING

The newly-manufactured foam set in a matter of seconds. It was 75% water by weight at that time. The subsequent drying and curing took up to several months depending on the temperature, the ability of the cavity construction to permit the water to vent, the method of application and the chemicals used. On drying, most UFFI shrank and cracked, allowing air convection in the cavity.

UFFI found in buildings generally has the appearance of a friable, easily-deformed, open-cell foam. Depending on the age and history of the foam, it may have cracked or crumbled into a collection of loose pieces or even, in extreme cases, to powder. A friable, easily-deformed substance is one that can be crumbled readily with the fingers. It does not bounce back when lightly pressed. New foam, or foam which has aged well, will have the appearance of a mass of extremely small bubbles like a good soap lather. Older foam, or foam in poor condition, will have a loose, open structure resembling a mass of loosely connected strands.

1.2 MANUFACTURE OF UFFI

Factors which affected the emission of UFFI gas during manufacture were moisture, temperature, pressure and delivery volume. The quality of UFFI insulation in homes varied widely. Problem identification is complicated by the fact that two apparently similar houses having the same brand and batch of UFFI installed by the same operator may contain material so different that one house could have a problem and the other not.

1.3 LOCATIONS INTENDED FOR UFFI INSTALLATION

UFFI was intended for installation only in dry empty wall cavities of wood frame construction.

1.4 LOCATIONS NOT INTENDED

Installation of UFFI was not intended for use in masonry cavities, in flat roofs, in attics, in cathedral ceilings, around fireplaces, in overhangs, in canopies, in intermediate floors, in interior partitions or in areas below grade, or any other area which might be subject to high temperature or moisture or both.

1.5 UFFI DETERIORATION

UFFI is unstable. Its characteristics change over time and its lifespan depends upon the severity of conditions to which it is exposed and the standard of quality with which it was manufactured. New foam consisted of many small open cells. Stress, built up in the foam as it cured, caused breakage of the cell walls, releasing UFFI gas and causing shrinkage and cracking. The rate of deterioration increases substantially with moderate increases in temperature and moisture content. The deterioration rate has not been established, since the product has not been in use for a sufficient length of time, and because of the wide variations of mixtures.

1.6 RELEASE OF UFFI GAS

Much UFFI gas was released shortly after installation. Generation of the gas continues as UFFI deteriorates and accelerates with increased moisture content and/or increased temperature.

1.7 OTHER SOURCES OF FORMALDEHYDE

Ambient (outdoor) formaldehyde levels range in concentration from less than 0.01 ppm to 0.05 ppm. These levels are due to:

a) urban and industrial sources;
b) the decay of animal and vegetable matter;
c) vehicle exhaust;
d) other materials which have absorbed formaldehyde.

In the home, formaldehyde is emitted from:

a) tobacco smoke;
b) particle-board and chipboard or furniture made of such materials;
c) some materials containing urea formaldehyde resins;
d) household products such as cosmetics, cleaning fluids, textiles, air fresheners, fabric softeners, permanent press materials;
e) artificial logs, burning wood and coal in stoves and fireplaces;
f) furnaces, particularly those burning natural gas;
g) gas ranges, kerosene stoves and heaters.

1.8 HOW TO DETERMINE IF UFFI HAS BEEN INSTALLED IN A BUILDING

The company that insulated a home should have identified on the contract the type of insulation installed, its trade name, or its Canada Mortgage and Housing Corporation (CMHC) acceptance number for urea formaldehyde foam insulation which was accepted for the Canadian Home Insulation Program (CHIP).

Acceptance Number	Trade Names
6047	Urea Formaldehyde Thermal Insulation
6490	Isoschaum/UFC
8209	Rapco Foam
8211	Insulspray

8216	Key Foam
8220	Key Foam
8336	Foam-Ulate
8350	Key Foam
8651	Urea-formaldehyde
8921	Urealite
9115	Instant Foam
9160	Celsius Foam
9161	Interfoam/Blue Ultrafoam
9583	Enfoam

Cards containing this information may have been attached by the contractor to the electrical service panel or to a rafter near the attic-access hatch.

If such information is not available, the homeowner should have the structure examined to determine whether or not UFFI has been installed.

1.9 PLACES TO LOOK FOR UFFI

To determine whether in fact a dwelling has been insulated with UFFI, it is important to check a number of places either for the foam itself or for evidence of its installation. In general, if there is reason to suspect the presence of UFFI, every possible place should be examined. Some suitable places to investigate are discussed in Chapters 2 and 3.

Once UFFI has been found, and if the homeowner has decided to implement some form of corrective measure, it becomes doubly important to find all the places where it has penetrated. Because it was applied under pressure, the foam may have travelled great distances within the structure of the house and penetrated into numerous cavities. Generally, examination by an experienced technician is advised.

SECTION B: HEALTH

1.10 INTRODUCTION

Some persons exposed to UFFI gas and particles experience health problems. The severity of any reaction depends upon the concentration, the duration of exposure, and the susceptibility of the individual.

1.11 LEVEL OF FORMALDEHYDE ACCEPTED FOR RESIDENCES

In 1981, the level of 0.1 ppm was established by Health and Welfare Canada as the acceptable limit in the living environment of residential buildings.

1.12 TYPES OF EXPOSURE

Exposure to UFFI and other chemicals may occur in the problem home before, during, and after any corrective action is taken.

Health problems may result from exposure to:

a) UFFI gas;
b) UFFI itself;
c) dust particles that are small enough to pass through a vacuum cleaner;
d) sodium bisulphite powder;
e) sodium bisulphite solution and spray;
f) sulphur dioxide gas;
g) any other chemical used;
h) caulking and sealing materials;
i) cleaning materials.

1.13 EFFECTS UPON HUMAN HEALTH

The health problems caused by exposure to formaldehyde in the air include eye, nose and throat irritation, coughing, headaches, dizziness, and in very high concentrations, bronchopneumonia and pulmonary oedema. **When any of these symptoms are encountered, a doctor should be consulted** to determine the cause or to advise the patient on the likelihood of the symptoms being related to the presence of UFFI. A specialist may be required to identify the possible causes of the symptoms.

Persons who have become sensitized to formaldehyde should take precautionary steps to prevent skin contact with materials which may contain formaldehyde and cause a reaction:

a) liquid detergents;
b) cleaning solvents;
c) deodorizers;
d) concentrated fabric softeners;
e) perfumes;
f) skin creams;
g) other cosmetics.

Inhaled formaldehyde from other sources such as tobacco smoke, particle board, plywood and treated fabrics may also cause symptoms.

1.14 OCCUPANT HEALTH

The occupant of any problem home may be exposed to UFFI gas and dust particles any time after the installation of UFFI.

Contaminants other than formaldehyde in open cavities and materials used in the corrective measures may affect the health of the occupants until the living environment is properly cleaned and ventilated. **When removal of UFFI is undertaken, any persons who are sensitized to UFFI gas should vacate the premises unless the gas and dust can be sealed off entirely from the occupied area.**

1.15 WORKER HEALTH

The contractor should be informed of the worker's history of exposure to UFFI, formaldehyde and other chemicals or pollutants both at home and work. Sensitivity to formaldehyde may have been initiated by exposure to high concentrations of the gas as evidenced by:

a) strong odours that may have occurred at the time of removal of the UFFI;

b) repeated physical contact with the UFFI, especially when wet;

c) inhaling UFFI particles.

If investigations fail to find a correlation between a health problem and exposure to formaldehyde, but there appears to be a correlation with the environment in the house, the insulated cavities should be checked for the presence of fungi. The actual reaction of the worker to fungi will depend upon the presence of spores of particular species in the air of the living environment. Although most fungi do not cause a problem, others are known to cause reactions or diseases in some people. Some fungi induce respiratory sensitization in susceptible individuals; subsequent exposures can then provoke an asthmatic attack.

When removing UFFI from the interior, the levels of formaldehyde and of UFFI particles may be as high as 20 ppm, particularly when the walls are first opened. In these cases, the worker must use the proper safety procedures as outlined in Chapter 8, Section A. Workers should be aware of the possibility of inhaling particles from the sodium bisulphite powder which may burn membranes in the nasal passages or burn unprotected skin. The gases given off during the spraying operation may also be hazardous.

Sulphur dioxide, produced when sodium bisulphite is mixed with water, is unpleasant. In large enough concentrations, sulphur dioxide is a respiratory irritant and an asphyxiating agent.

Both occupants and workers should be aware that gas concentrations and dust will have a more serious effect on extremely warm days and when the relative humidity is high.

To reduce the possibility of health hazards related to the problem and the corrective measures, occupants and workers must follow the safety procedures outlined in Chapter 8 and in the chapters describing each corrective measure.

SECTION C: THE ASSISTANCE PROGRAM FOR UFFI HOMEOWNERS

1.16 INTRODUCTION

This section outlines briefly the roles of the UFFI Centre, the contractor, and the homeowner, with particular reference to the conditions which must be met and the procedures to be followed by the homeowner to be eligible for assistance under the UFFI Program.

1.17 THE UFFI PROGRAM

As part of the Program, the government has established a registration program for contractors to be eligible to carry out corrective measures.

One of the conditions for receiving financial assistance is that the work must be done by a registered contractor or by a homeowner who has passed the examination given by the UFFI Centre.

Although the registered contractor must employ key employees who have demonstrated a level of technical knowledge in UFFI-related measures, and satisfy specific business requirements outlined in UFFI Centre Specification 82-02R for this Program, **the fact that a contractor is registered does not constitute a guarantee of the quality of the work. The homeowner is responsible** for making certain that the corrective measures are carried out to his satisfaction and that relevant warranties are provided and permits obtained.

Homeowner Registration for assistance under the Program closed September 30, 1983. However, the government is continuing a number of long term research projects and educational programs and continues to support and sponsor technical and medical research related to UFFI.

Information can be obtained by calling the UFFI Centre at the toll-free number 1-800-567-6870.

1.18 THE INFORMATION GUIDE

The UFFI Centre's Information Guide to the Assistance Program for UFFI Homeowners is an indispensable guide for the homeowner. This handbook defines clearly the steps which must be followed by the homeowner registered with the UFFI Program.

1.19 UFFI CENTRE SPECIFICATIONS 82-01R AND 82-02R

These documents contain the specifications, program policies and procedures which apply to the Contractor Registration Program, and requirements which contractors must meet and maintain to satisfy registration requirements.

1.20 CONTRACTOR BULLETIN

This information bulletin is published on a regular basis and contains technical information and policy updates. Knowledge of this information is essential to those involved in corrective measures. It is sent to all UFFI-registered contractors.

Chapter 2

TESTING AND INVESTIGATIONS

Contents

2.0 INTRODUCTION

This chapter provides an outline of the various tests and methods of investigation, where they are used, and who, under the government plan, will do the tests.

2.1 OVERVIEW OF TESTS AND TESTING

2.1.1 **Relationship of UFFI Gas and Formaldehyde in Relation to Testing.** Throughout the manual, both the terms UFFI gas and formaldehyde have been used. When UFFI deteriorates, it produces UFFI gas, which is a combination of formaldehyde and other contaminants. Although in this Program tests are conducted only for formaldehyde, the measurement of the level of formaldehyde is a good indicator of the potential level of UFFI gas in the living environment.

2.1.2 **Types of Tests** covered in this section are:

a) passive tests for formaldehyde concentration in the living environment;
b) active tests for formaldehyde concentrations in the UFFI filled cavities;
c) measurement of moisture content in wood.

2.1.3 **Responsibilities for Testing.** The Program provides for an initial passive test to determine the concentration of formaldehyde within the living environment of the house. This test is described in Section 2.2.

In some cases, when further testing may be required, the UFFI Centre will notify a private testing company whose technicians will perform more extensive tests by arrangement with the homeowner. Some of these tests are described in Sections 2.3 and 2.4.

Following the completion of corrective measures, another passive test can measure the effectiveness of the work.

2.2 PASSIVE TEST FOR FORMALDEHYDE IN THE LIVING ENVIRONMENT

The passive test for formaldehyde in the living environment uses a device called a dosimeter, which contains sensitized material, and is exposed to the air for a specified period of time. It comes in an air-tight package and after exposure is sealed in a pre-addressed container and sent to a laboratory for analysis. The laboratory analyzes the samples, calculates the average concentration of formaldehyde over the exposure period, and sends the results to the UFFI Centre.

2.3 TESTING FOR GAS IN THE WALL CAVITIES

Testing for formaldehyde in wall cavities containing UFFI is conducted to determine potential for formaldehyde emissions, which helps to determine the appropriate corrective measure. Testing for formaldehyde in wall cavities, after the UFFI has been removed and the contaminated materials neutralized by appropriate treatments, determines the effectiveness of the corrective measures.

During the winter months, when temperatures are lower, formaldehyde emissions are reduced. To obtain readings on a comparable basis to those obtained in the summer:

a) the wall temperature must be maintained at least above 5°C;
b) a UFFI sample may be removed from the cavity, placed in a bag and allowed to reach room temperature and then tested;
c) an adjustment in the reading may be made, based on experimental data.

2.3.1 **Handpump Sampling Equipment.** A known quantity of air is drawn through a detection device by means of a handpump. A sampling tube, called a Draeger, is inserted into an appropriately-sized hole in the wall. It shows the concentration of formaldehyde when the indicating layer (part 8 in Figure 2.1) matches the colour comparison layer (part 9).

The equipment for this test is portable and easy to use in the field; the results are obtained immediately, and provide a reasonable indication of the concentration.

1 and	2	fused tips
	3	writing surface
	4	reagent ampoule (contents: solid paraffin and xylene vapour)
	5	breaking point (marked with two dots)
	6	shrunk-on tubing
	7	pre-layer (light grey)
	8	indicating layer (white) (Note the length of this layer is about 2 to 3 mm)
	9	colour comparison layer (pink)
	10	arrow (must point towards pump during testing)

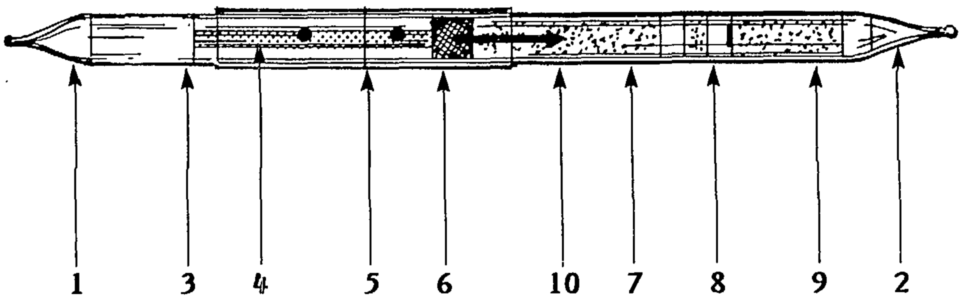


FIGURE 2.1 DRAEGER TUBE
(0.5/a formaldehyde Detector tube)

2.3.2 **Test Hole Preparation.** The diameter of the hole should be 9 mm, as this provides a snug (but not tight) fit. The hole must be enlarged if an extension tube is to be attached to the sampling tube. The hole should be of sufficient depth to ensure that the end of the tube is not embedded in the foam. Following preparation of the hole, it should be taped or plugged for a minimum of 15 minutes to allow the cavity to return to an equilibrium state.

2.3.3 **Preparation of Draeger Pump and Sampling Tubes.** The following steps must be taken:

a) **pump verification** to ensure the integrity of the device must be completed before each series of tests. This is done by inserting an unopened tube into the pump that operates the bellows and by ensuring the bellows do not return to their relaxed state in under 60 seconds;

b) **tube preparation** for sampling involves cracking open the reagent-containing ampoule in the middle of the tube and inserting the tube into the pump after having broken off the tips. Remove pieces of broken glass, as they might puncture the bellows of the pump.

2.3.4 **Extension Tubing** must be used when sampling the gas concentration in a cavity through thick walls such as a masonry finish. To avoid contamination, use the following procedures:

a) separate the two parts of a used sampling tube. Clean out the end which was inserted into the handpump.
CAUTION: Use protective gloves during the cleaning process to protect the skin from contact with sulphuric acid in the tube;

b) attach one end of a length of plastic tubing snugly to the cleaned piece of sampling tube;

c) prepare the test sampling tube by cracking the reagent-containing ampoule and by breaking off the tips;

d) push the end of the tube which normally goes into the handpump snugly into the other end of the plastic tubing. The extended tube is ready for insertion into the handpump. The completed attached extension should appear as in the following diagram;

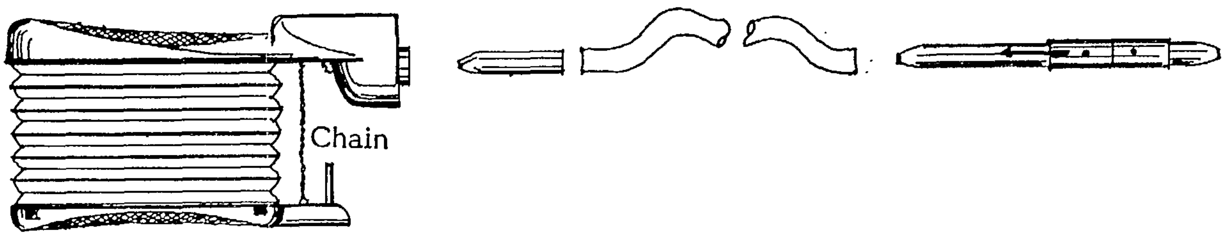


FIGURE 2.2 EXTENSION OF DRAEGER TUBE

e) proceed with sampling procedures below.

2.3.5 **Sampling Procedures.** After preparing the pump and the sampling tube:

a) insert the tube into the wall and operate the pump;
b) squeeze the pump and allow the chain to extend to its full length;
c) squeeze the pump again to draw air through the sampling tube.

During each Draeger measurement it is necessary to record both the number of pulls on the pump and the converted ppm value. This should be done at the time of the sampling. Conversion of the number of strokes to a formaldehyde ppm level should be as follows:

Number of Strokes	Formaldehyde ppm
16	0.5
13	0.7
10	1.0
07	1.5
05	2.0
03	4.0
02	7.0
01	10.0

NOTE: After the test has been performed, the holes must be sealed.

2.3.6 **Sampling Results.** Having operated the pump according to the manufacturer's recommendation, one of three situations will occur by the time the maximum of 16 strokes have been taken:

a) at some point, a colour change to pink may be noted in the indicating layer;
b) a yellow or brown stain may develop in the tube;
c) no change may occur in the tube.

Case (a) indicates a satisfactory colour match measurement.

Case (b) indicates the presence of interfering gases which may mask the presence of formaldehyde. This requires that the test be taken in the same cavity at a higher elevation to attempt to achieve an accurate reading. Drill another hole in the wall 1.5 meters from the floor and retest this cavity. Follow all conditions in the initial drilling situation.

Case (c) shows that a value of less than 0.5 ppm is measured in the wall cavity.

2.4 MEASUREMENT OF MOISTURE CONTENT IN WOOD

Moisture meters are simple electrical ohmmeters which measure the electrical resistance between two needle-like probes. Probes are available with needles of various lengths. The probes are thick, insulated needles with bare tips. These tips can be driven through the gypsum board or lath and plaster into a stud or bottom plate. A reading of the moisture content of the wood is then taken. If the needles are too short to allow the tips to penetrate through the interior finish into the wood, the baseboard should be removed and a section of interior finish cut away. This should be done so that the cut-away and any sealing is covered when the baseboard is reapplied.

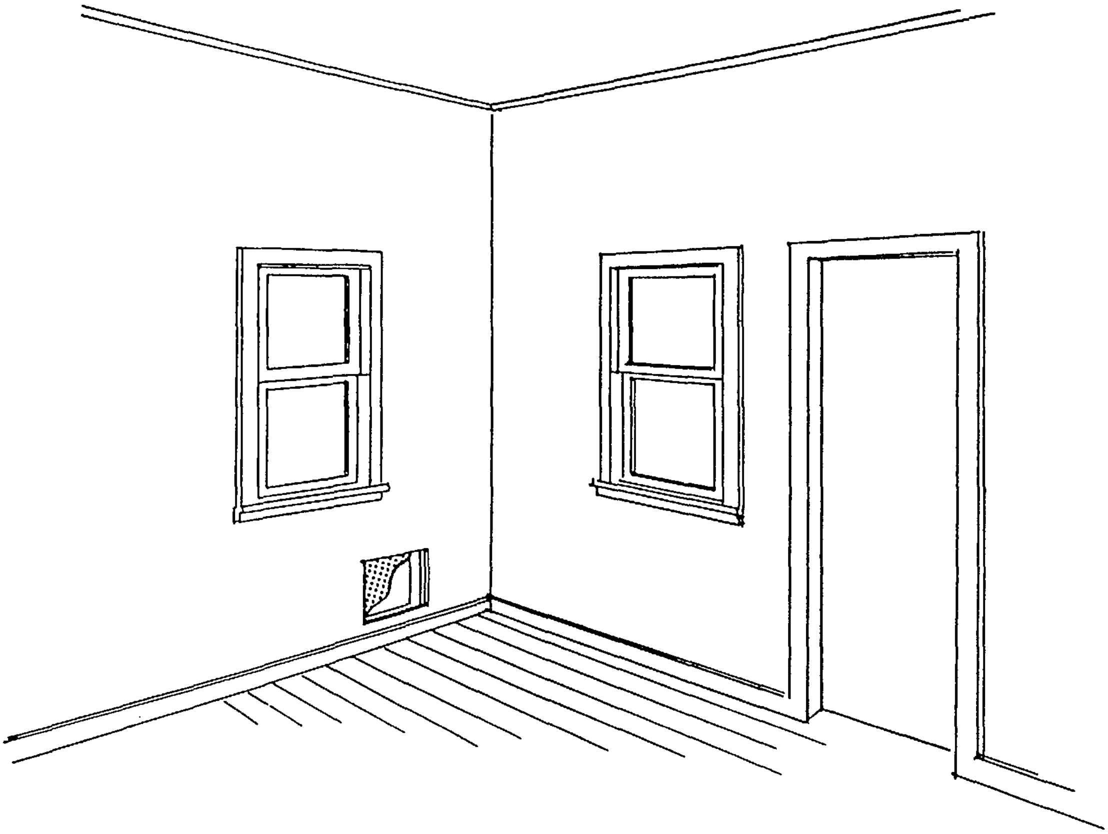
2.5 VISUAL INSPECTION

At times, a visual inspection of the inside of a wall from either the interior or the exterior may be necessary. Test openings are used for the purpose of checking:

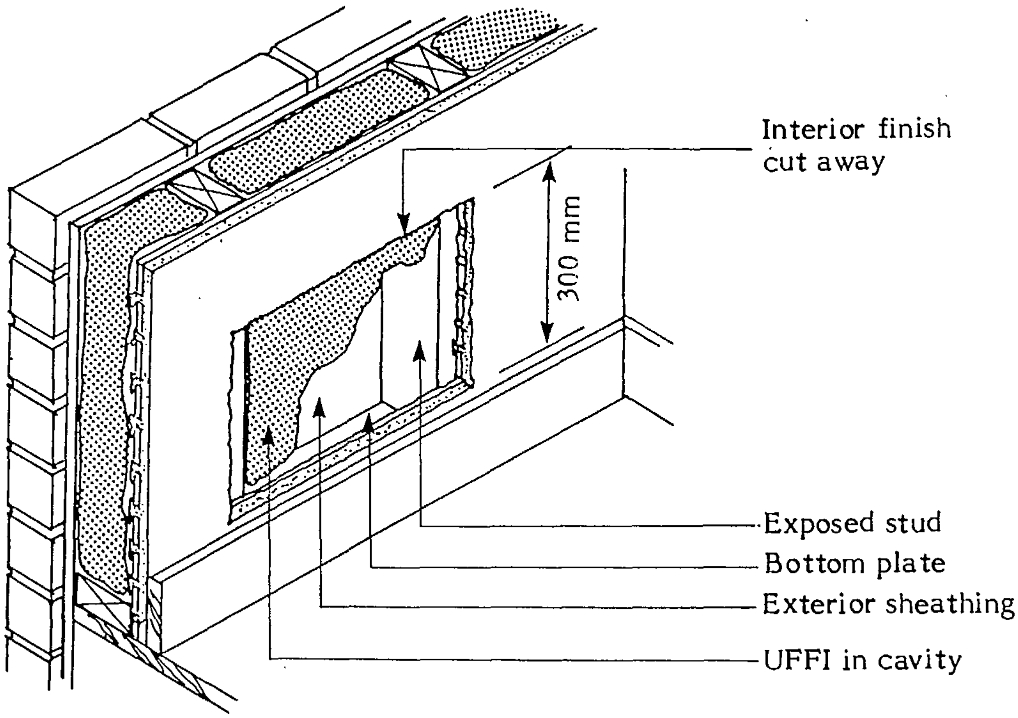
a) for the presence and proper identification of UFFI (Section 1.1);
b) for moisture or degradation due to fungal growth;
c) the construction of the wall.

2.5.1 Openings in the Interior Surface of the Exterior Wall. If an opening in the interior of the wall is necessary, select a location which can be easily repaired and where the finish is not critical to the appearance of the room. Where possible, avoid locations in which electrical outlets or electrical wires may be present. Check the basement or attic for wires leading into the wall cavity (Figure 2.3).

Having selected a cavity, expose the bottom plate as well as the studs. To make repairs easier, cut an opening about 300 mm high and wide enough to span from the centre of one stud to the centre of the next.



A INSPECTION HOLE CUT IN EXTERIOR WALL



B DETAIL OF OPENING

FIGURE 2.3 TEST OPENING: INSIDE FACE; EXTERIOR WALL

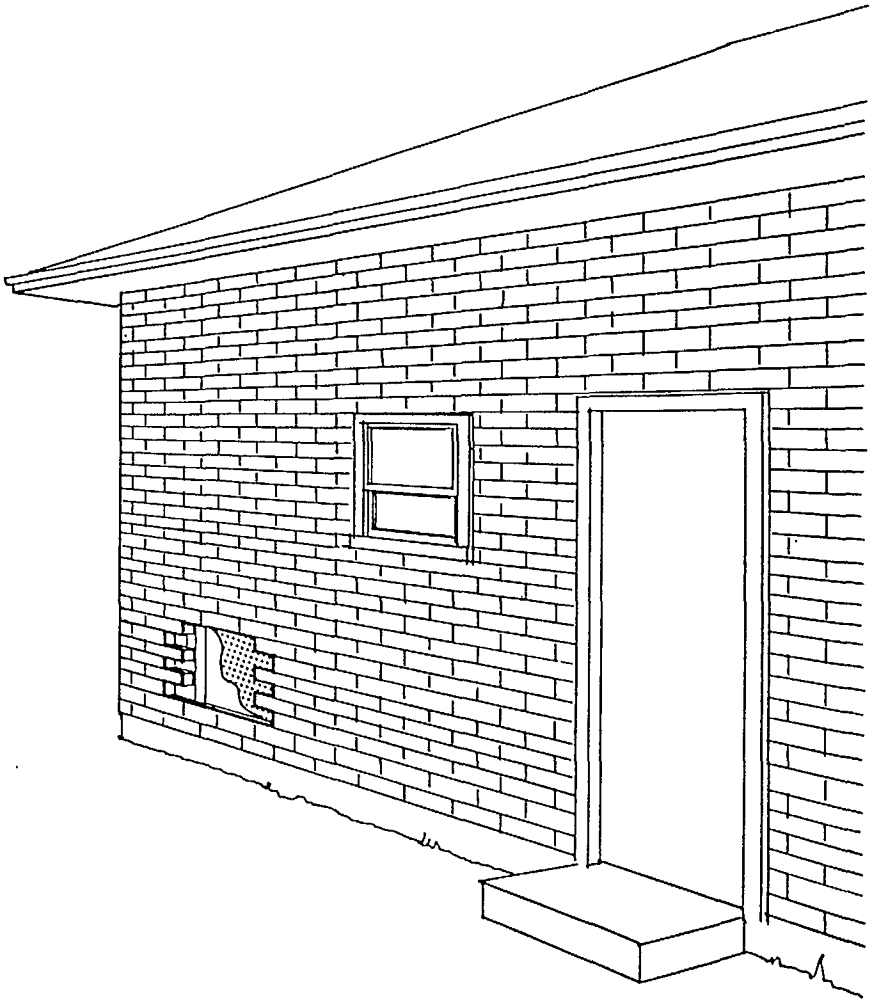
2.5.2 Openings in the Exterior Wall. If an opening in the exterior wall is necessary, choose a location which can be repaired easily and is relatively inconspicuous.

Use bored holes as much as possible. Bore the holes into the cavity slowly and check the borings for the presence of UFFI and moisture. To explore the cavity, use a wire probe or, if available, a lighted optical probe (see Section 2.6.3).

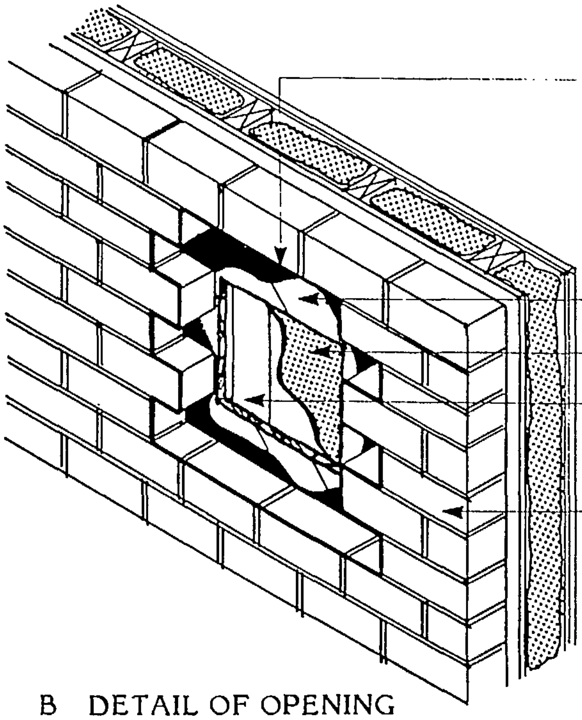
If larger holes are necessary, their size will vary with the type of exterior cladding. If the cladding is brick veneer, a hole three bricks long and six course bricks high is sufficient. This will allow a clear view of the air space between the bricks and the exterior sheathing. Remove an area of sheathing about 300 mm high between the centres of two adjacent studs to examine the cavity (Figure 2.4).

With other types of exterior cladding, make an opening approximately the same size, or sized to make repair easy.

2.5.3 The Optical Probe is a lighted viewing device with either a rigid or a flexible probe. It illuminates the space and allows a wide area around its end to be viewed. Photographs can be taken with proper additional equipment, which is relatively expensive.



A INSPECTION HOLE CUT IN EXTERIOR BRICK VENEER WALL



B DETAIL OF OPENING

FIGURE 2.4 TEST OPENING: OUTSIDE FACE; EXTERIOR WALL

Chapter 3

BUILDING CONSTRUCTION

Contents

3.0 GENERAL INTRODUCTION

This chapter describes the most common Canadian building types. Diagrams are provided to assist in locating cavities in which UFFI may have been installed. A thorough knowledge of this chapter is required to understand the implementation of the different corrective measures required to correct UFFI related problems and to determine the scope of work.

3.0.1 Types of House Construction. Although there is a variety of construction types in Canada, houses are usually of wood frame or solid wall construction. The variety is due mainly to available building materials. Solid wall construction did not provide natural cavities into which UFFI could be foamed; however, cavities may have been created by the addition of strapping and cladding on the interior or exterior of the solid walls.

Wood frame construction types include platform frame, balloon frame, post and beam, and plank frame. Other types are modifications of these. The frame structures are enclosed by interior finishes and exterior cladding. Masonry construction types include solid as well as cavity walls.

Cavities which may contain UFFI are highlighted in this chapter as each type is presented. Hidden cavities which may contain foam are also described.

3.0.2 Assessment of Type of Construction. It is important to assess correctly the type of construction before proceeding to the corrective measures.

For a general assessment of the type of construction it may be useful to consider the patterns of building in the area as well as the age of the house. Very often, a given area developed at a certain time will present the same type of construction. A section of a suburb or a portion of a street may have been built by one developer and therefore, it is most probable that the same method of construction and range of materials was used. Type of construction may also vary from one geographical area to another due to differences in tradition, climate and availability of materials.

There are a number of visible characteristics of the various types of wall which may help to identify them. These characteristics will be studied further in this chapter. Nevertheless, in some cases different wall types may appear very similar, and thus correct assessment may not be possible without opening the wall either from the interior or exterior.

SECTION A: WOOD FRAME CONSTRUCTION TYPES

3.1 INTRODUCTION

This section outlines different wood frame construction types, and will provide a better understanding of unique features found in platform frame construction, balloon frame construction, post and beam construction and plank frame construction.

3.2 PLATFORM FRAME CONSTRUCTION

In platform frame construction, a structural floor assembly comprising floor joists, joist headers and subflooring is assembled and supported by the foundation. The wood frame exterior walls, comprising bottom plates, single storey wall studs and double top plates, are assembled and erected on the working platform. The exterior sheathing and interior finishing materials contain the framed wall cavities which are single storey in height. A second storey platform can sit on the first storey walls and the framing process is repeated. This type of construction has been in extensive use since the 1940's.

Figures 3.0 and 3.1 provide exterior and interior views of platform frame construction. This construction technique may be used for single- or multi-storey structures.

Figure 3.2 shows extra fill ports drilled at the floor joist levels. The implementation of corrective measures for this type of situation will be covered in Chapter 8.

LOOK FOR FILL PORTS AS AN INDICATION
OF POSSIBLE UFFI LOCATIONS

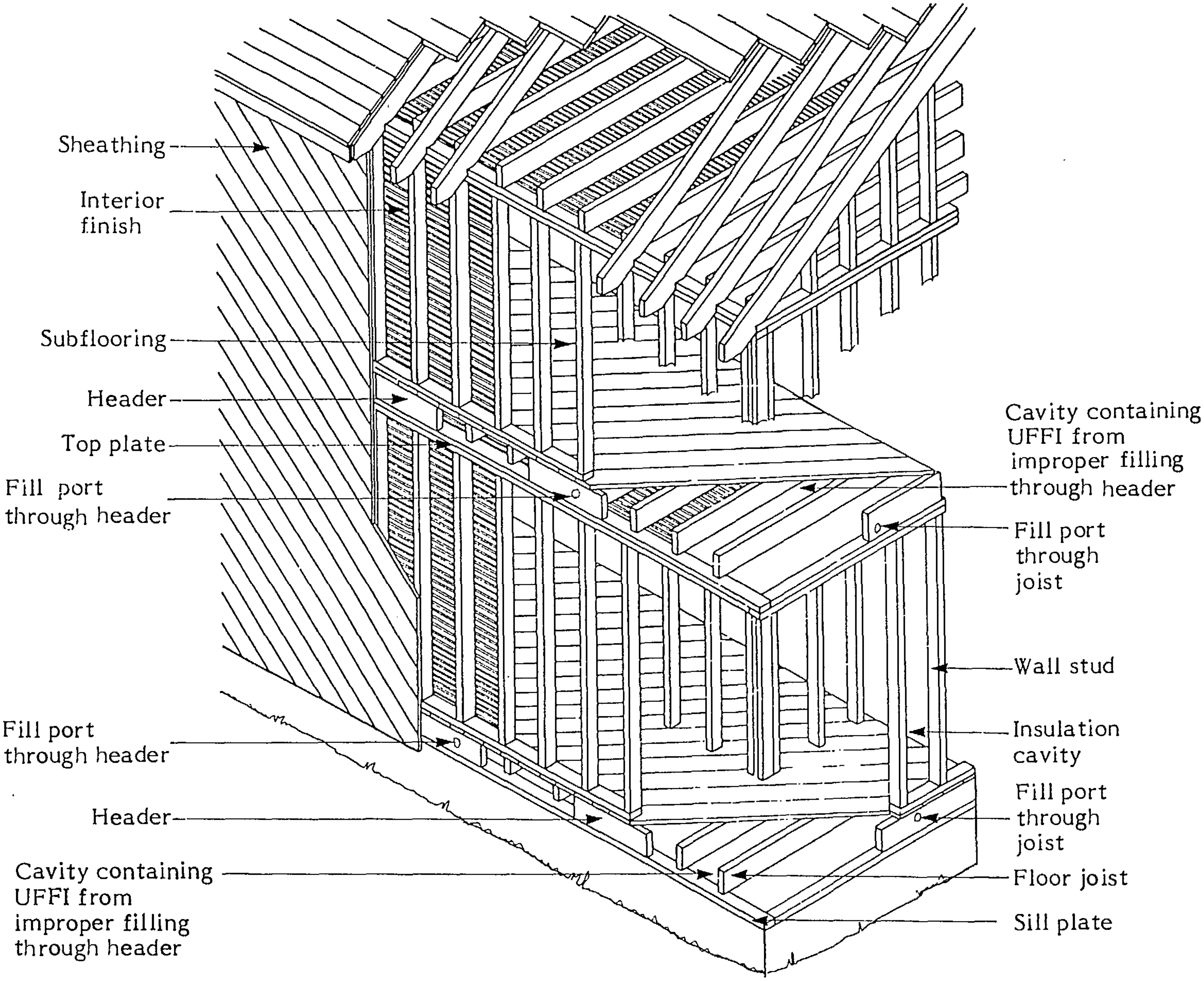


FIGURE 3.0 PLATFORM FRAME -
IMPROPER DRILL PORTS AT FLOOR OR CEILING JOIST LEVEL

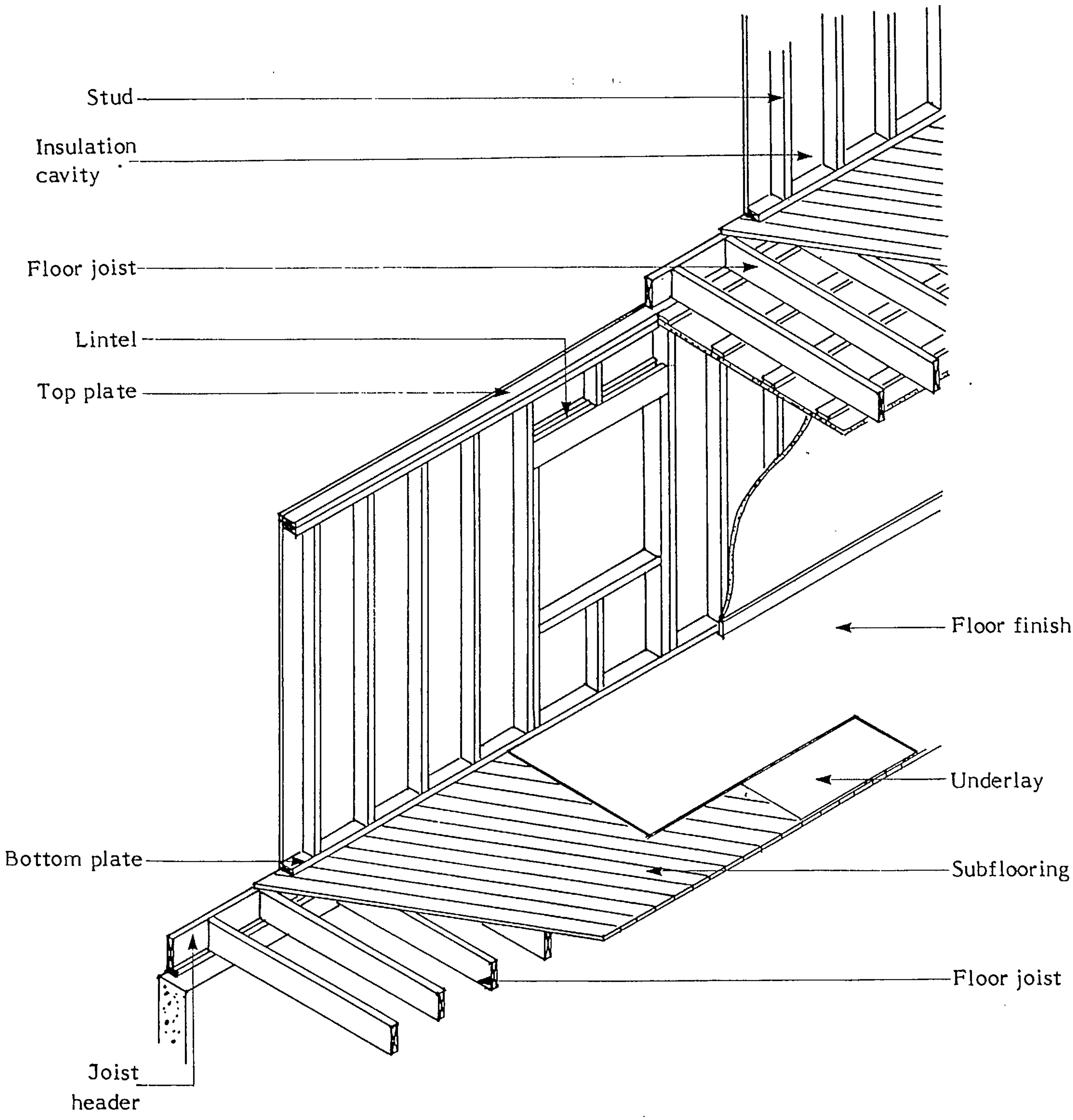


FIGURE 3.1 PLATFORM FRAME: INTERIOR VIEW

Figure 3.2 shows a fill port where two parallel joists are separated by a narrow cavity. It would be extremely difficult to gain access to this cavity.

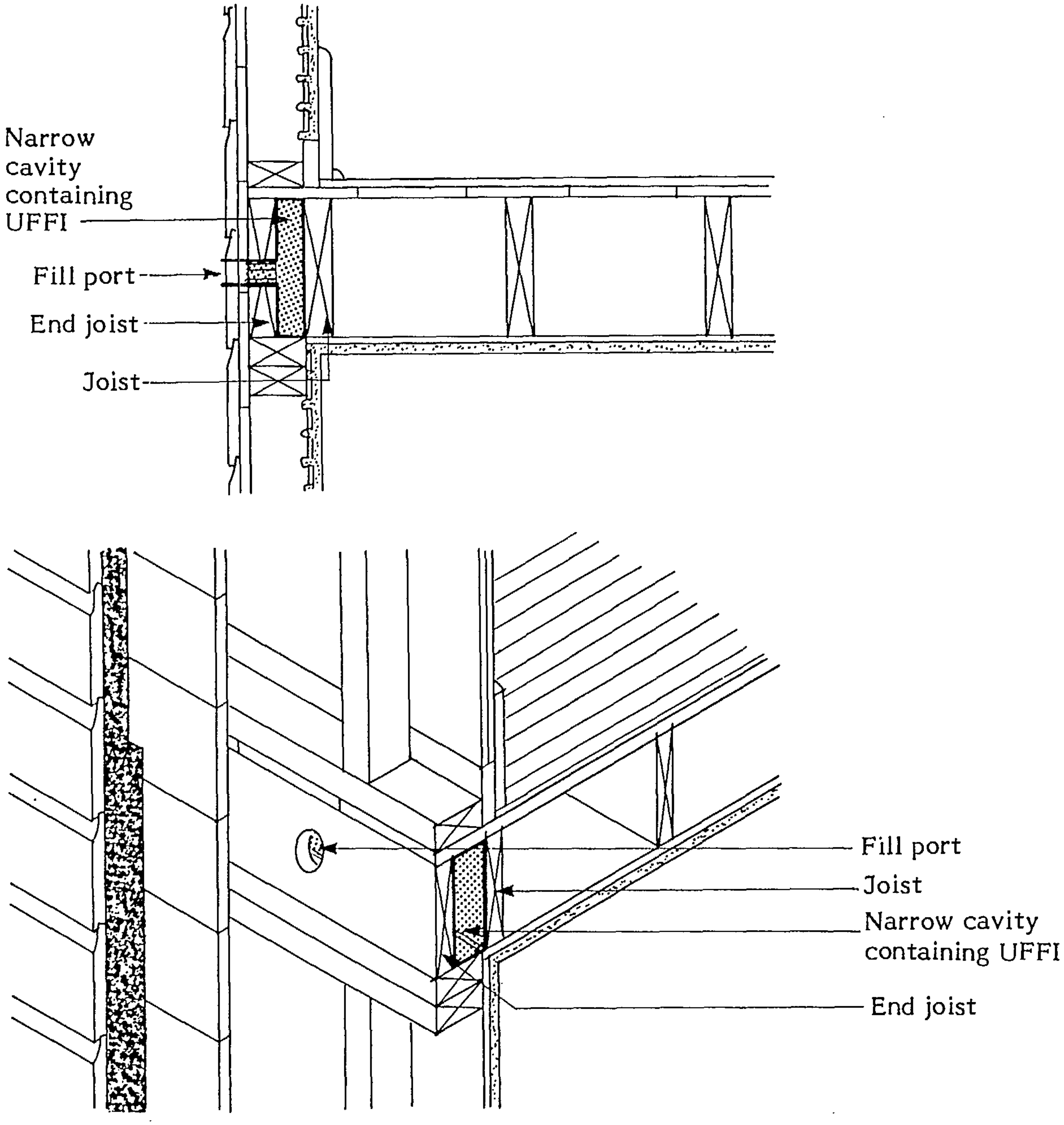


FIGURE 3.2 FILL PORT TO NARROW CAVITY MAY INDICATE PRESENCE OF UFFI

3.3 BALLOON FRAME CONSTRUCTION

In balloon frame construction, the studs bear on a sill plate anchored to the foundation wall. The studs extend as continuous members from the sill plate to the top plates at the roof support level. The first storey floor joists bear on the sill plate and extend outward through the cavity to the exterior sheathing line.

Second floor joists and the uppermost ceiling joists are supported on a ribbon which is let into the studs at ceiling height as well as being nailed directly to the studs. These floor and ceiling joists extend outward through the cavity to the exterior sheathing line. This type of construction was mainly used from the 1900's to the 1940's.

The cavities, as framed by the sill plate, roof line top plates and the building height studs, except as interrupted by subflooring, extend from the sill plate to the roof line. With proper framing, a fire stop would be installed between the studs at or near the top of the floor joist. However, in many instances, the firestops were not installed*. In such cases the individual cavities, enclosed by exterior sheathing and interior cladding, extend virtually uninterrupted from the top of the foundation wall through floors and ceilings to the roof line wall plates. In addition, in the absence of joist space blockings,* the wall cavity is open to the floor/ceiling joist space at each storey.

Figures 3.3 and 3.4 provide exterior and interior views of balloon frame construction. This type of construction creates wall cavities different from those contained in platform construction.

***NOTE:** If the cavity is exposed adequately, then firestops and blocking which were not included during original construction should be installed during the restoration stage.

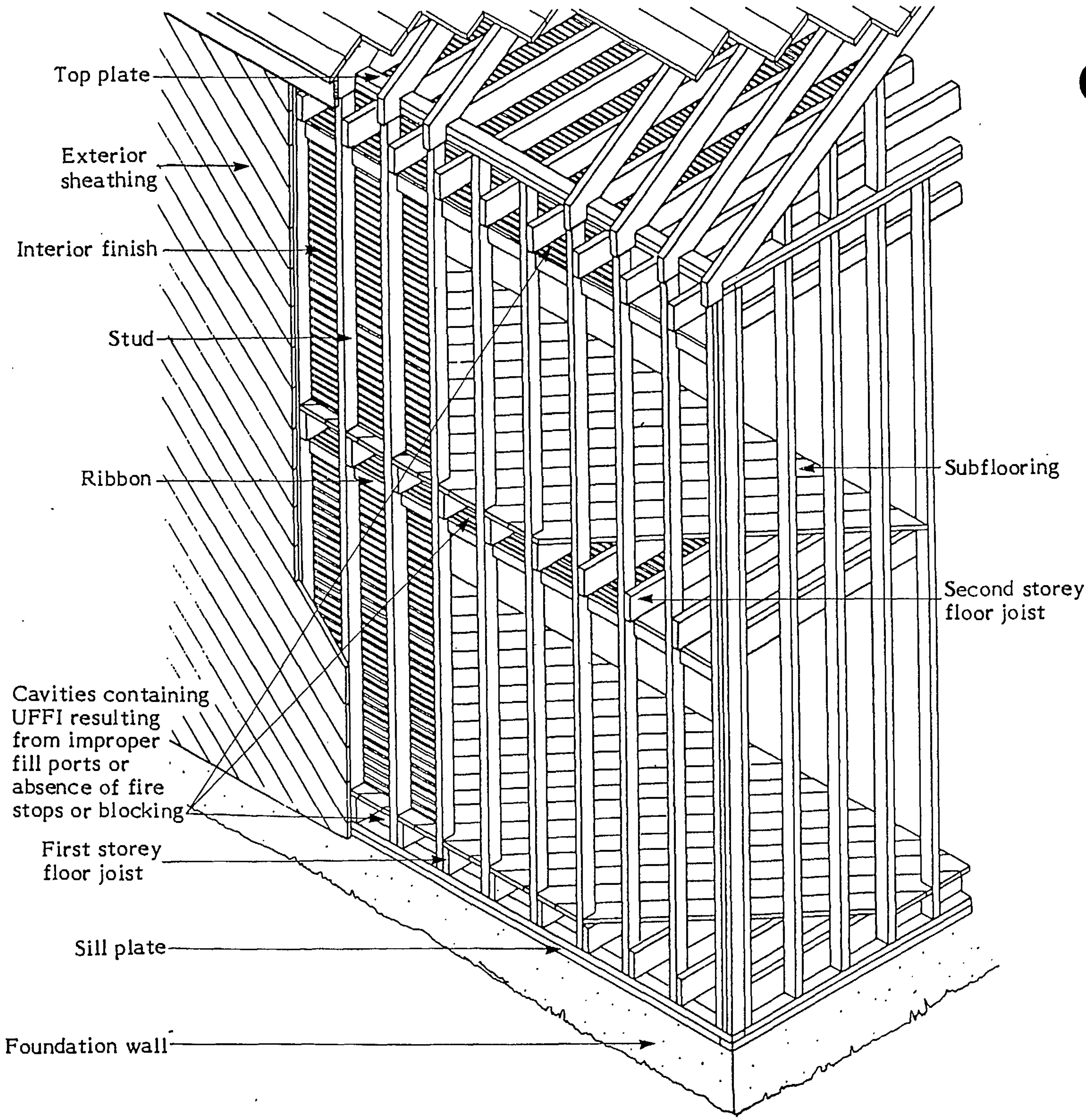


FIGURE 3.3 BALLOON FRAME - EXTERIOR VIEW SHOWING CAVITIES CONTAINING UFFI RESULTING FROM IMPROPER FILL PORTS OR ABSENCE OF FIRE STOPS OR BLOCKING BETWEEN JOISTS

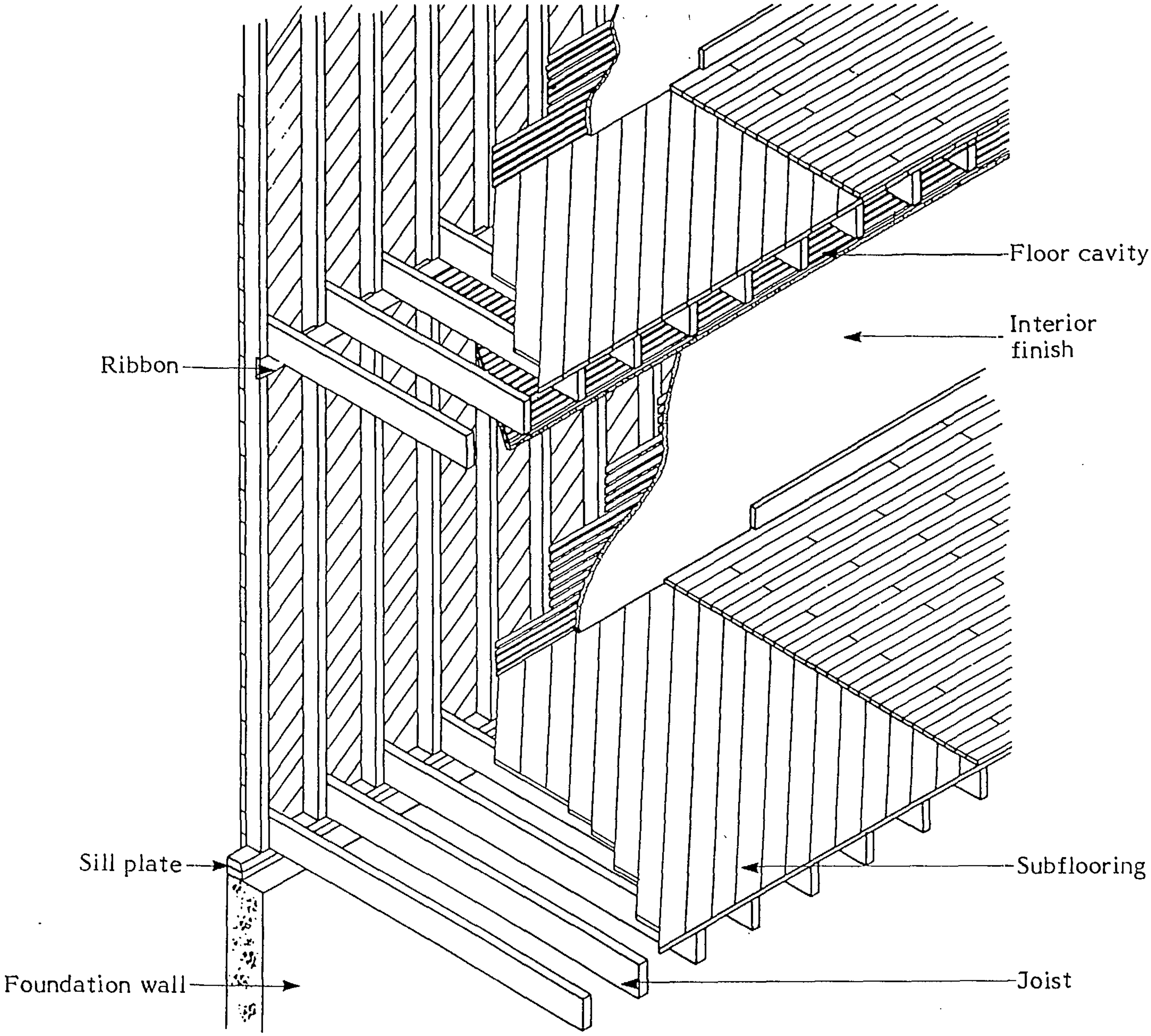


FIGURE 3.4 BALLOON FRAME - INTERIOR VIEW

3.4 POST AND BEAM CONSTRUCTION

Post and beam is a system of construction in which posts and beams support the load and the infilling walls are not load-bearing. This framing system produces individual, enclosed single-storey height insulation cavities similar to those described under platform framing. This type of construction became common in the pre-1900's and still exists.

Figure 3.5 shows post and beam construction utilizing heavy beams and posts, with lighter beams as bracing. The larger cavities formed by the main post and beams are sectioned by rough lumber studding, and planking is used to enclose the smaller cavities.

Figure 3.6 shows a more modern post and beam construction which uses dressed lumber of construction grade. The structural bracing in these modern methods does not tie in the post and beam directly, but takes the form of:

a) diagonal lumber sheathing;
b) plywood sheathing;
c) diagonal bracing set into the face of the stud.

Ceiling/floor joist spaces containing UFFI are to be treated similarly to platform frame.

NOTE: Plank flooring is often used as a structural member. To maintain the structural integrity, access to the foamed cavity should be from the ceiling. The implementation of corrective measures for this type of structure will be covered in Chapter 8.

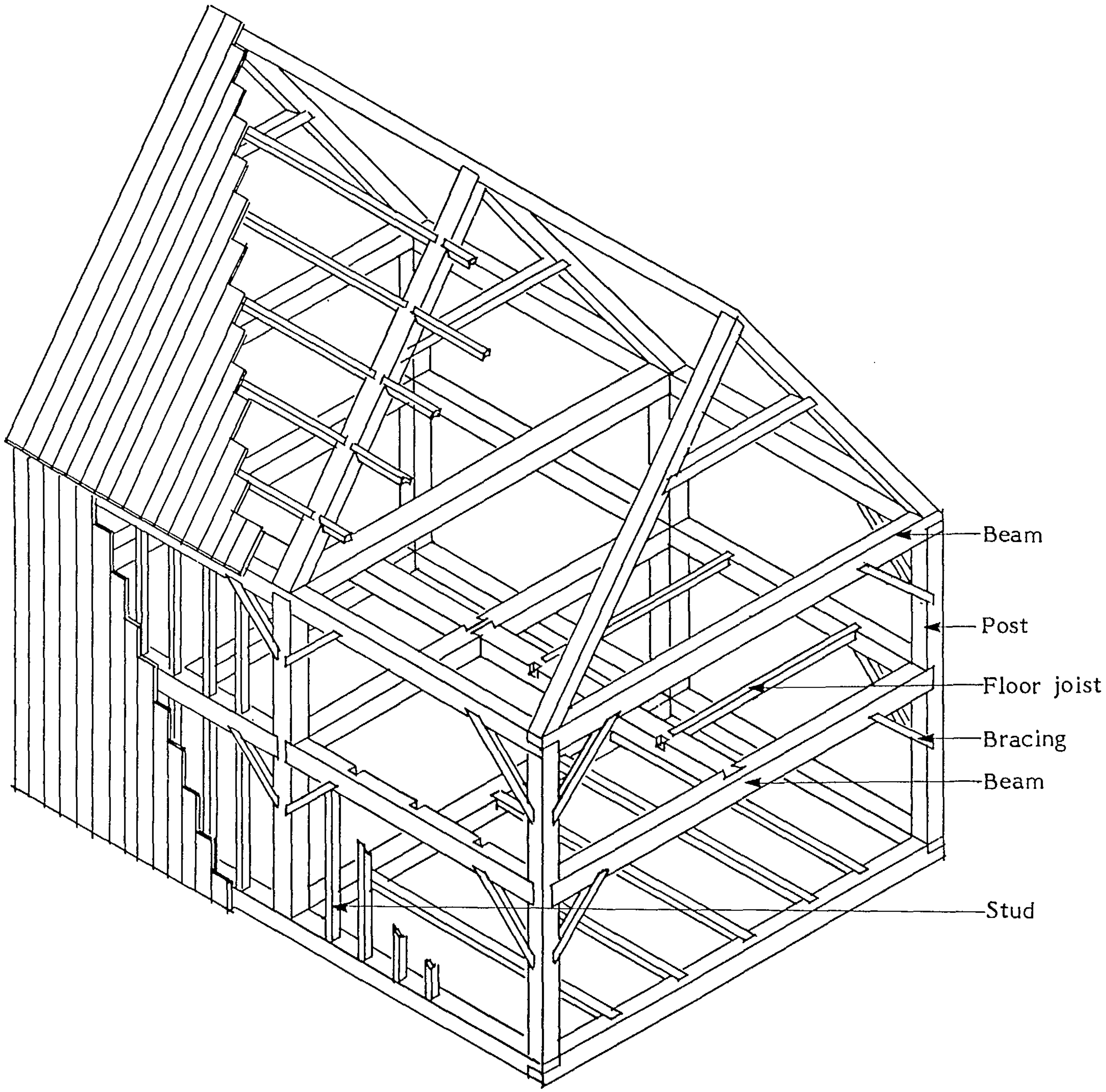


FIGURE 3.5 EARLY POST AND BEAM

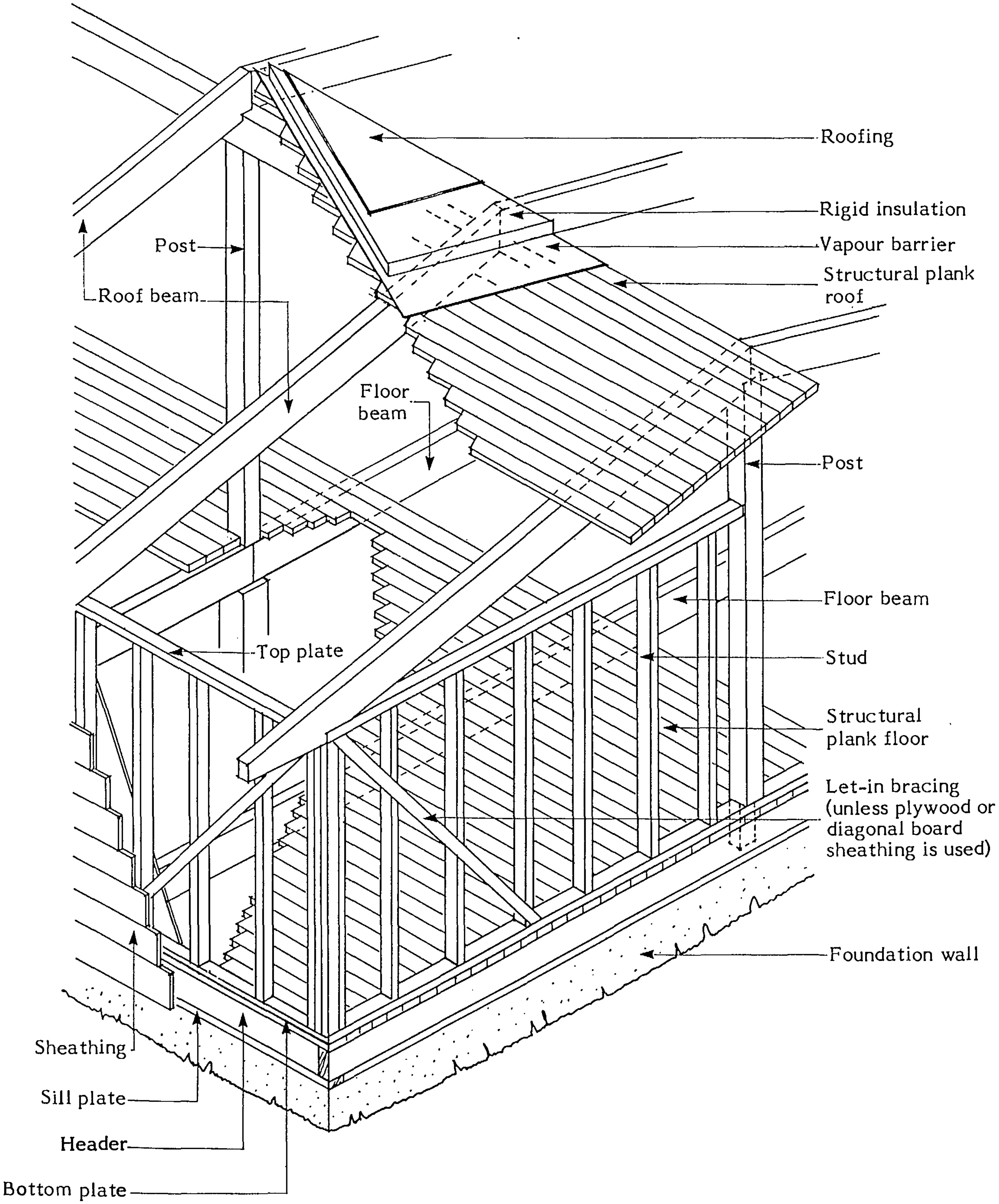


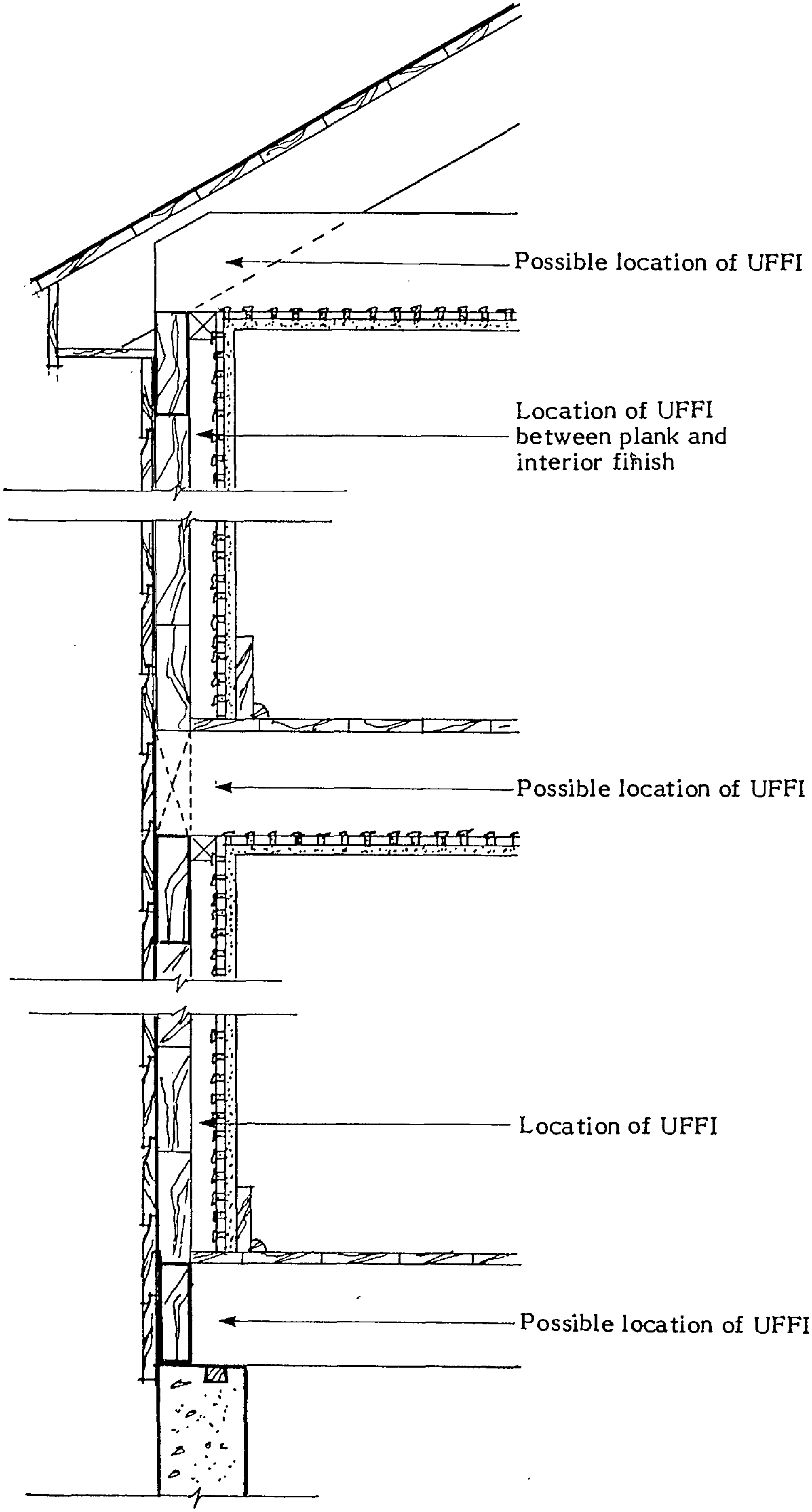
FIGURE 3.6 MODERN POST AND BEAM

3.5 PLANK FRAME CONSTRUCTION

Plank and frame construction employs vertical structural members, with horizontal plank beams tied into them with an infilling of planks on edge. Cavities on the interior and/or exterior surfaces are created by furring or strapping required for the installation of standard wall claddings.

Though this type of construction is fouhd primarily in Quebec, variations can be found across the country. In such homes, where foam has been installed in cavities, access to UFFI is gained through either the interior or exterior cladding, depending upon which side the UFFI was installed.

Figure 3.7 shows details of a plank frame construction.



3-16 **FIGURE 3.7 PLANK FRAME CONSTRUCTION - DETAIL SHOWING POSSIBLE UFFI LOCATION**

SECTION B: MASONRY VENEER HOUSES

3.6 INTRODUCTION

Masonry veneer is a very popular cladding in residential construction. The veneer, which can be facing brick or tile, stone or other material, is laterally supported by the load-bearing structure.

The veneer supports no vertical loads other than its own weight.

3.7 METHODS OF ATTACHING THE VENEER

There are two methods by which the exterior finish is laterally attached to the frame:

a) the brick veneer is anchored to the frame with metal ties, leaving approximately 25 mm of air space. This air space resists water penetration into the inner wall construction and is flashed at the bottom (Figures 3.8 to 3.10). The weepholes at the junction of the foundation, are to drain water which may have entered the air space from the exterior;

b) 13 mm thin bricks or stone veneer are attached directly to the waterproofed sheathing by means of mortar or grout (Figure 3.11). Since the veneer does not have a structural capacity, support depends on well-braced framing and backing and good anchorage of the veneer to the structure.

3.8 UFFI INFILTRATION IN MASONRY VENEER HOUSES

Where masonry veneer exterior finish creates an air space between the veneer and the frame structure, it also creates a cavity where UFFI could have been injected.

Figures 3.8 to 3.11 also show possible UFFI filled cavities behind the brick veneer of platform frame, balloon frame, and plank frame construction. With other types of veneer, whether 13 mm brick or stone veneer, the cavities formed by the support framing will have to be checked for UFFI.

NOTE: See Section A for other possible locations for UFFI.

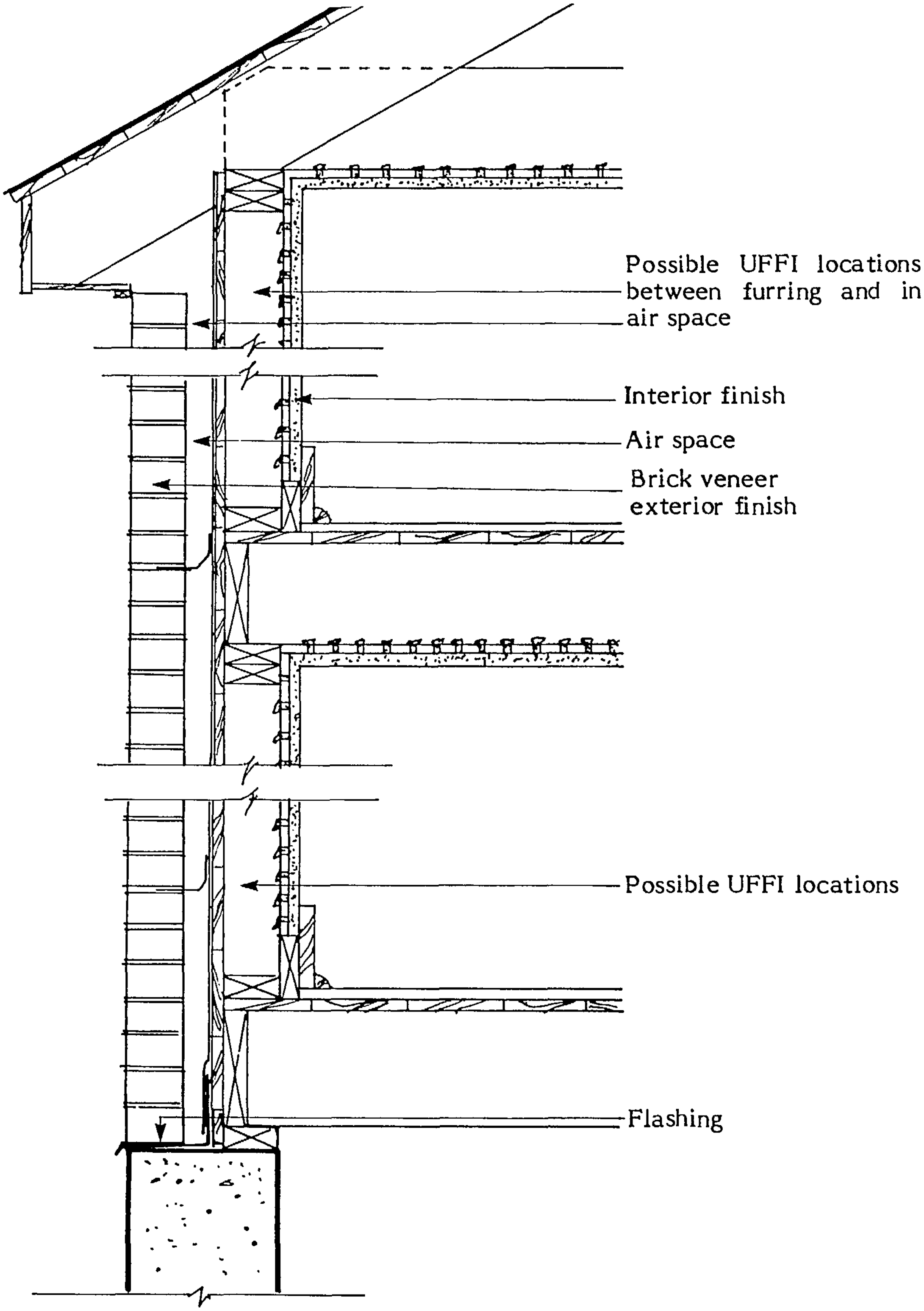


FIGURE 3.8 POSSIBLE UFFI LOCATIONS IN A BRICK VENEER PLATFORM FRAME WALL

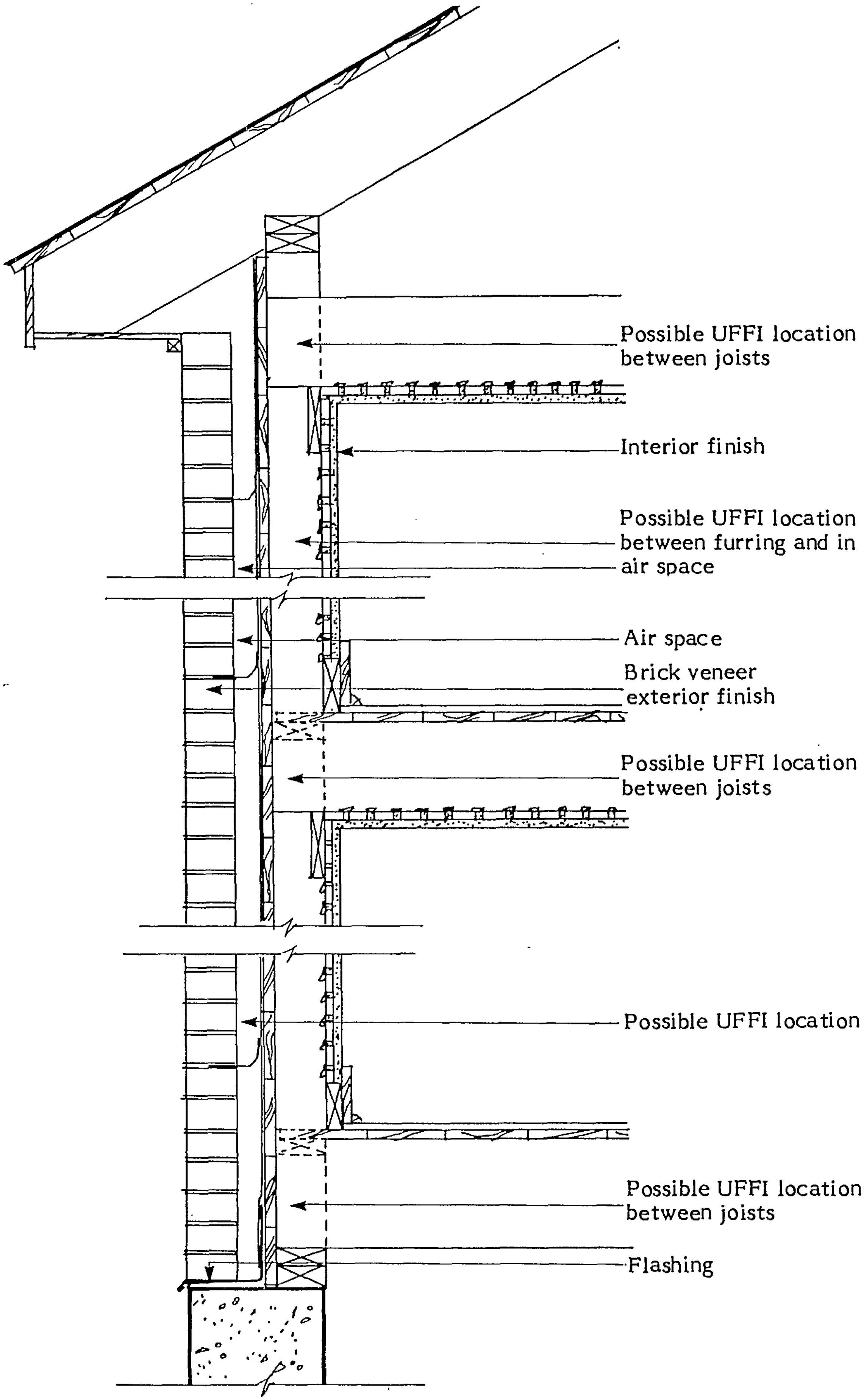


 FIGURE 3.9 POSSIBLE UFFI LOCATIONS IN A BRICK VENEER BALLOON FRAME WALL

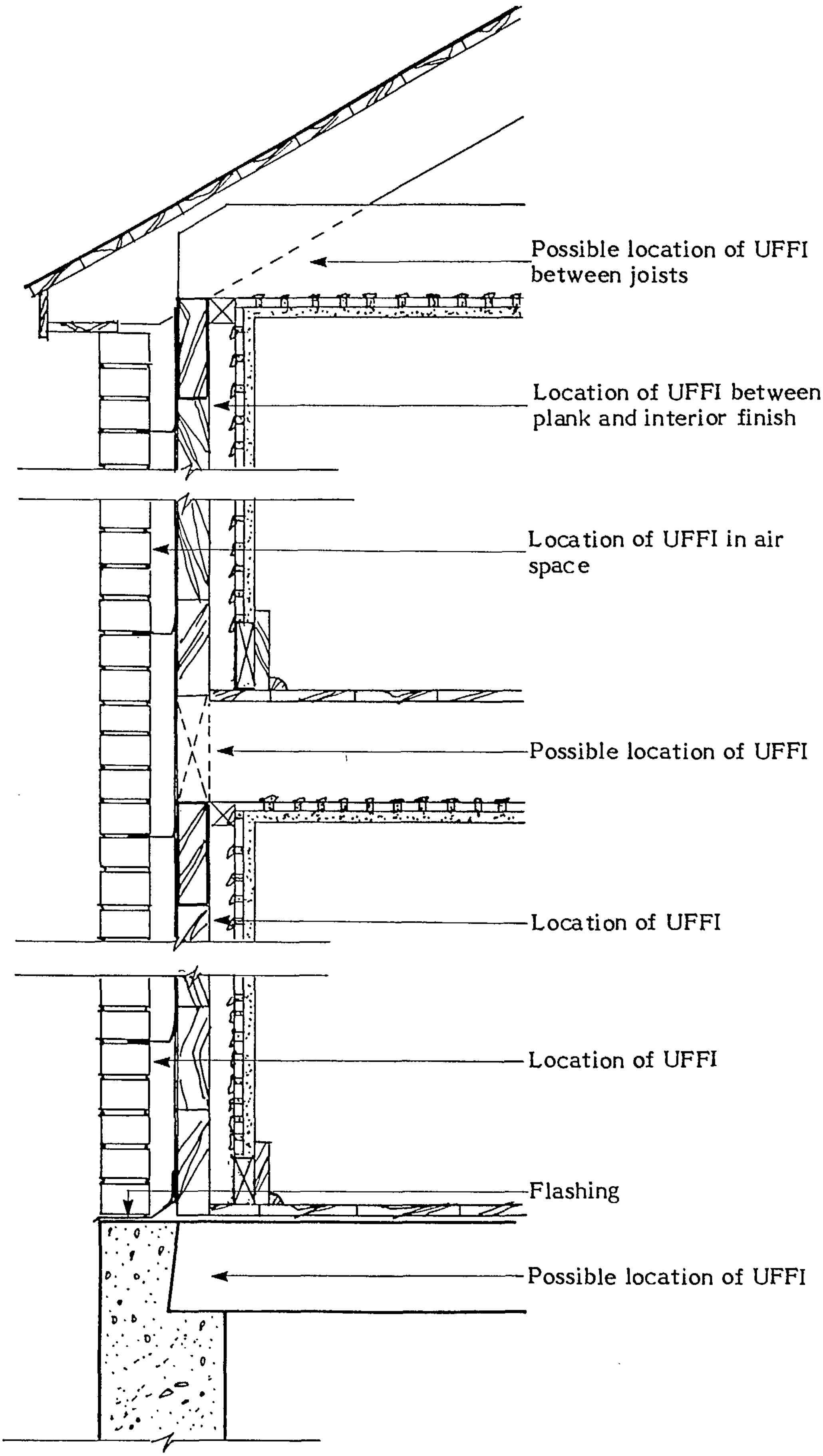


FIGURE 3.10 POSSIBLE UFFI LOCATION BRICK VENEER PLANK FRAME CONSTRUCTION

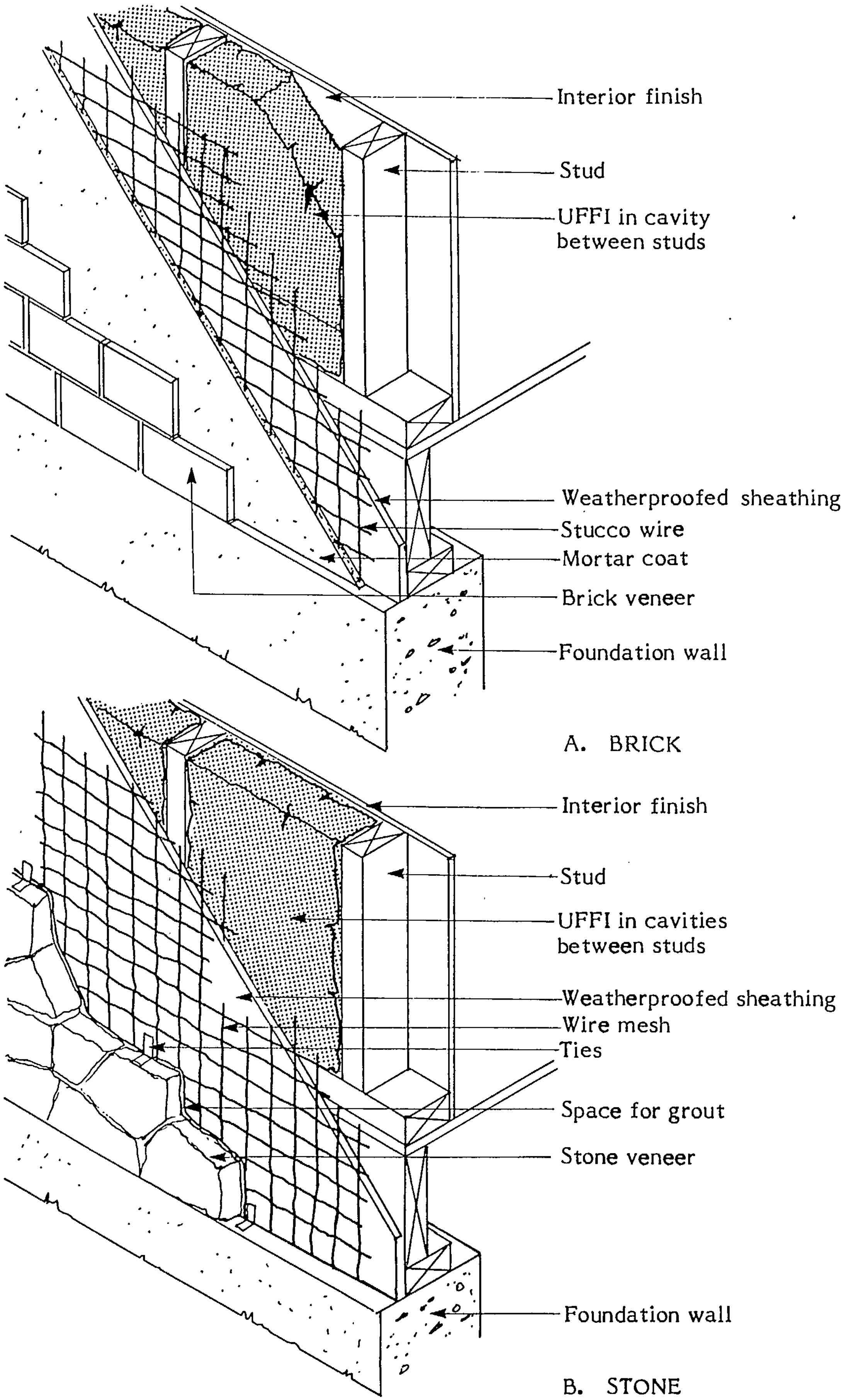


FIGURE 3.11 MASONRY VENEERS ON WOOD FRAME CONSTRUCTION

SECTION C: MASONRY CONSTRUCTION TYPES

3.9 INTRODUCTION

Solid wall and cavity wall masonry construction were commonly used in some areas from the pre-1900's to the 1960's. There are several shapes, sizes and varieties of masonry units.

The bonding of walls by masonry units is achieved by using units as "headers" to join two or more adjacent wythes. A wythe is a masonry wall or part of a masonry wall comprising in depth the width of one masonry unit only.

These headers can be placed in a horizontal line at intervals or in continuous courses. Such types of bonding can be seen in Figures 3.12, 3.13 and 3.14 (A) to (D).

Bonding of walls may also be done by metal ties (Figure 3.15). Such bonding allows more flexibility, accommodating the movement between wythes, thus preventing cracking.

For familiarization with some commonly used masonry terms such as: soldier, header and stretcher, see Figure 3.16 (A), (B), and (C).

Solid and cavity masonry walls generally act as composite units to carry roof and floor loads to the foundation.

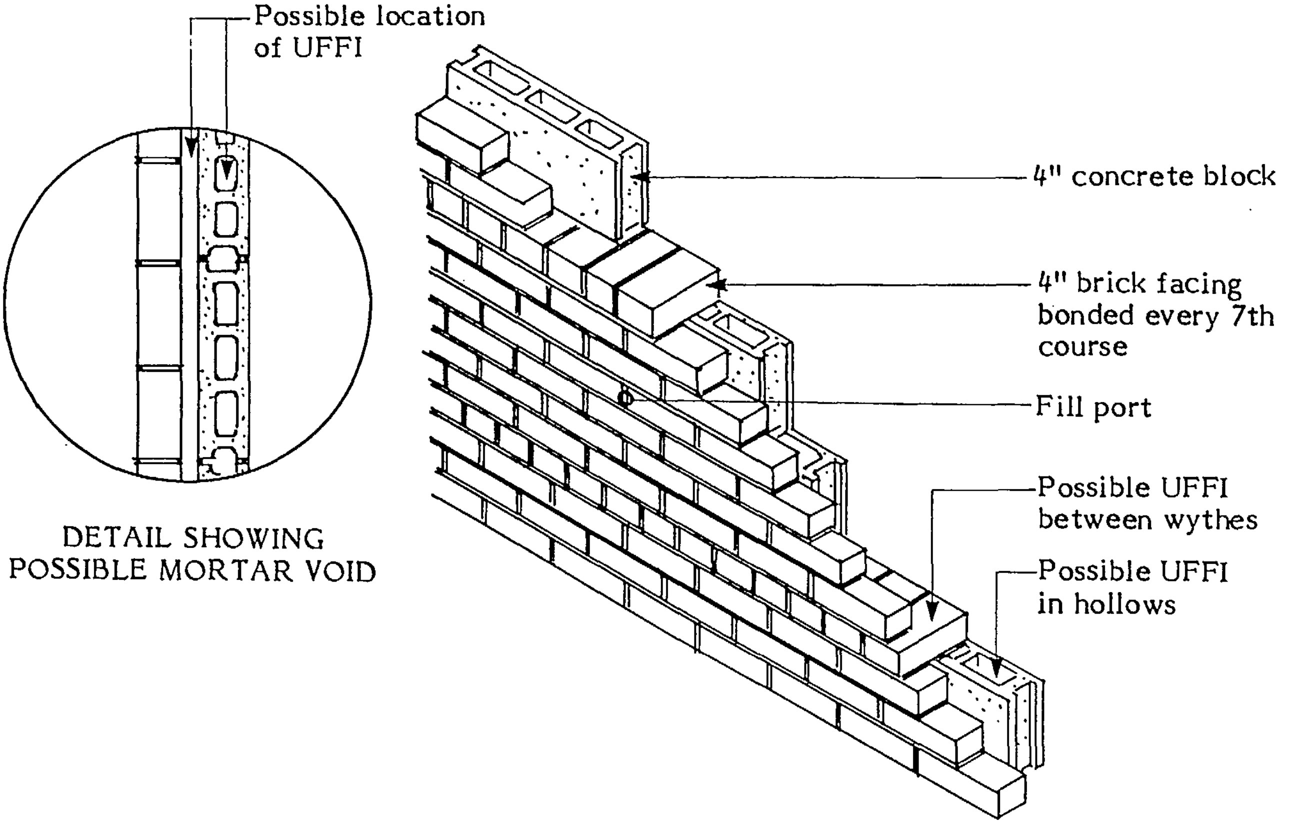


FIGURE 3.12 8" BRICK AND BLOCK BONDED MASONRY WALL

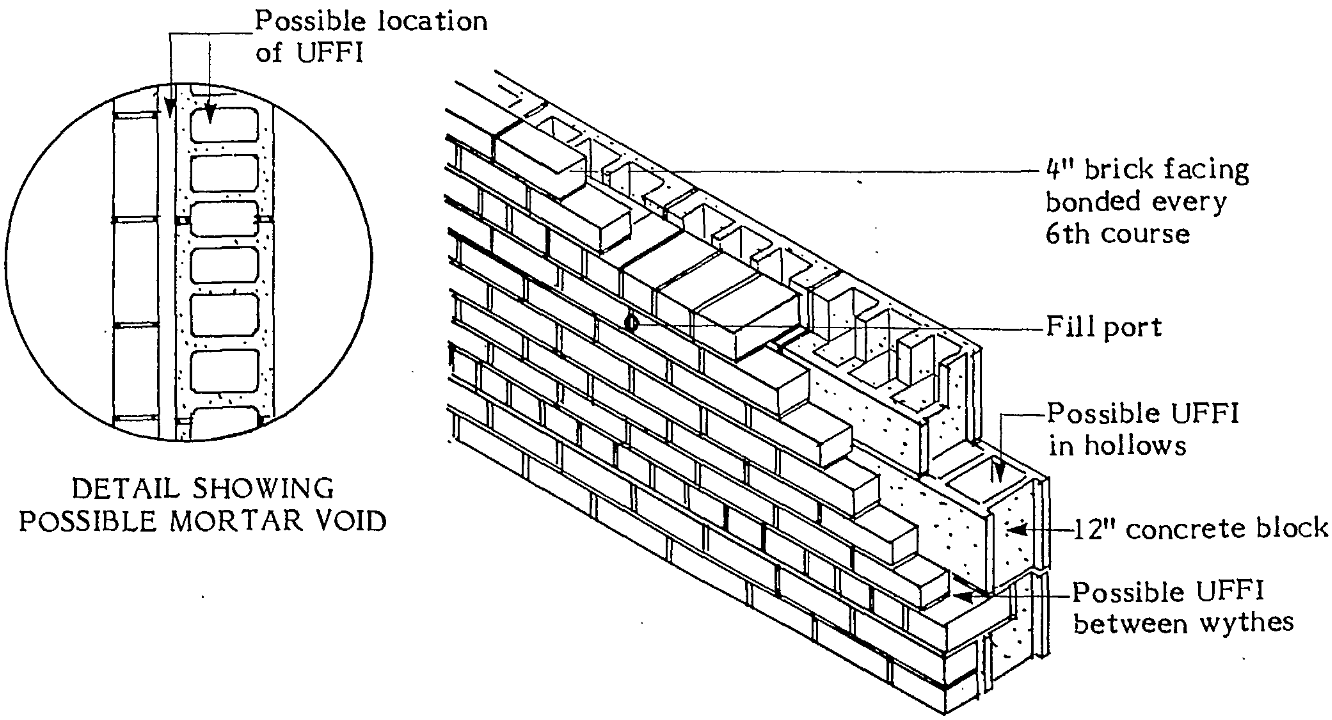
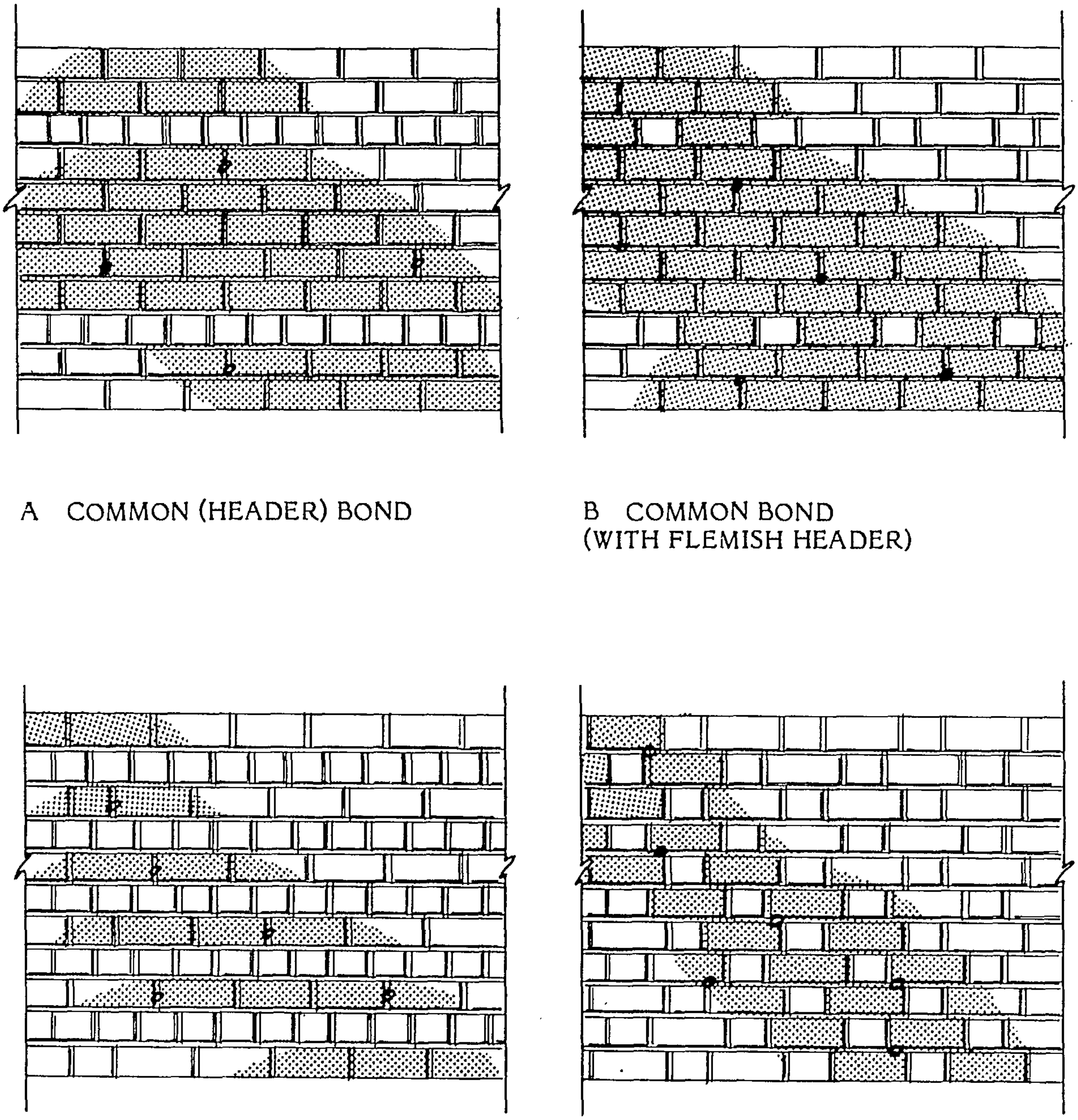


FIGURE 3.13 12" BRICK AND BLOCK BONDED MASONRY WALL



A COMMON (HEADER) BOND

B COMMON BOND (WITH FLEMISH HEADER)

C ENGLISH BOND

D FLEMISH BOND

FIGURE 3.14 TYPES OF BOND IN BRICK WALLS HATCHING INDICATES EXTENT OF SPACE BETWEEN WYTHES AND POSSIBLE UFFI INFILTRATION INTO THEM

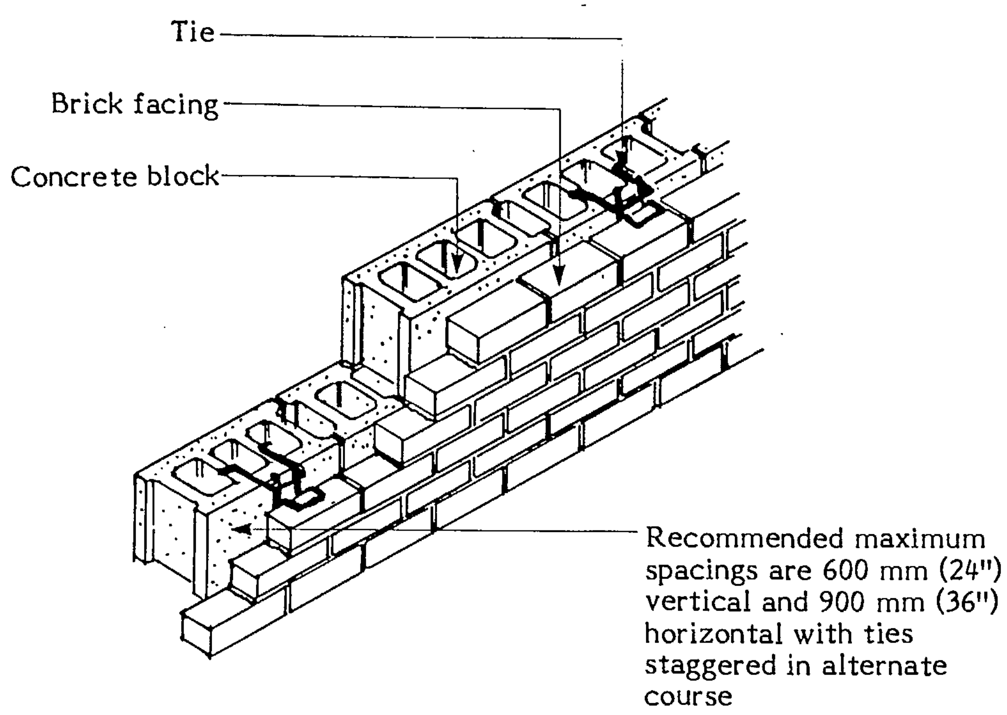


FIGURE 3.15 BRICK AND BLOCK CAVITY WALL SHOWING TYPICAL PLACEMENT OF TIES

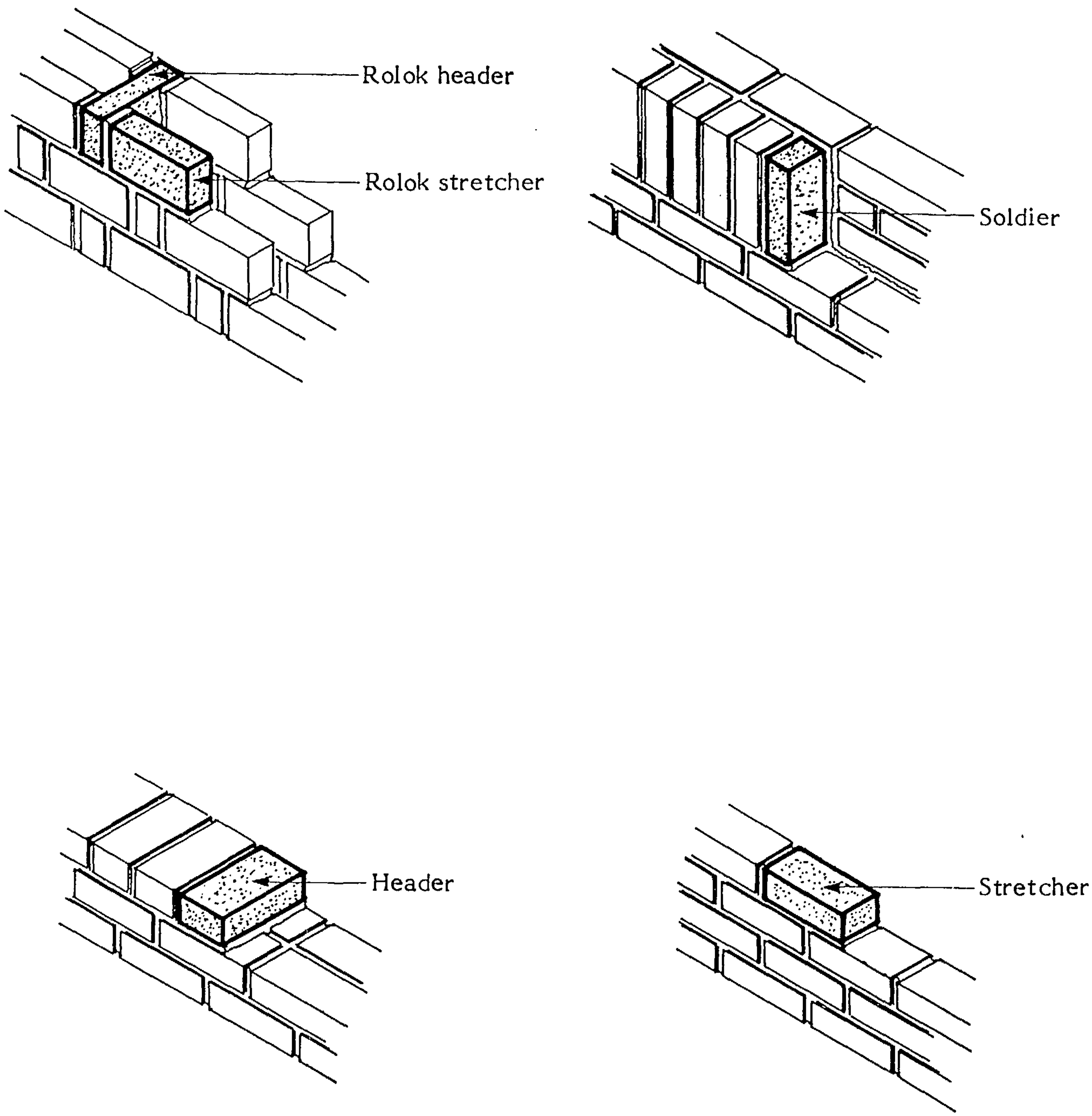


FIGURE 3.16 TERMS APPLIED TO BRICK WALL

3.10 SOLID WALLS

Solid walls consist of masonry units laid close together, ideally with all joints filled with mortar. Walls can vary in thickness with different wythes being tied together by masonry units or metal ties. Masonry units can be stone, brick (clay, concrete, sand-lime), structural clay tile, or concrete block. The walls can be of one unit or a combination of different ones.

3.10.1 **Solid Walls of Solid Units** do not contain cavities between wythes and UFFI could have been injected only behind the interior finish or between the pieces of furring (Figure 3.17). A small quantity of UFFI may be located in the vertical joint between wythes that were not properly filled with mortar.

Figures 3.17 and 3.18 show two types of solid brick walls furred on the inside. At first glance, this looks like veneer, but actually the brick is the load-bearing component. It can usually be identified by the length of brick (12") and the width (6"), which can be seen at the corners.

Fieldstone walls consist of rough stone, approximately square or rectangular, usually bedded in lime hydrate mortar. The interior of the wall is generally furred out from the stone with wood studs and lath and plaster finish (Figure 3.19).

In all these types of wall, UFFI could have been injected in the space immediately behind the interior finish. Under pressure, UFFI could have travelled from behind the interior finish, through cracks and gaps in the structure, into the roof or into the floor joist areas near the exterior walls.

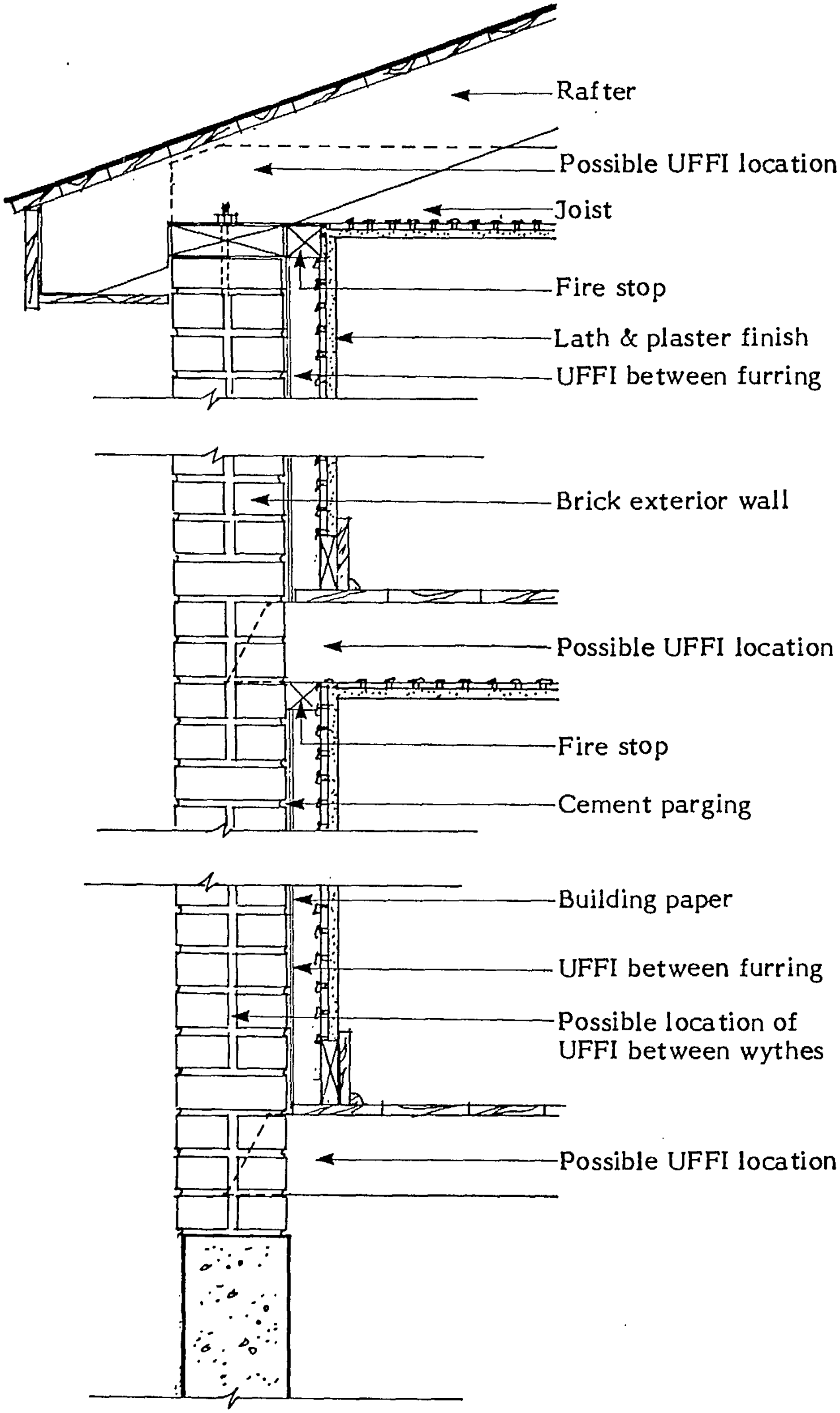


FIGURE 3.17 SOLID BRICK WALL
(SOLID WALL WITH SOLID UNITS)

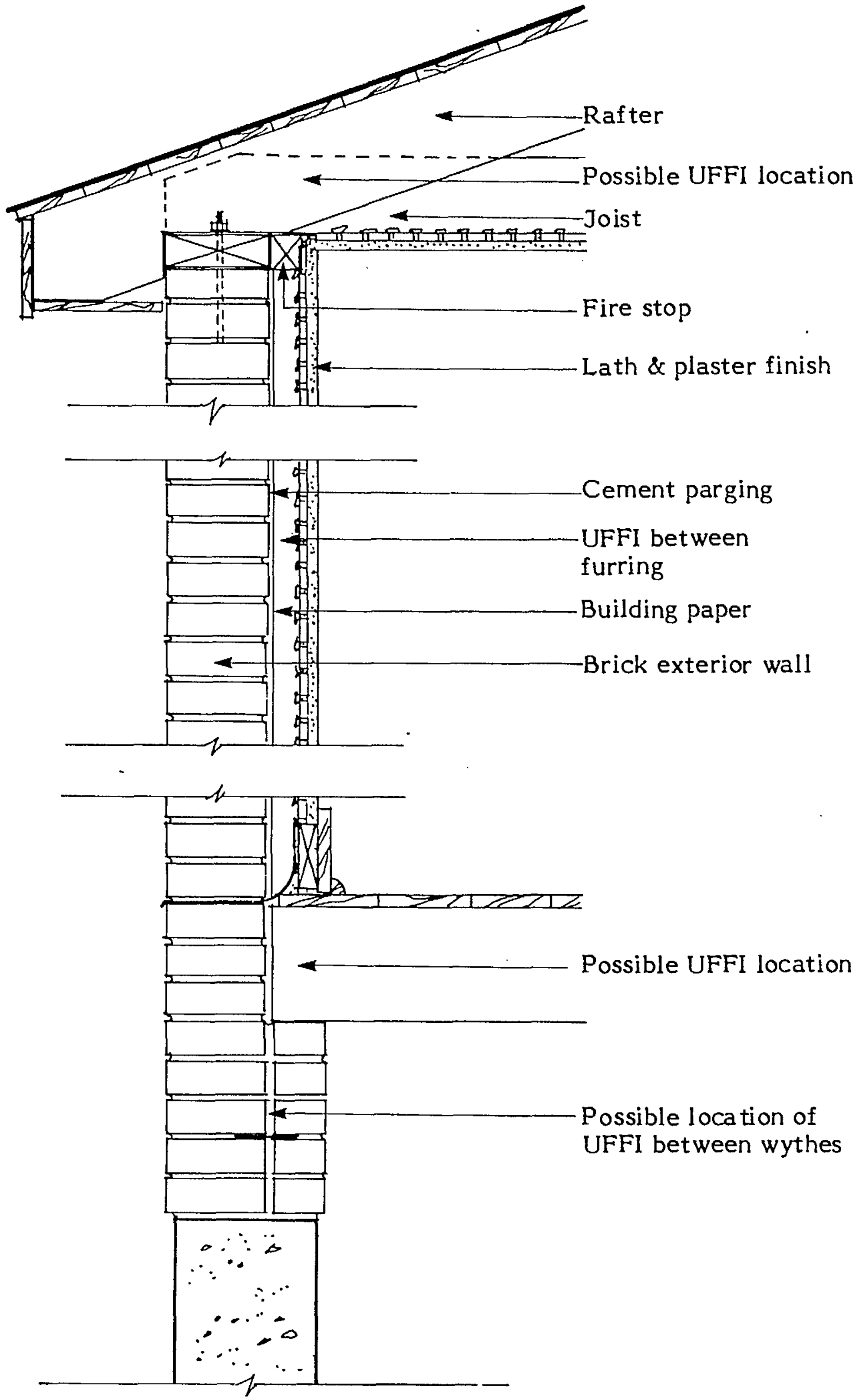


FIGURE 3.18 THROUGH-THE-WALL (TTW) BRICK CONSTRUCTION

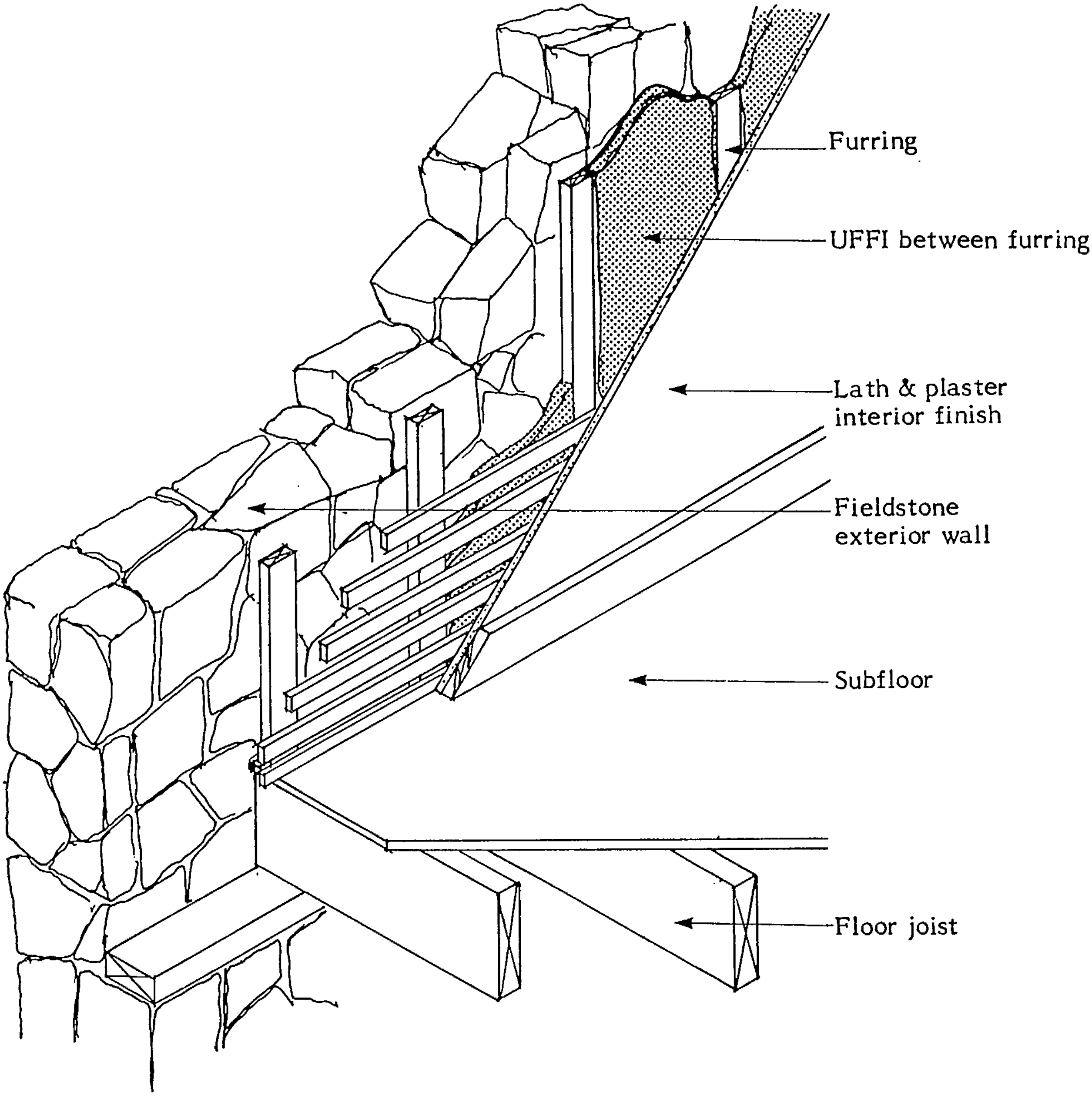


FIGURE 3.19 FIELDSTONE WALL

It is apparent that, since UFFI was fluid (75 percent by weight water) at the time of installation, there may have been penetration of UFFI into the joints of the exterior wall and into more porous surfaces by pressure. Acidic water may have travelled into the pores of bricks.

3.10.2 **Solid Walls of Hollow Units** can be structural clay tile or concrete block. The structural clay tile wall contains parallel cavities created through the juxtaposition of hollow units (Figure 3.20). These narrow cavities run vertically or horizontally, depending on the way in which units were laid. The concrete block wall contains parallel cavities which usually run vertically (Figure 3.21). Their dimensions vary with the size and design of the blocks.

UFFI may have been injected either in the space between the wall and the drywall or plaster finish, or directly in the hollows of the units, or in both. In the case of the structural tile wall, it would have been difficult and time consuming to place UFFI into individual cells or sets of cells, however, the material could have been randomly injected into these areas.

Where the wall was made of hollow core units, it is entirely possible that the cores within that block wall were filled with UFFI. Inadvertent travel of UFFI into the floor or roof areas is also possible.

3.10.3 **Composite Walls** combine an exterior wythe of solid units, clay brick or stone, bonded to a backup wythe of hollow units, structural clay tile or concrete block (Figures 3.22 to 3.24). All the wythes contribute to the strength of the wall as they are bonded together by masonry units or metal ties.

Various combinations resulting in a range of thicknesses are represented in Figure 3.25 (A) through (F). The limited or continuous cavities formed by the hollow block may contain UFFI

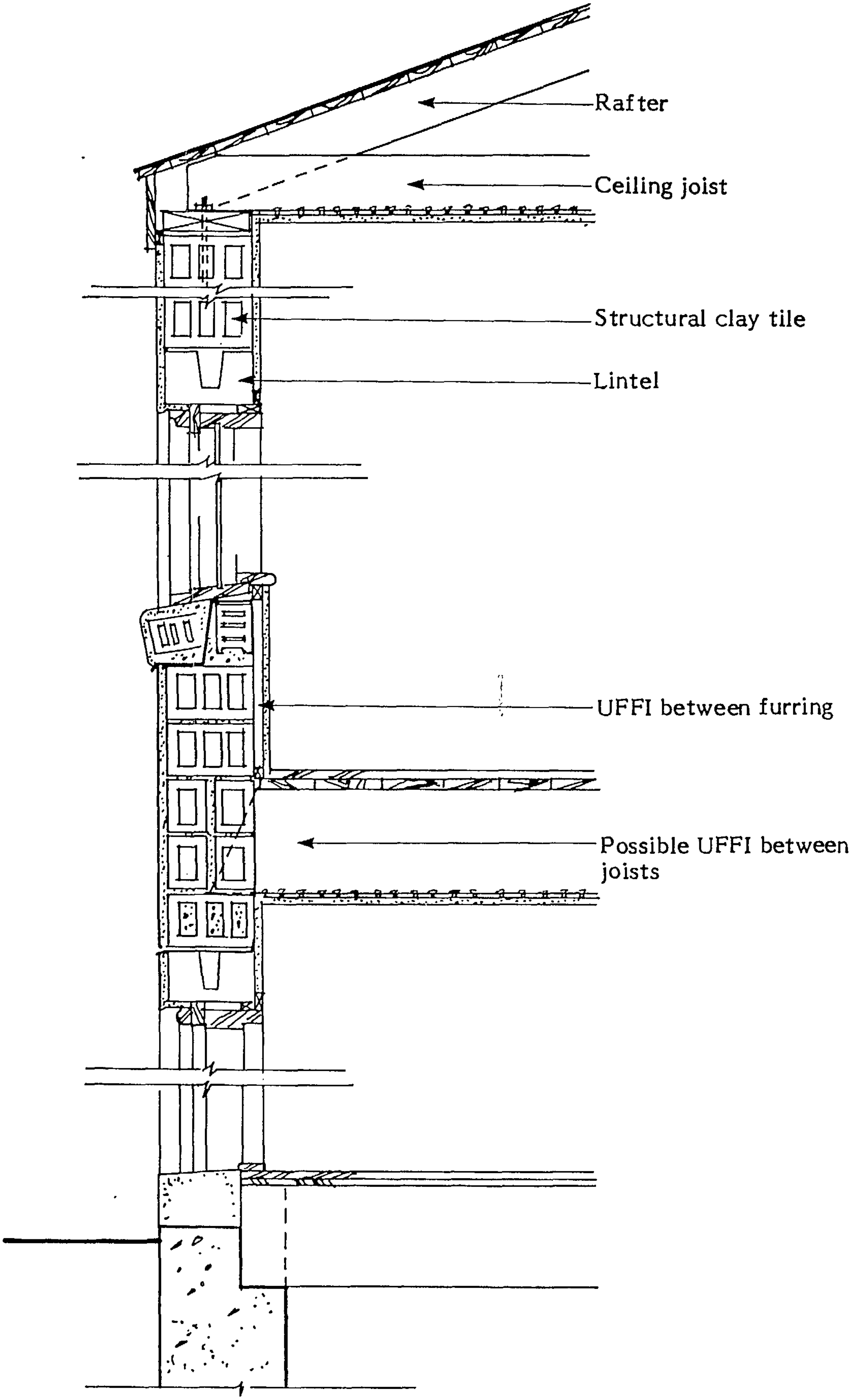


FIGURE 3.20 STRUCTURAL CLAY TILE WALL
(SOLID WALL WITH HOLLOW UNITS)

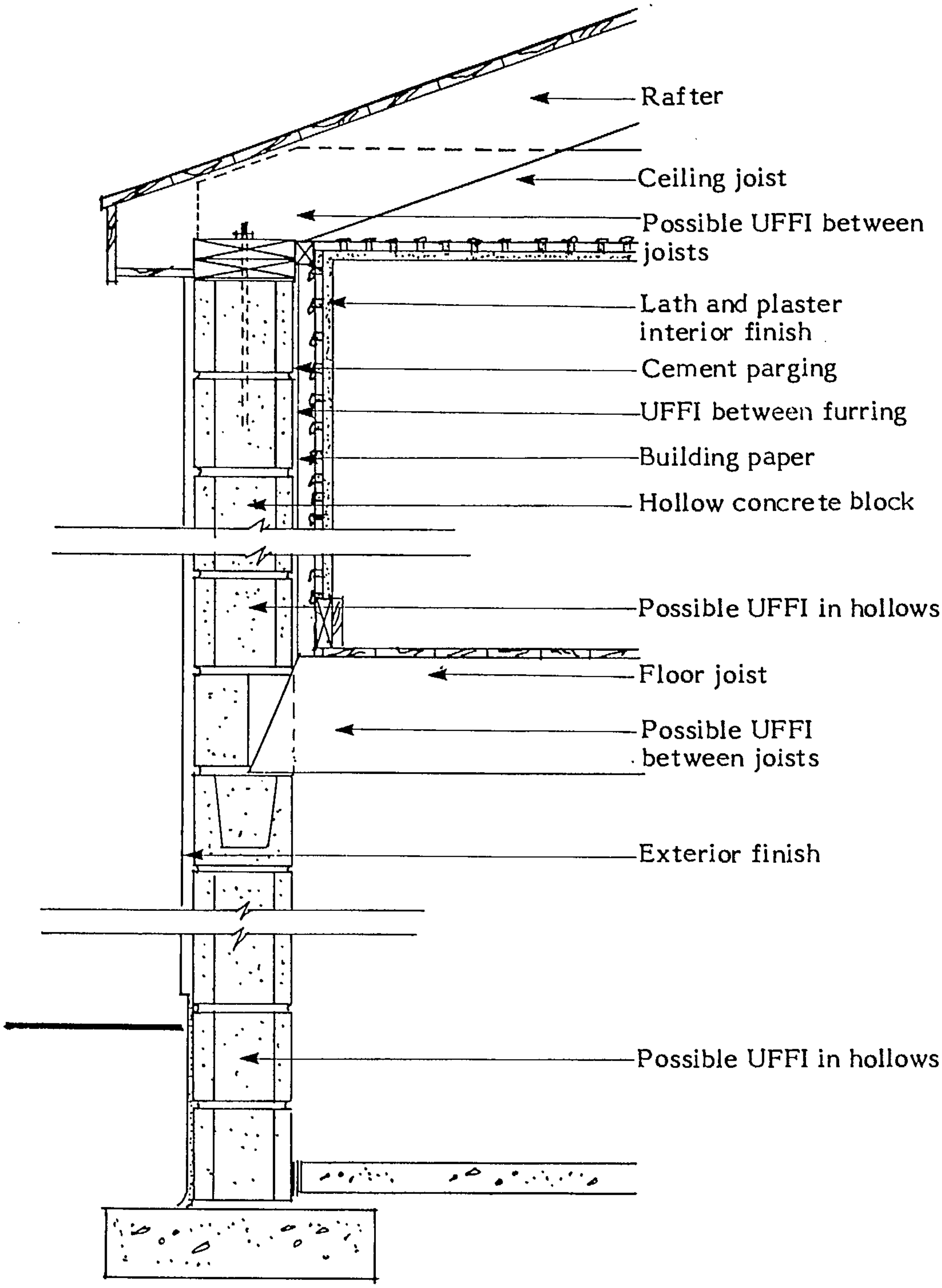
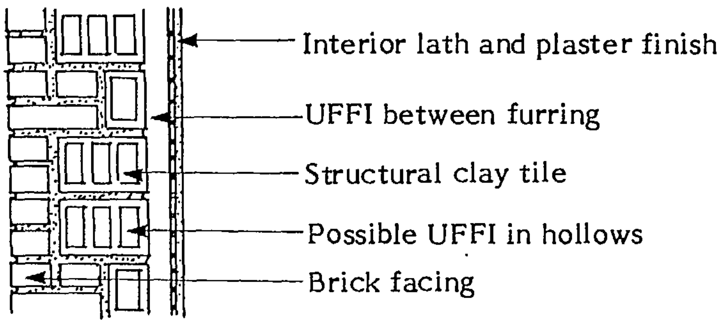


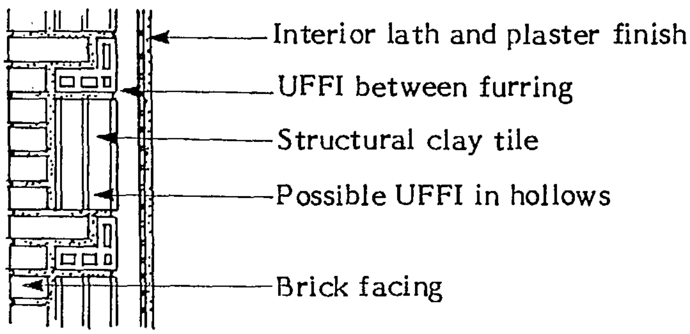
FIGURE 3.21 CONCRETE BLOCK WALL

injected directly inside them, or some random or inadvertent injection may have taken place where UFFI was not intended for injection.

In all these types, the method of installing UFFI was the same as for solid walls of hollow units. UFFI can, therefore, be found in the interior air space behind the finish or in the hollows within the wall itself or in both.



A. 12" BACK-UP WALL



B. 10" BACK-UP WALL

FIGURE 3.22 STRUCTURAL CLAY/BRICK WALLS
(COMPOSITE WALL - SOLID AND HOLLOW UNITS)

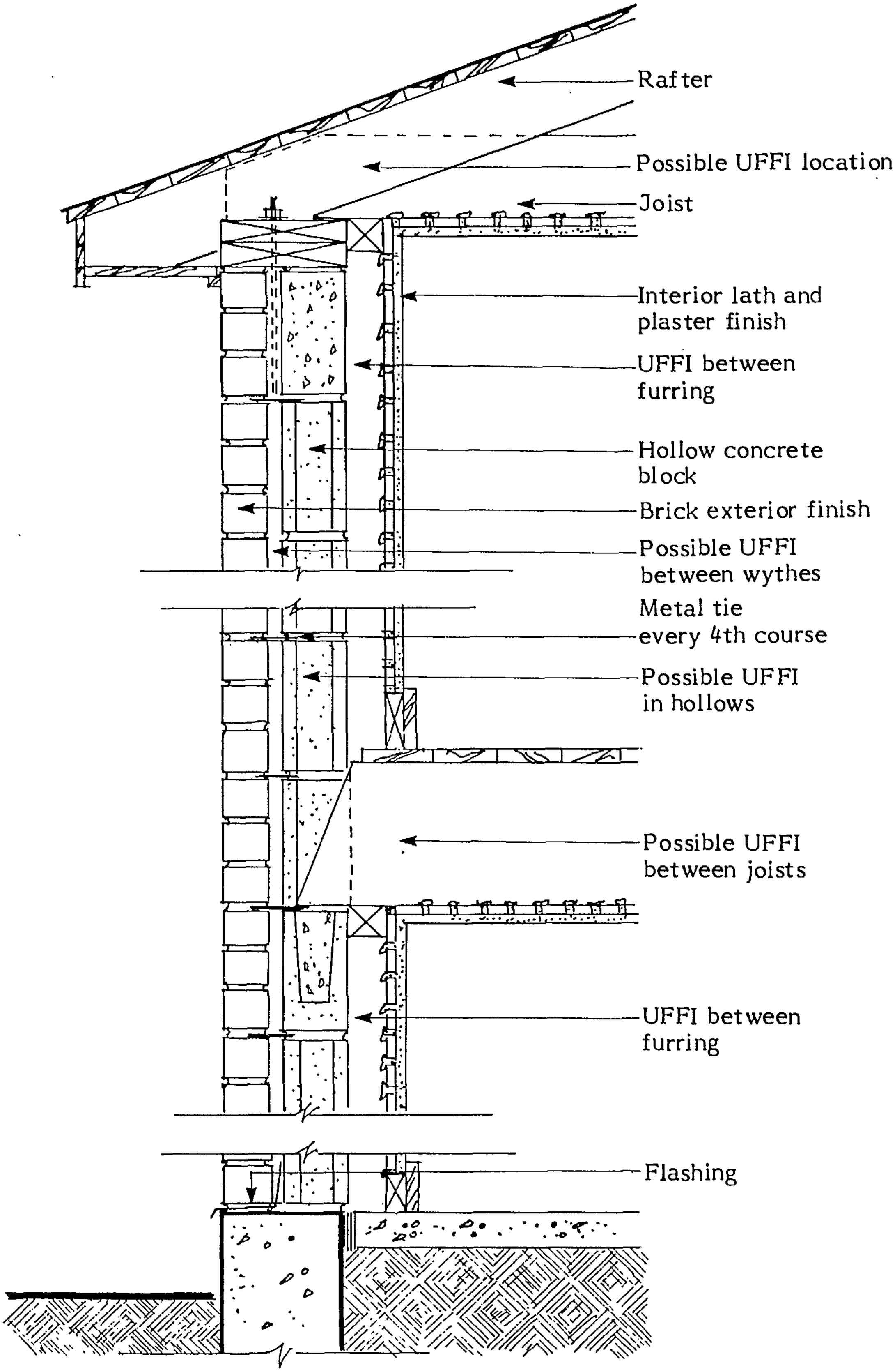
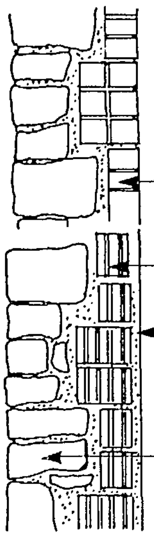
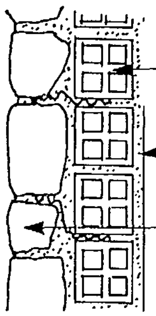


FIGURE 3.23 BRICK AND CONCRETE WALL WITH METAL TIE BOND





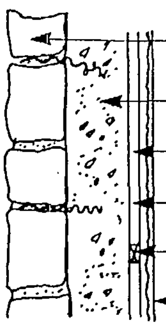


FIGURE 3.24 STONE-FACED WALL CONSTRUCTION

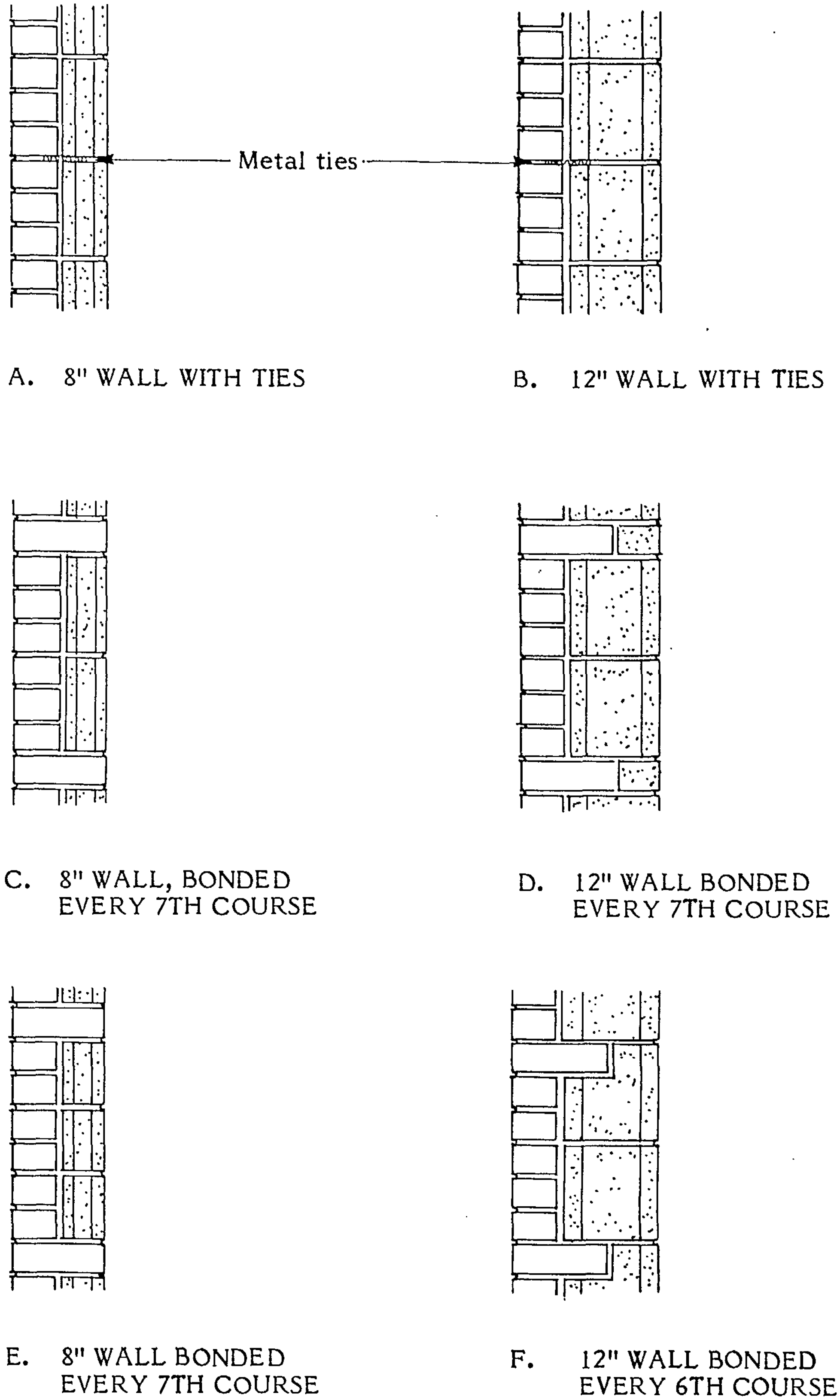


FIGURE 3.25 BRICK AND CONCRETE BLOCK WALLS, 8" AND 12" THICKNESSES WITH VARIOUS BONDS

3.11 CAVITY WALLS

Both the Rolok and true cavity wall contain cavities between the interior and exterior wythes of masonry.

3.11.1 Rolok Wall (Rowlock) type is the little-known forerunner to the cavity wall. Typical details are shown in Figures 3.26 and 3.27. Bond pattern for both faces is generally Flemish with brick laid on edge, but other patterns are possible.

If UFFI was injected into the spaces created by the construction of the Rolok wall, then its travel would depend on the depth of the space created and the type of bonding that was used on the wall. In the case of English bond, the space is limited to the stretcher course between the upper and lower headers (Figure 3.14 (C)). A similar case would exist for the common bond configuration, excepting that the vertical distance is much greater between the header courses (Figure 3.14 (A)). In the Common bond with Flemish header configuration (Figure 3.14 (B)), and Flemish Bond (3.14 (D)), UFFI would have travelled the total height of the wall since it would have penetrated into the spaces left between two vertical consecutive headers.

3.11.2 Cavity Wall consists of two wythes separated by a continuous air space of normally about 5 cm. The bond between inner and outer wythes is by metal ties. The wall can be of brick (Figure 3.28), concrete block (Figure 3.29), or brick and block (Figure 3.30). The inside face of the walls can either be plastered or furred out.

The cavity is designed to ensure drainage of any rain which penetrates through the exterior wythe of masonry by use of flashing and weep holes.

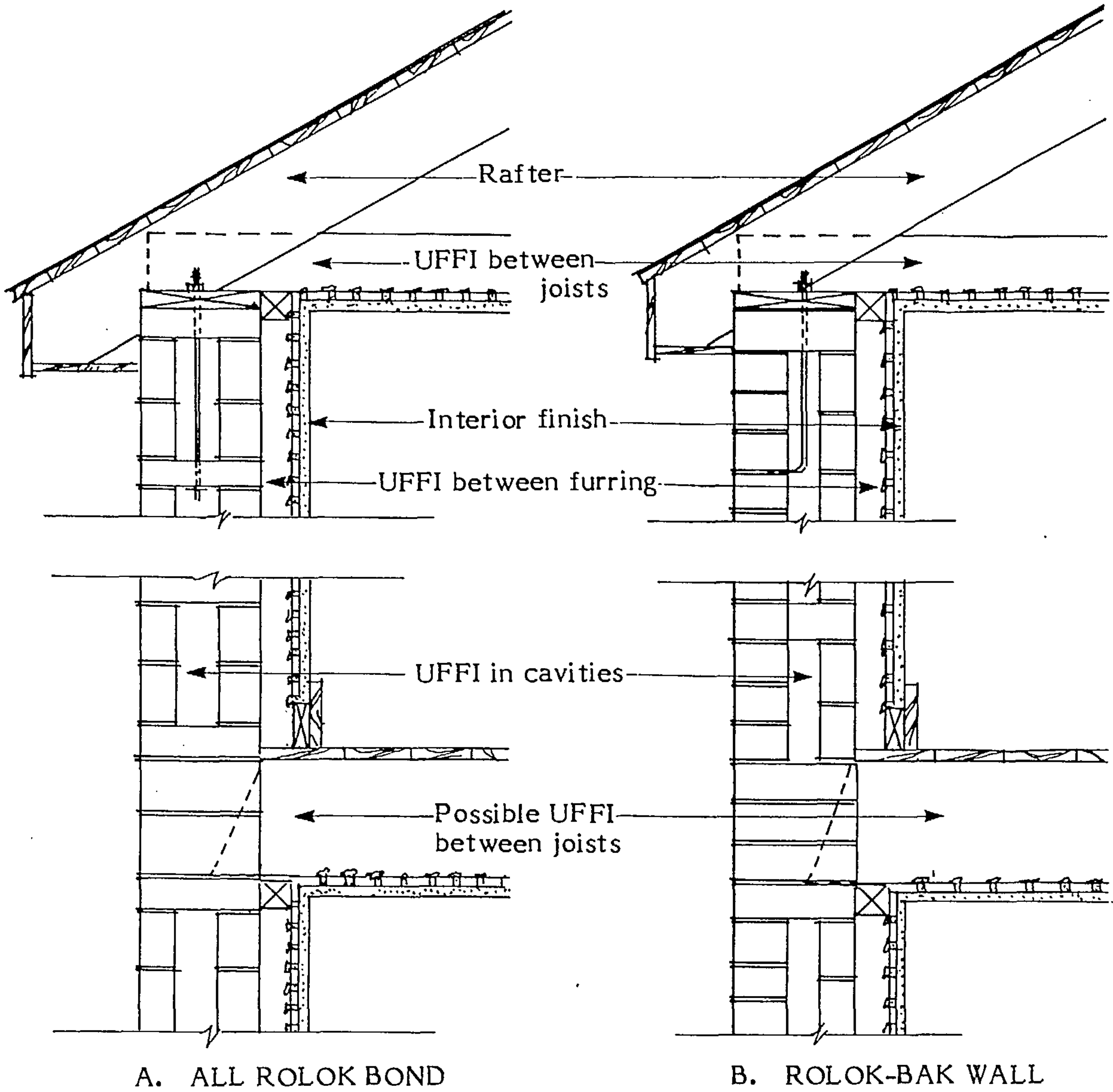


FIGURE 3.26 ROLOK WALL CONSTRUCTION

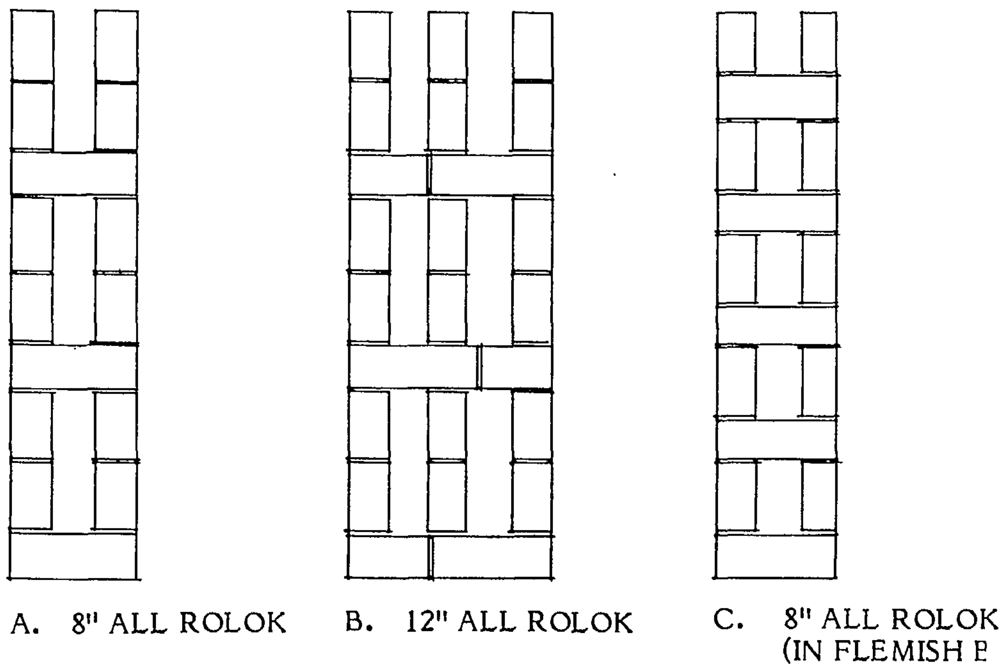


FIGURE 3.27 ROLOK WALL CONSTRUCTION VARIOUS THICKNESSES AND BONDS

The facing wythe of cavity walls will usually be 4" brick and the backing wythe could be approximately 4" concrete block. Overall thickness of a cavity walls including air space could be 25-30 cm or more.

Metal ties are usually to be found about every five courses vertically and at about the same spacing horizontally.

Since water can penetrate the exterior wythe, the base of the cavity is flashed to the outside and weepholes are provided approximately every two feet at the bottom of the cavity to allow water to pass to the exterior (Figures 3.28 and 3.30).

UFFI was usually pumped inside the cavity but may also be found between the interior masonry wythe, the interior finish and vertical strapping. If UFFI was injected into the cavity space between the facing and back-up wythes, then it is possible that it may have entered the roof through the joints between the top plate anchor.

The floor joists are supported by the interior wythe. UFFI may have travelled through spaces left around the build-up between the joists, into the space between the ceiling and the floor and eventually upward into the cavity space left between the inner wythe and the interior finish.

Figure 3.31 shows the possible travel of UFFI from the cavity to unintended areas such as along the floor joists or inside the furring in a brick cavity wall and Figure 3.32 in a brick/concrete block cavity wall. The arrows indicate the direction of travel.

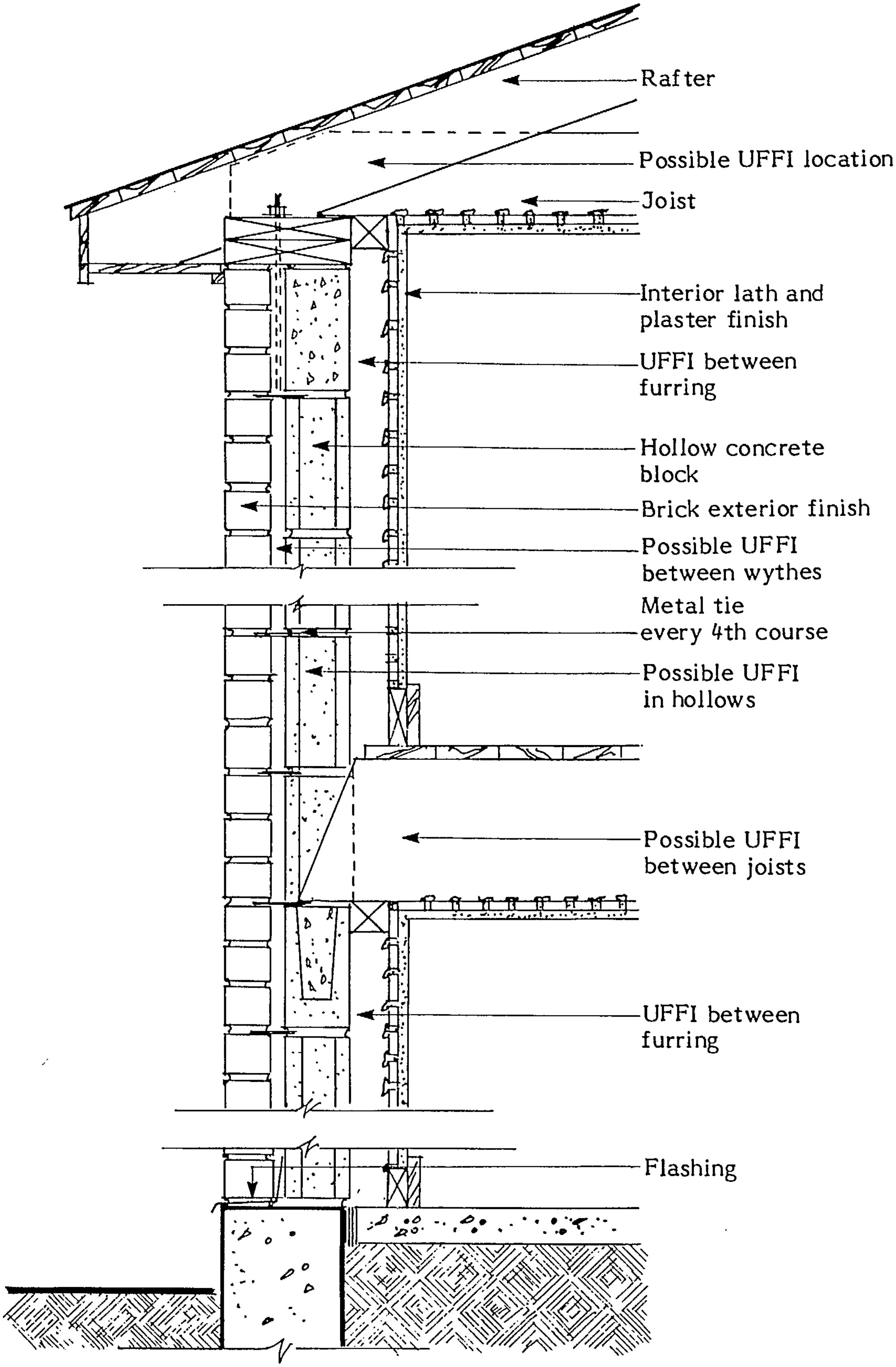


FIGURE 3.28 BRICK CAVITY WALL CONSTRUCTION
(CAVITY WALL WITH SOLID UNITS)

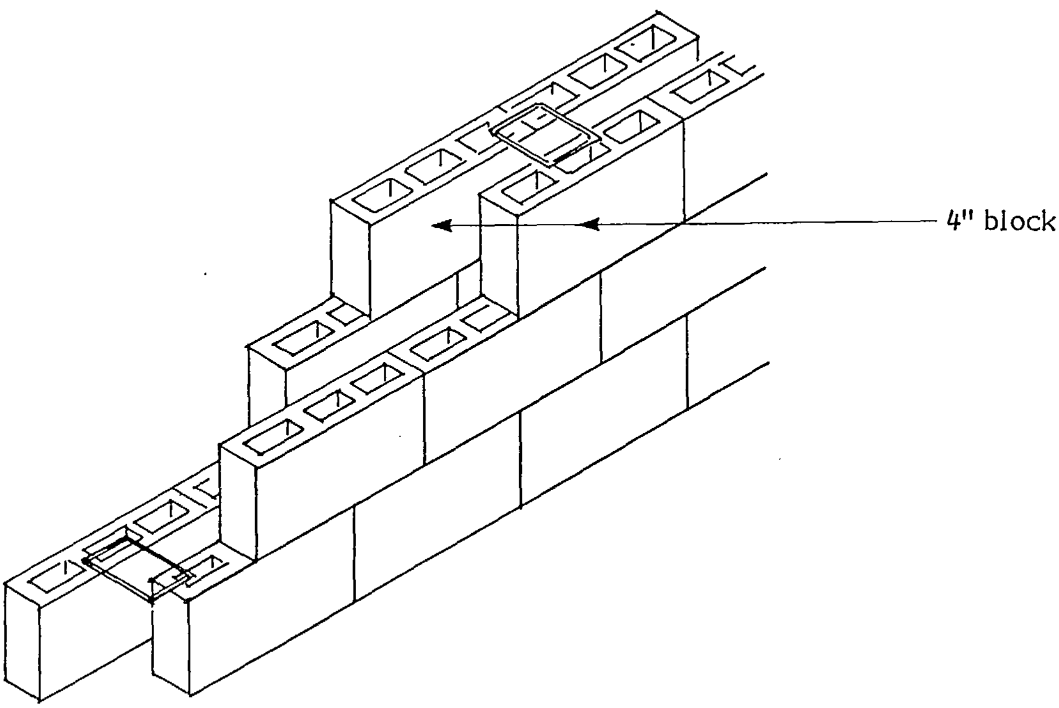


FIGURE 3.29 CONCRETE BLOCK CAVITY WALL
(CAVITY WALL WITH HOLLOW UNITS)

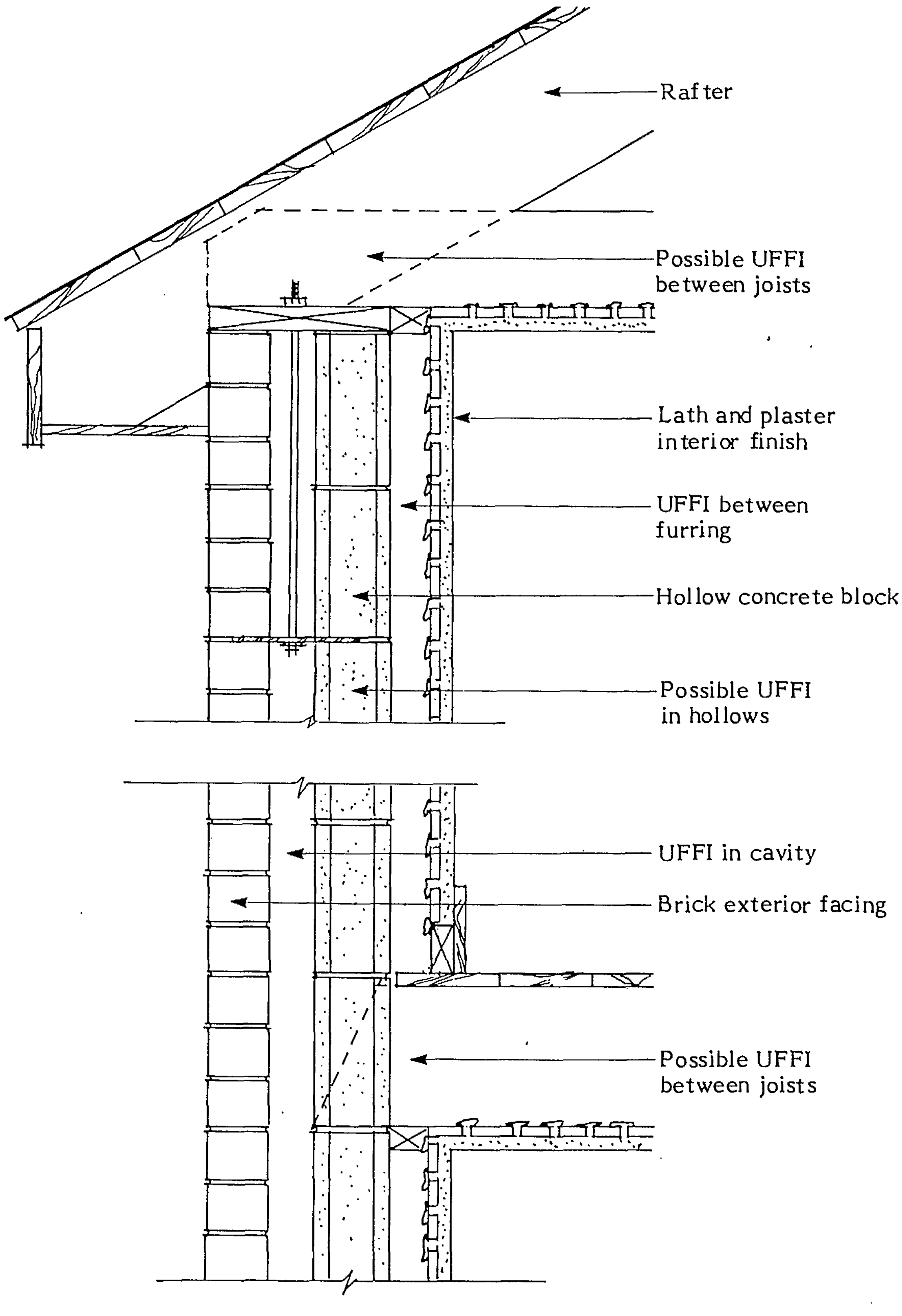


FIGURE 3.30 BRICK/CONCRETE BLOCK CAVITY WALL
(COMPOSITE WALL WITH SOLID AND HOLLOW UNITS)

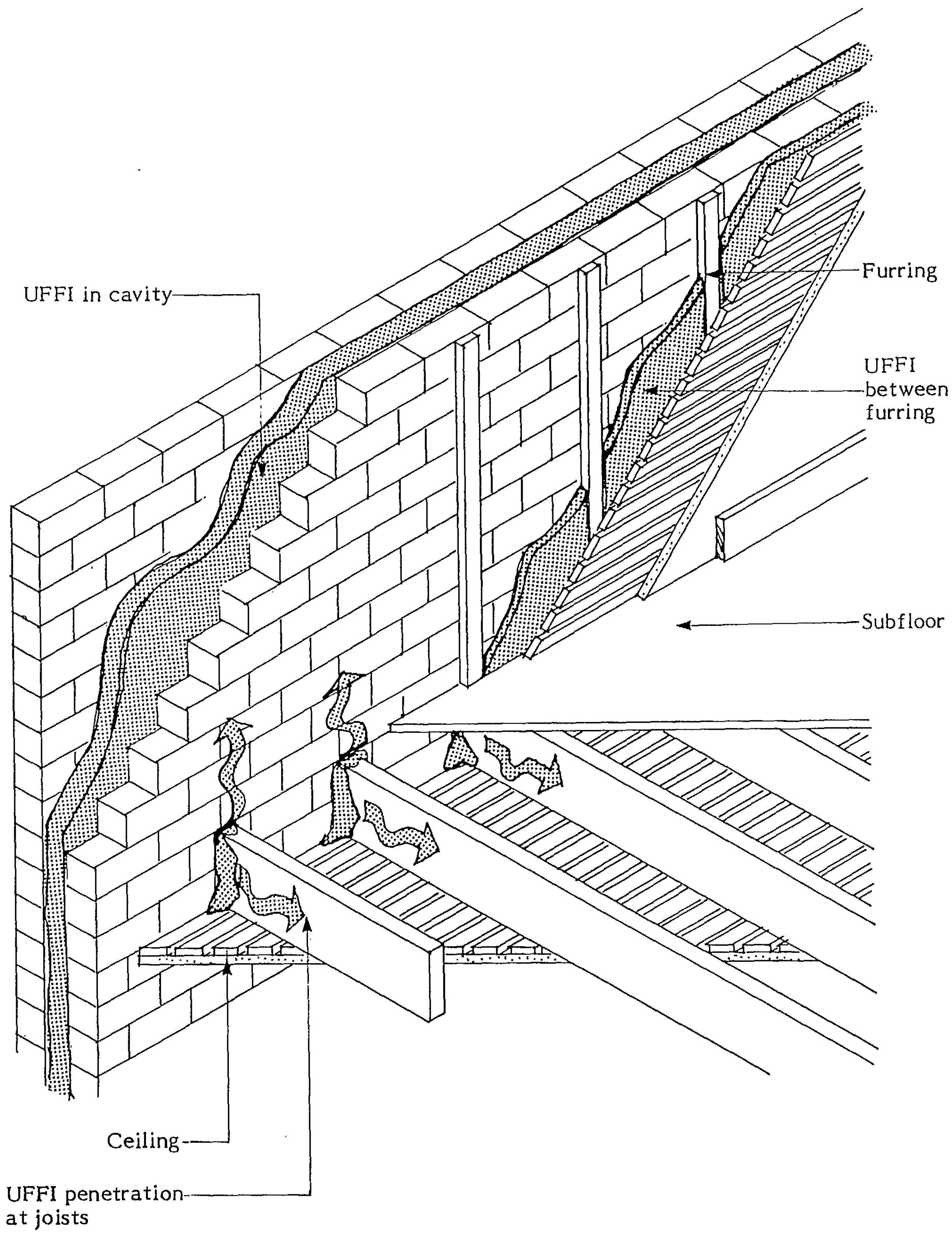


FIGURE 3.31 BRICK CAVITY WALL
ARROWS INDICATE UFFI TRAVEL

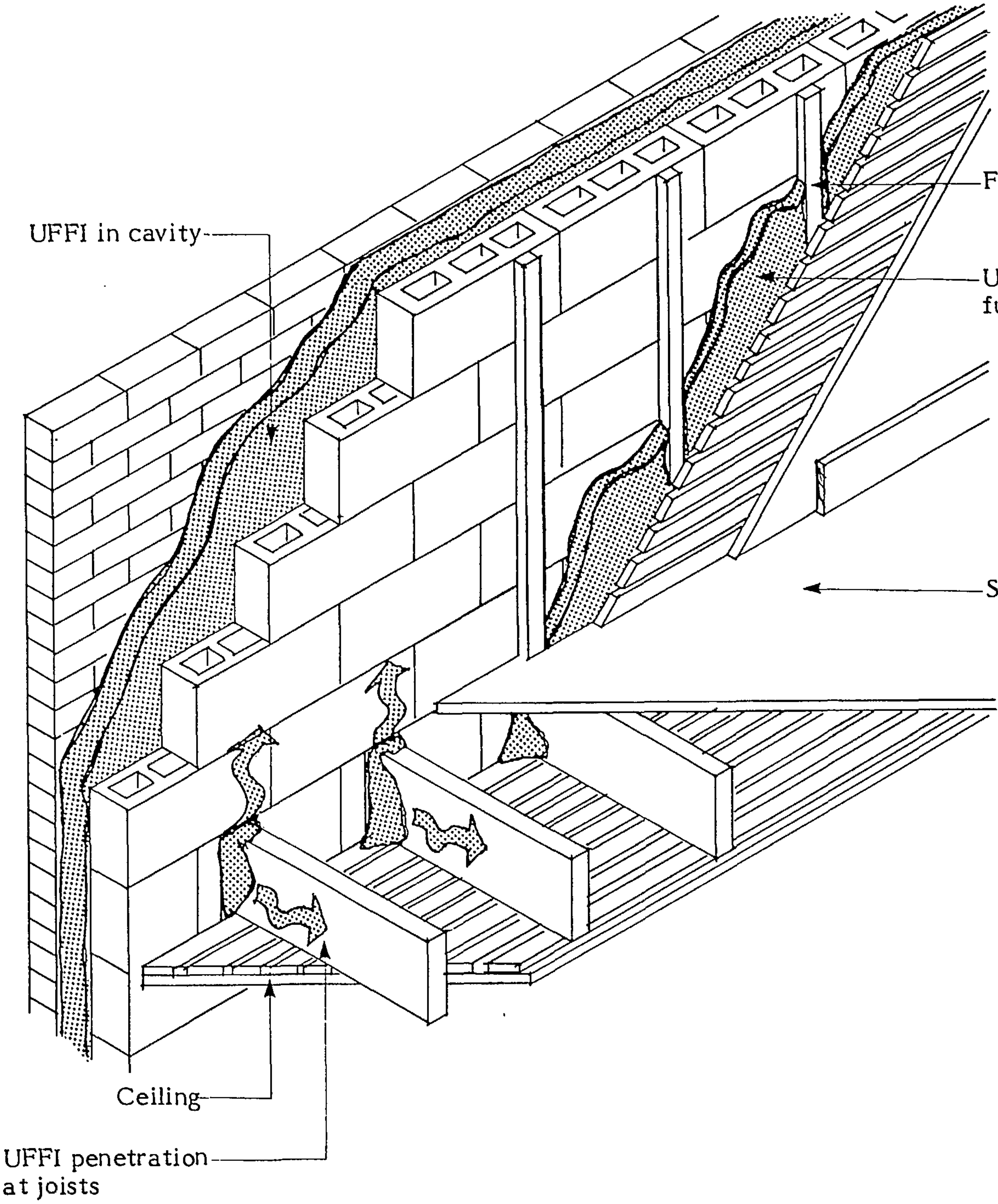


FIGURE 3.32 BRICK/BLOCK CAVITY WALL
ARROWS INDICATE UFFI TRAVEL

SECTION D: UFFI IN OTHER AREAS

UFFI IN OTHER AREAS

Due to the nature of UFFI at the time of installation (fluid and under pressure), the variety of installation practices and sometime inadequate knowledge or incomplete investigation of the building construction by the installer, UFFI may have penetrated or been injected into many locations other then those intended. These may be hidden from direct view and not readily inaccessible. Some typical locations are as follows:

a) UFFI may be found in attics and ceilings but contractors should investigate beyond the open attic and should check soffits (Figure 3.33), ducts and vents. In finished attics, it may have been installed in dormers (Figure 3.34), in kneewalls, the short rafter section and the ceiling of a storey and a half (Figure 3.35), under the attic floor or in a cathedral ceiling (Figure 3.36);

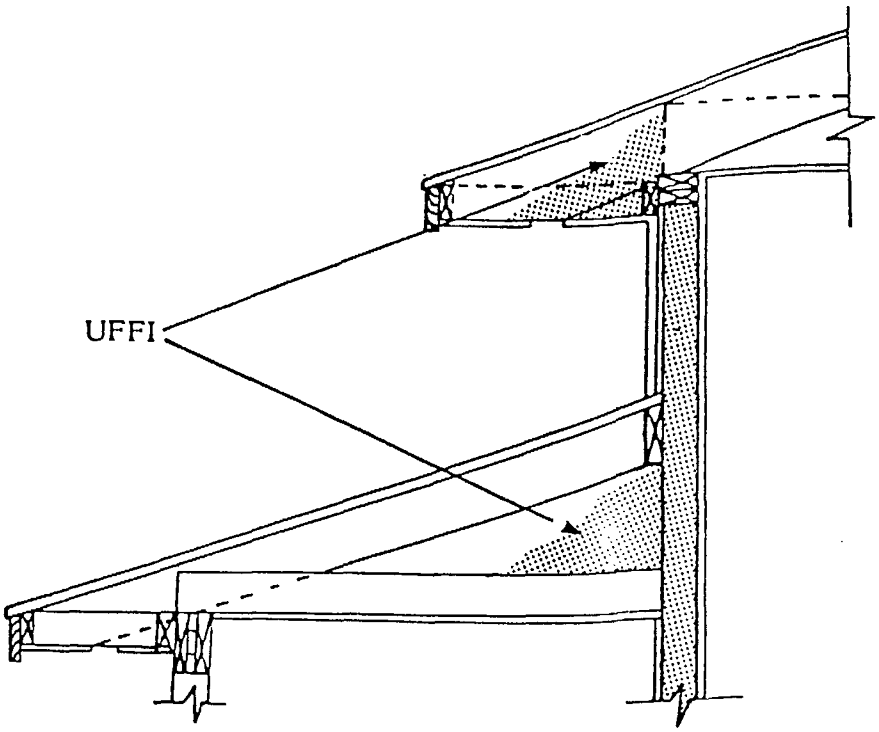
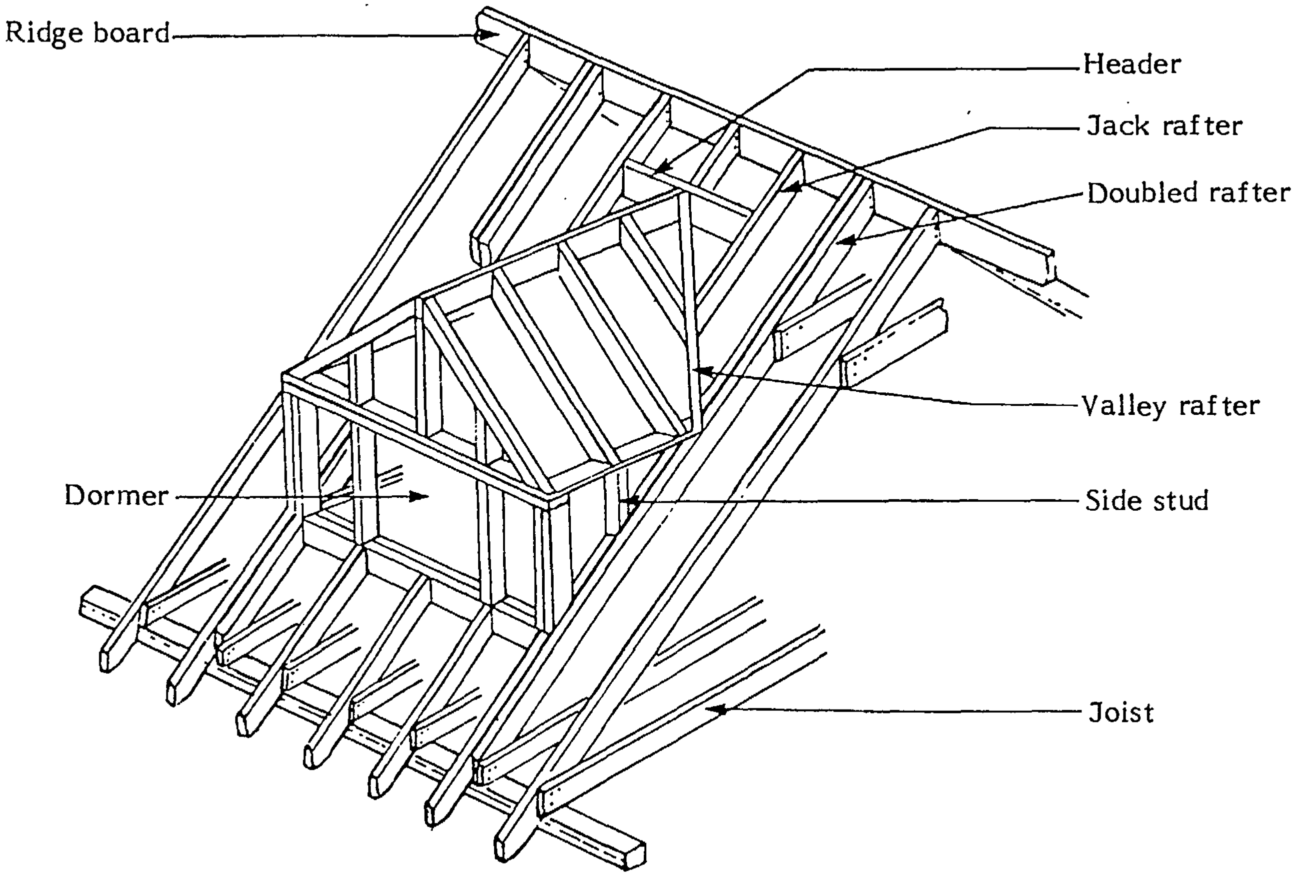


FIGURE 3.33 SOFFITS AND OVERHANGS (CANOPIES)



Check all cavities for presence of UFFI

FIGURE 3.34 TYPICAL DORMER CONSTRUCTION

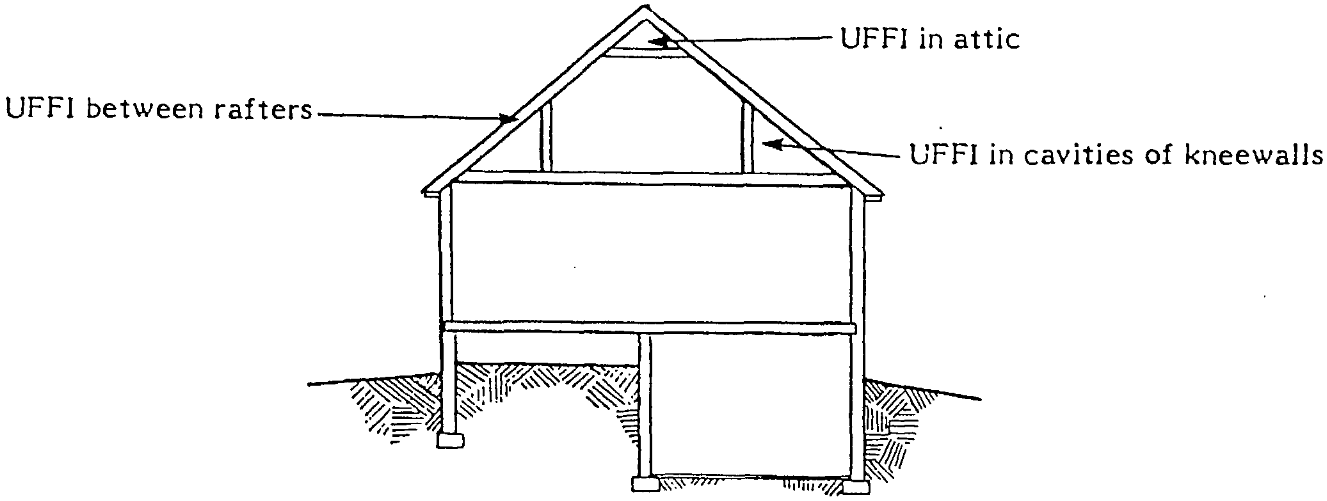


FIGURE 3.35 STOREY AND ONE-HALF

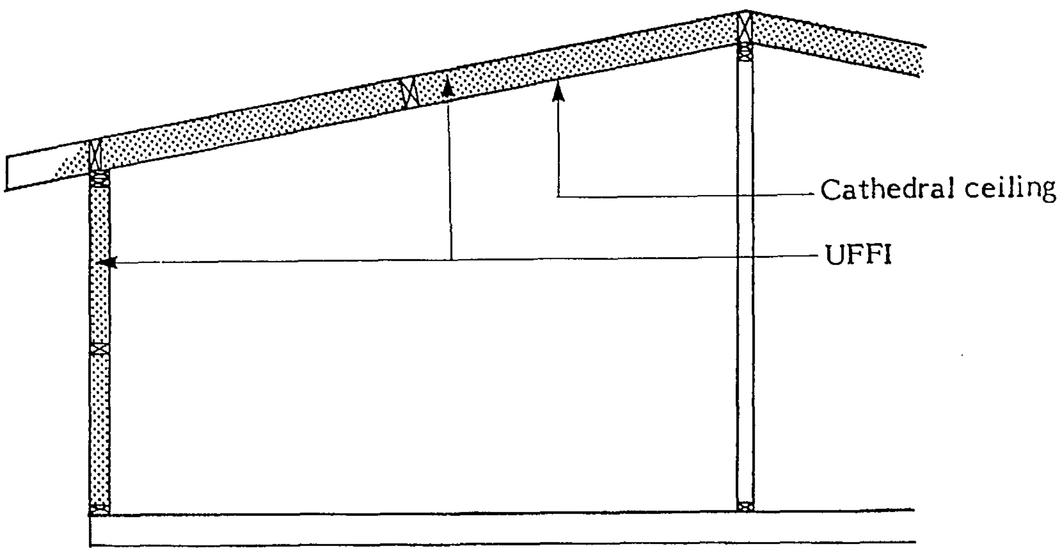


FIGURE 3.36 CATHEDRAL CEILING

b) Dropped (lowered) ceilings, canopies, bay windows (Figure 3.37) and cantilevered floors or overhangs (Figure 3.38) should be checked;

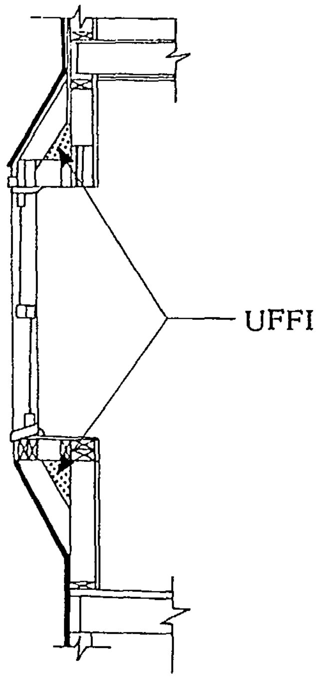


FIGURE 3.37
BAY WINDOW

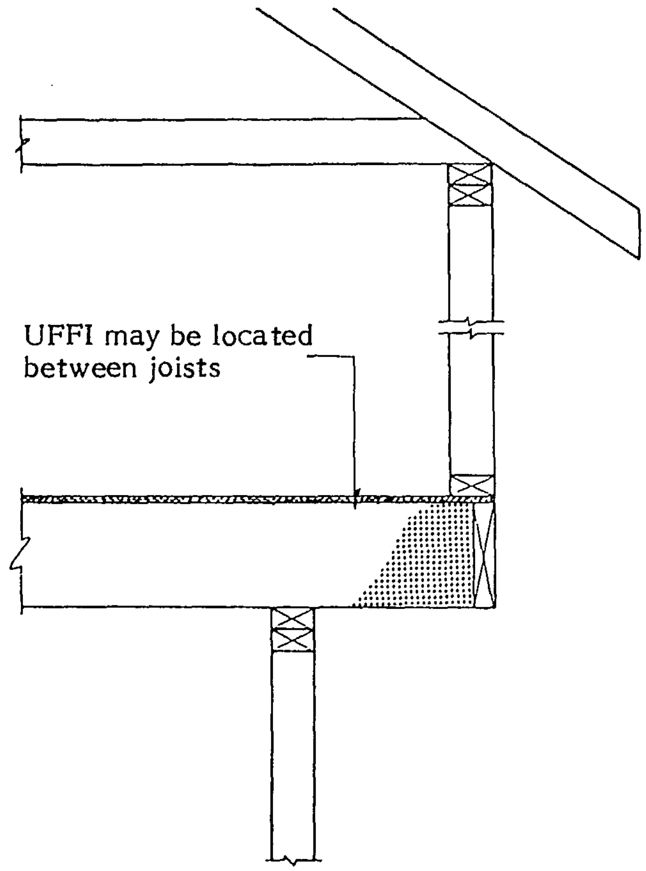


FIGURE 3.38
CANTILEVER FLOOR

c) UFFI may have been installed in the spaces between joists, particularly at the junction of floor framing and insulated cavity walls. The UFFI may have penetrated holes or gaps in the construction materials immediately below the insulated cavity (see Figure 3.39);

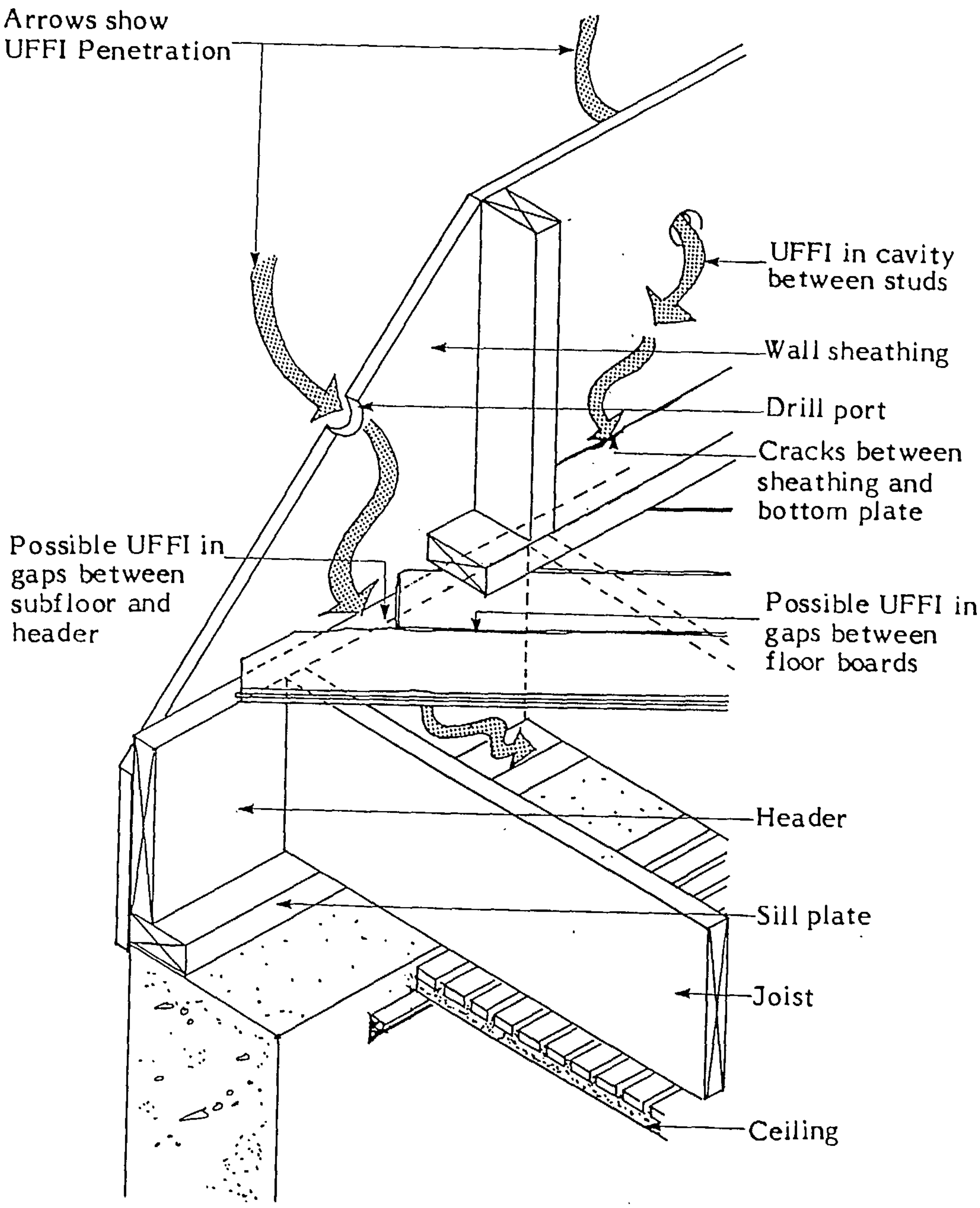


FIGURE 3.39 UFFI PENETRATION INTO JOIST SPACES
BY LEAKAGE AT FLOOR JUNCTION

d) UFFI may have been installed between lintels separated by blocking (Figure 3.40), between corner posts separated by blocking (Figure 3.41), or in an exterior wall cavity enclosed by the outside stud of an interior partition wall (Figure 3.42);

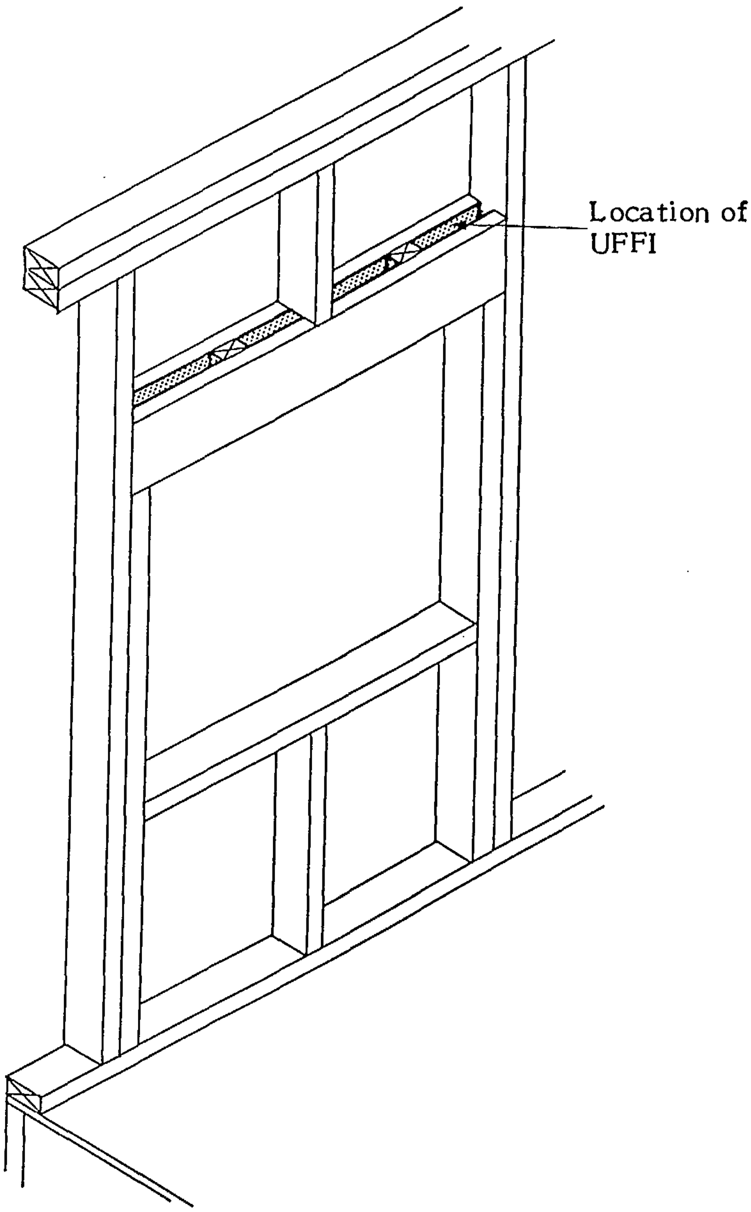


FIGURE 3.40 LINTELS SEPARATED BY BLOCKING

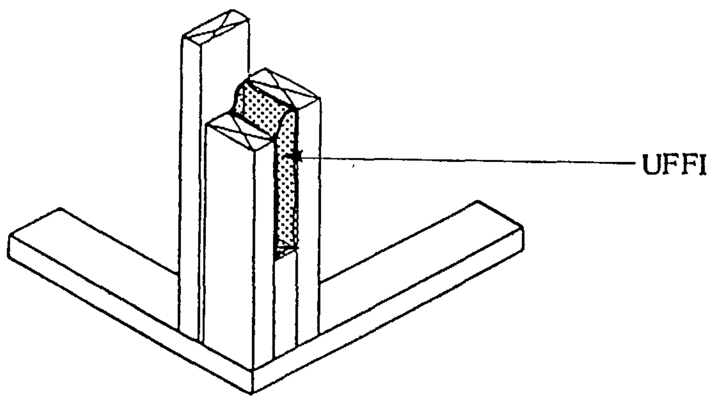


FIGURE 3.41 CORNER POST SEPARATED BY BLOCKING

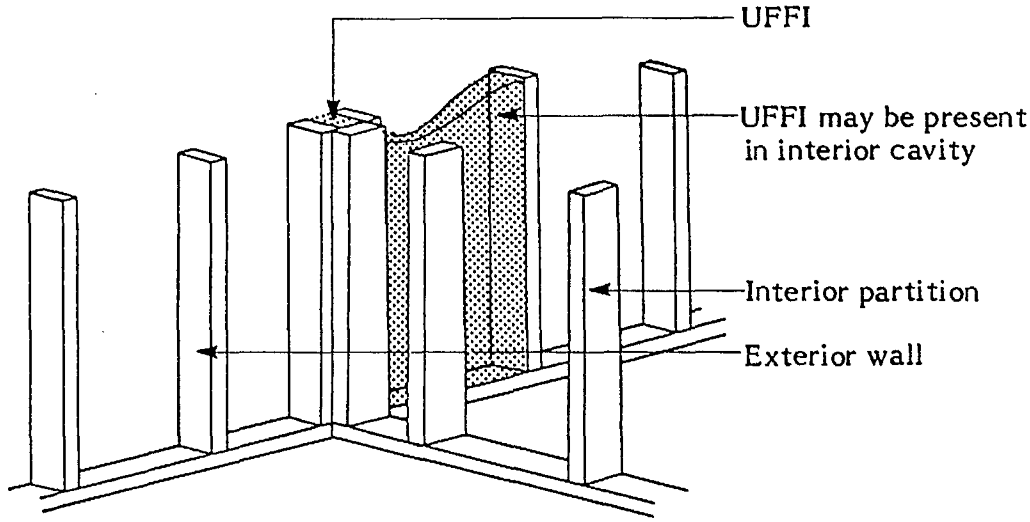


FIGURE 3.42 EXTERIOR WALL ENCLOSED BY THE OUTSIDE STUD OF AN INTERIOR PARTITION WALL

e) there may be UFFI in interior cavities adjacent to an exterior wall cavity, such as: partition walls, closets, cabinets or cupboards (Figure 3.43), enclosures for bathtubs or showers (Figures 3.44 and 3.45) and pipe chases;

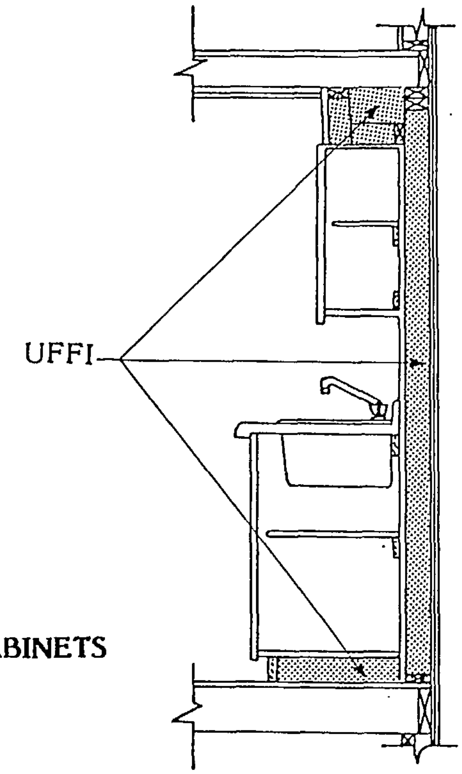


FIGURE 3.43 CUPBOARDS AND CABINETS

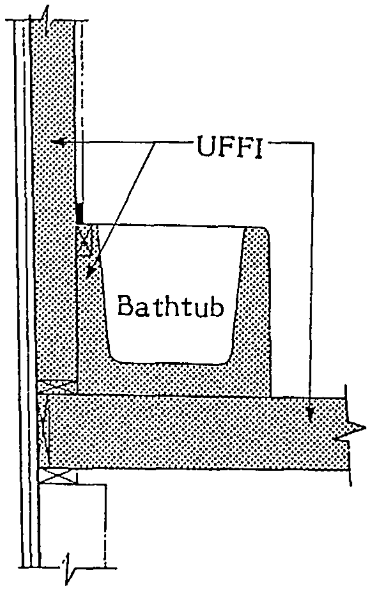


FIGURE 3.44
BATHTUB ENCLOSURE

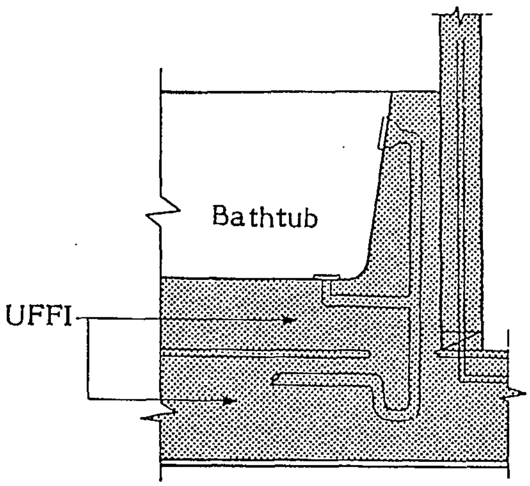


FIGURE 3.45
BATHTUB ENCLOSURE

f) the interior of exterior basement walls may have been strapped and foamed (Figure 3.46). UFFI may have been foamed directly onto the inside of exterior basement walls without framing, as well as into the cores of the concrete block;

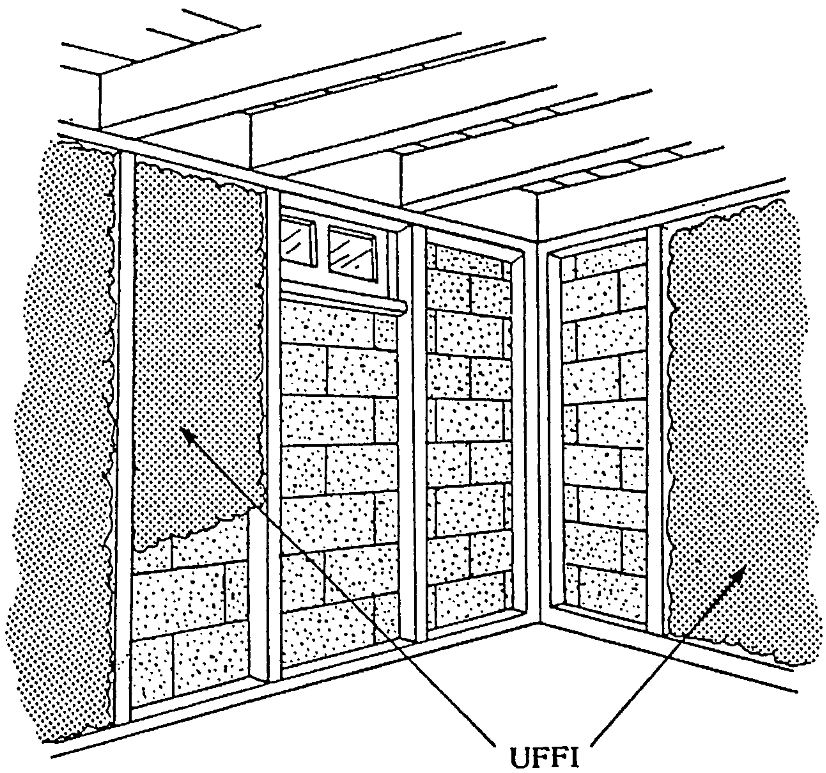


FIGURE 3.46 BASEMENT WALL CONTAINING UFFI

g) UFFI may have found its way into the duct system through accidental injection or by penetration through the duct joints. Closed joist spaces and stud spaces which were used as ducts, should be closely inspected. A similar condition may also occur where the ducts are immediately adjacent to the wall containing UFFI or where ducts are within the UFFI-filled stud cavity;

h) UFFI may be found in stairways with soffits, especially when the stairway runs parallel to an insulated wall where the stringers may be nailed directly to the studs of the insulated wall and the drywall was not installed tightly to the underside of the stringer;

i) UFFI may be found in the garage ceiling under a bedroom or other living space;

j) UFFI may have found its way into electrical outlet receptacle boxes and junction boxes (via openings in the boxes) in an insulated cavity wall and into the backs of service boxes or panel boards (due to gaps around service entry conduit).

Chapter 4

UNDERSTANDING CONTAMINATION AND CORRECTIVE MEASURES

Contents

4.0 INTRODUCTION

Air quality in insulated homes is becoming a matter of concern. The air becomes stale and odours persist in homes which have fewer complete air changes per hour.

The air in a UFFI house becomes contaminated because the air leaking in through the UFFI-filled cavities contains UFFI gas. More formaldehyde may be added from tobacco smoke, cooking and combustion fumes, plywood and some types of furniture and drapes. They combine to produce a concentration of gases in the living environment which may exceed the normal ambient (outside air) range of 0.01 ppm to 0.05 ppm.

This chapter explains, in Section A, how the UFFI gas is generated and how it reaches the living environment and, in Section B, how this condition may be improved.

SECTION A: UNDERSTANDING CONTAMINATION

4.1 AIR CONTAMINATION

4.1.1 **Source of Contamination.** Moisture penetrating into UFFI-filled cavities accelerates the degeneration of UFFI, thus producing UFFI gas and dust. UFFI crumbles easily into a fine dust; the particles are so fine that they will pass through an ordinary vacuum cleaner. Moisture and high temperatures also accelerate the degeneration.

This section outlines how moisture condenses in the cavities - this is called **moisture dynamics** -- and what can be done about it, as well as air dynamics -- the forces which cause air leakage through air leakage pathways in the house envelope. Pathways are formed by the cracks, holes and gaps in the building elements.

4.1.2 **Fungal Growth on UFFI.** Under certain conditions fungus will grow on a variety of building materials, including wood, plasterboard, insulating materials, ceramic tile grout, upholstery, carpeting, etc. The main condition which promotes fungus growth is moisture. Given sufficient moisture, UFFI is also a suitable material for fungi to grow on.

Fungal growth on UFFI can often be identified as patches of discolouration on the foam; in some cases, however, it may not be noticeable at all except to a trained technician.

There is no special fungicide or treatment for fungus, but it should be brought to the homeowner's attention that it is present. THE ONLY EFFECTIVE PREVENTION OF FUNGAL GROWTH IS TO ELIMINATE THE MOISTURE, which may originate from a structural/mechanical problem, excessive humidity in the home or trapping of condensation within the cavity.

4.1.3 **Sources of Cavity Wetness.** Water in the wall cavities arises from four sources: condensation, leakage from building disrepair, residual water, and ice ridging.

Residual water produced when the foam was manufactured should have evaporated by now, since UFFI was banned in 1980. Water infiltration from disrepair can be eliminated by repairing any plumbing, roofs or flashing. **Condensation is by far the most persistent problem and the most difficult to correct.**

4.2 MOISTURE DYNAMICS

4.2.1 **Moisture Fundamentals.** Moisture in the form of water vapour is present in air at all times. The water vapour in the air is referred to as humidity, and is measured in terms of relative humidity, which is an indication of the amount of water vapour in the air compared to the maximum amount possible at a given temperature. When the relative humidity is 50%, it means that the air is carrying one-half the amount of water vapour it is capable of holding at that temperature. When the relative humidity reaches 100%, the water vapour will begin to condense as fog or as ice crystals (Figure 4.1). It has reached its saturation or "dew" point.

Another measure of humidity is absolute humidity. This is the amount (in grams of water per kilogram of air) of water vapour actually present in a given quantity of air.

4.2.2 **How Moisture Travels.** Air, UFFI gas, and moisture enter the wall cavities in two ways: by diffusion and by flowing through air leakage pathways in the wall. Diffusion is the action of a substance moving directly through another substance. Water vapour diffuses from an area of high relative humidity to one of low relative humidity. Similarly, formaldehyde and other contaminants given off by UFFI in a wall cavity can diffuse slowly inward through the interior finish to the living space. The air movement through the air leakage pathways is from an area of higher air pressure to an area of lower air pressure.

The following analogy illustrates the basic differences between the principles of diffusion and leakage. If water is put into an ordinary cardboard container (cardboard has high permeability, i.e., low resistance to water flow), the outer surface will soon become wet and water will begin to drip from the container. The water is diffusing through the cardboard.

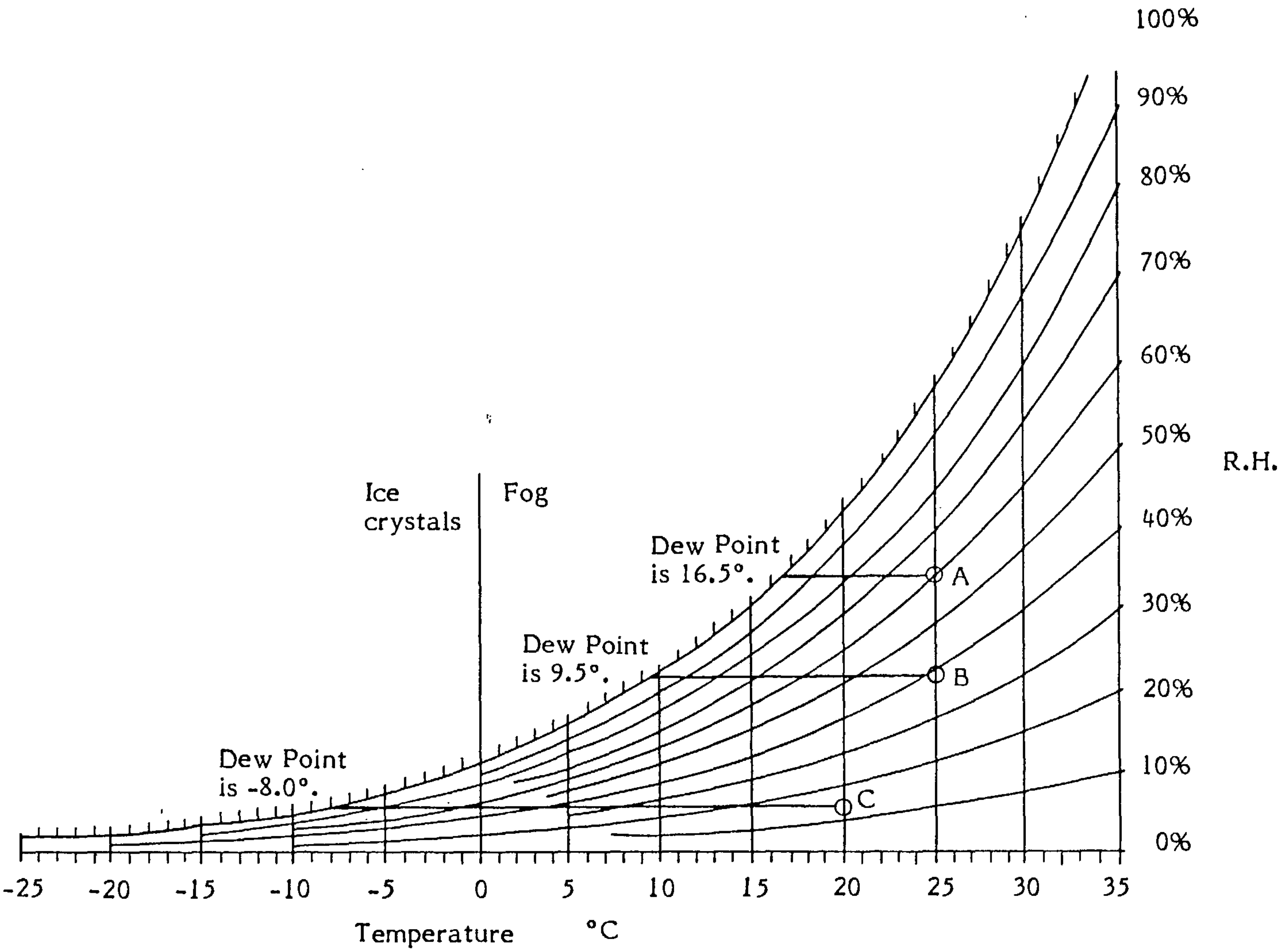


FIGURE 4.1 THE PSYCHROMETRIC CHART

EXAMPLE	TEMPERATURE	RELATIVE HUMIDITY	DEW POINT
A	25°C	60%	16.5°C
B	25°C	40%	9.5°C
C	20°C	18%	-8.0°C

If the bottom is punctured, water will run out through the hole and will continue to do so unless the hole is sealed or plugged. Leakage is usually much more significant than diffusion. In the same way, moisture in a home is carried into the cavities through holes in the building envelope. If these holes are sealed, the air leakage pathways are plugged and the moisture-laden air will not pass through. Likewise, had the entire inside of the cardboard container been water-proofed and all holes sealed properly, the water would neither diffuse through the cardboard nor leak out through the holes.

In comparison to cold air, warm air can hold a relatively large quantity of water vapour. Warm moist air in a home escapes mainly by air leakage pathways through the wall to the outside. The amount of moisture which is carried by air flowing through the air leakage pathways is about ten times that which diffuses through the walls. As the warm moist air passes by leakage and diffusion into the cold outer layers of the building, the water in the vapour may condense out as water droplets or as ice crystals (Figures 4.2 and 4.3). This wets the UFFI, accelerating gas generation. Wet UFFI generates gas regardless of the temperature.

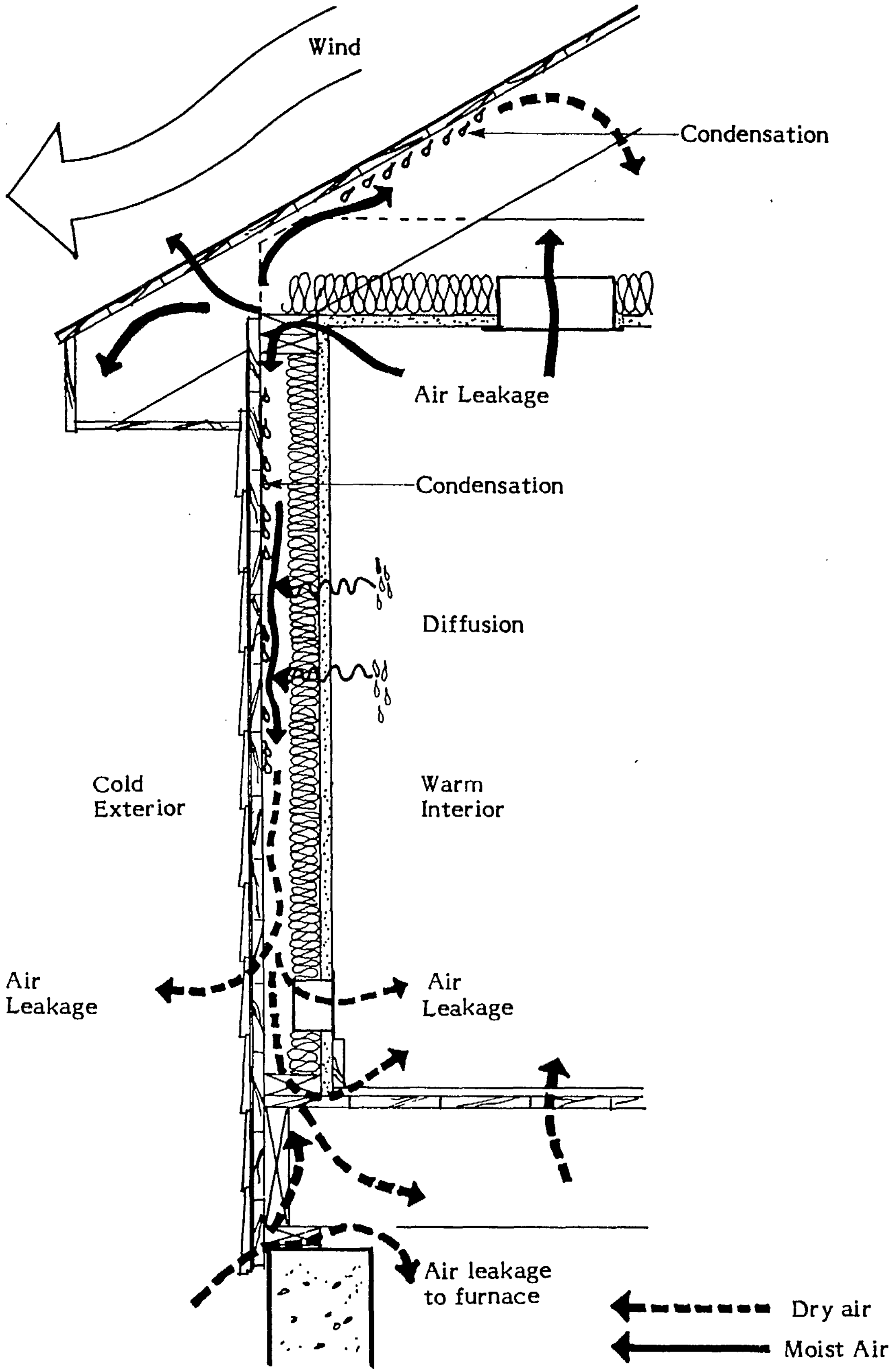


FIGURE 4.2 MOISTURE TRAVEL THROUGH A WALL

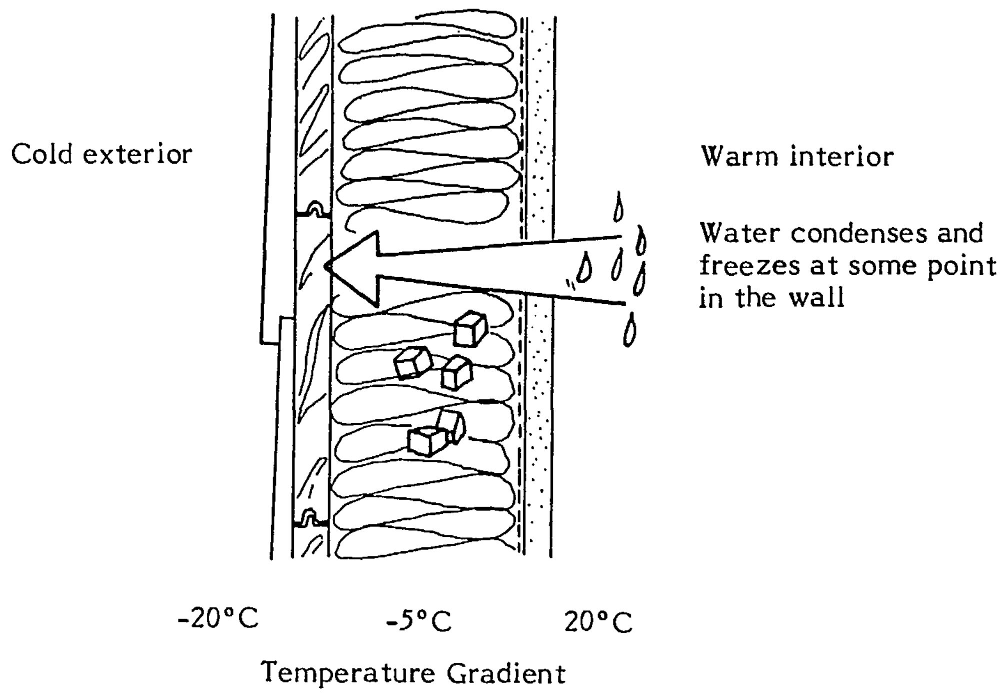


FIGURE 4.3 MOISTURE ACCUMULATION IN THE BUILDING STRUCTURE

4.2.3 **Sources of Moisture.** Day-to-day living adds water to the air. The following figures give an approximate idea of how extensive this impact is:

TABLE 4.1

Average Quantity of Moisture Added to the Air Through Normal Household Activities

Activity (for a family of four)		Moisture in litres each week
Cooking	(3 meals per day for 1 week)	6.3
Dishwashing	(3 times daily for 1 week)	3.2
Bathing	(0.2 L per shower) (0.05 L per bath)	2.4
Clothes washing		1.8
Clothes drying indoors, or using an unvented dryer		10.0
Floor mopping (per 9.3 m^2)		1.3
Occupants		38.0
TOTAL MOISTURE PRODUCTION PER WEEK		63.0

Humidifiers, house plants, and other activites will add to this total.

4.2.4 **Avoiding Moisture Problems.** There are three steps to avoiding moisture problems:

a) keep humidity levels low in the living space by reducing the amount of moisture generated and/or by ventilating;
b) ensure that the interior surface of the building envelope is sealed as well as possible against air leakage and diffusion;
c) ensure that any moisture which enters the building envelope can escape readily to the outdoors.

A vapour barrier, which will reduce moisture diffusion, is ideally a layer of material which is impervious to the passage of water vapour and air. It should envelop the building on the warm side of the insulation, minimize vapour diffusion through the wall and help to reduce air leakage. An air barrier consists of building materials, such as inside finish and sealants, combined in such a way as to reduce air leakage to a minimum.

In situations where a vapour barrier cannot be installed, an impermeable finish (such as an oil-based paint or a varnish) applied to the wall or ceiling on the warm side of the insulation, will help. Two coats should be applied. However, it is far more important to reduce air leakage by sealing air leaks (see Chapter 6).

Ventilation. Regardless of how well the barrier is installed, some leakage will occur. Make sure that the moisture which escapes from the inside is able to escape from the envelope to the outside air.

To permit a wall or ceiling to breathe to the outdoors, the exterior (cold) side of the building should be at least five (5) times as permeable as the indoor surfaces; that is, exterior materials should have no more than 1/5 the Resistance to Moisture Flow (RMF) of interior materials (see Appendix C).

4.3 AIR DYNAMICS

The contractor must know how to follow air movements to be able to apply corrective measures effectively. Moisture dynamics shows that air moving outward through the walls wets the UFFI and causes an acceleration of UFFI gas generation. Air moving inward transports UFFI gas and dust into the house through air leakage pathways.

Air and UFFI gas diffuse through the wall layers to a small extent. The amount of gas entering the living environment in this manner is very small compared to the amount passing through the air leakage pathways.

4.3.1 **Air Pressure Differences.** A house may be considered as a living environment surrounded by an envelope. The envelope encloses a volume of air at pressures and densities dependent on the temperature and size of the enclosure. Air tends to flow from an area of high pressure to one of lower pressure. This difference in pressure forces air through the envelope of the home along air leakage pathways.

If the air pressure inside the envelope exceeds the outside air pressure, the difference is known as a **positive air pressure difference.** If the air pressure inside the envelope is less than that outside, the pressure difference is known as a **negative air pressure difference.** If the air pressure difference across the envelope is negative, the air attempts to flow inward; this is known as **infiltration.** If the air pressure difference across the envelope is positive, the air attempts to flow outward; this is known as **exfiltration.**

4.3.2 **Factors Affecting Air Pressure.** Several factors will affect the air pressure difference across the envelope around the living environment:

a) **stack effect** is produced when warm (less dense) air rises and escapes through the upper areas of the home while cold (more dense) air tends to be drawn in through lower areas of the home, replacing the warm air;

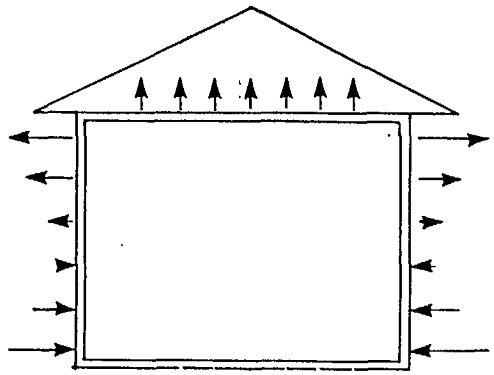


FIGURE 4.4 STACK EFFECT

b) **induced exhaust** is the movement of inside air directly to the outdoors, without passing through the air leakage pathways in the walls and ceiling of the building structure. This occurs regularly in most homes with the operation of furnaces, fireplaces, kitchen and bathroom fans or vents;

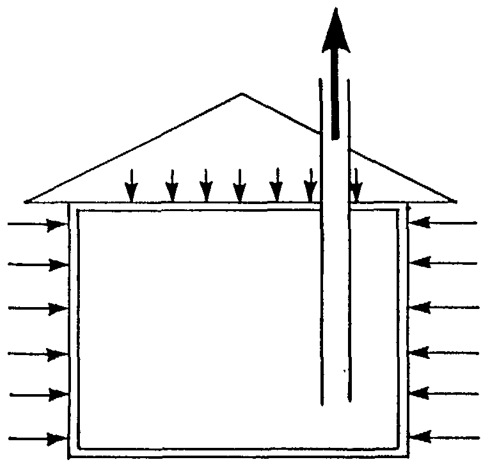


FIGURE 4.5 INDUCED EXHAUST

Chimneys and smoke pipes for fuel-burning appliances allow warm air to escape outside. This adds to the exfiltration due to stack effect. The result is to increase the negative air pressure difference across the lower part of the building and to increase the area through which air tends to infiltrate.

Fuel-fired furnaces consume air for combustion, further depressurizing the inside of the house. In energy-sealed homes, a separate intake should be used to bring in outside air for combustion purposes (see Appendix H);

c) **wind action.** Compared to the air pressure within the envelope, wind raises the air pressure against the windward wall and lowers the air pressure against both the leeward wall and along walls parallel to the wind direction;

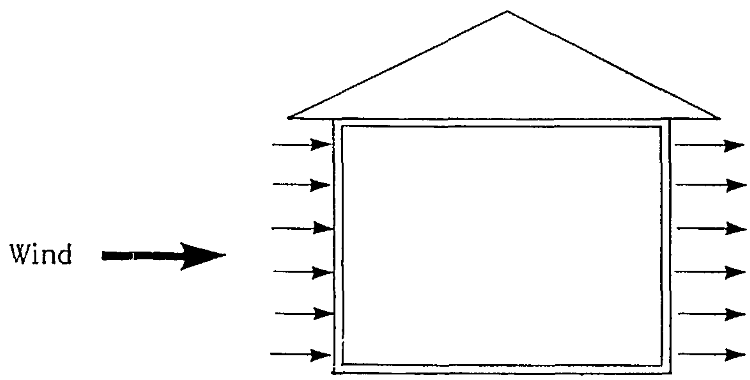


FIGURE 4.6 WIND ACTION

d) **natural ventilation.** Ventilation is a means of exhausting air from inside the envelope, intaking outside air or both. The outward flow of air tends to reduce the air pressure within the envelope, while inward flow tends to increase air pressure inside. Natural ventilation is achieved without mechanical assistance; that is, air moves through open windows or through the building envelope as a result of wind and stack effect;

e) **forced ventilation.** When fans are introduced into a ventilation system, they will force air flow either outward or inward, depending on their placement and their relative capacities, with the same results on air pressures as above;

f) **air change rate.** During moderate winds, a leaky or drafty home may exchange its entire volume of air several times an hour. On the other hand, an energy-sealed home may experience a complete air change only once in several hours. Air change rate is the rate at which a complete change of the volume of air within the envelope occurs. It is measured in air changes per hour (ach).

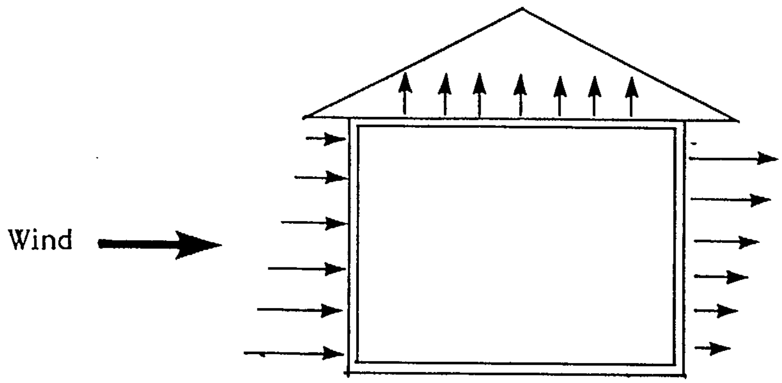


FIGURE 4.7 STACK EFFECT AND WIND ACTION (SIMPLIFIED)

Wind action, added to stack effect, changes the air pressure differences, increasing infiltration on the windward wall and exfiltration on the leeward wall.

4.4 SOURCE OF AIR LEAKS ALLOWING AIR FLOW

4.4.1 **Air Leakage** plays a very important part in carrying moisture into the building envelope and UFFI gases into the living space. Knowing how the leakage occurs in the structure will help to determine the approaches required when sealing is undertaken. Air leakage can be relatively direct or indirect. Partitions and floor systems present **hidden air leakage pathways** by which outdoor air can enter the living space. **Surface air leaks** can be direct or indirect. On exterior walls, surface air leaks can provide a relatively direct connection to the outdoors. On interior partitions, surface leaks are the **final entry points** for hidden air leakage pathways. For simplicity, we will assume only two air leakage classifications: surface air leaks and hidden air leakage pathways. (Figure 4.8 illustrates air leakage.) Smoke pencils, which may be purchased at building supply dealers and hardware stores, are the most effective means of locating air leaks.

4.4.2 **Hidden Air Leakage Pathways** are commonly found in the following locations:

a) within the exterior wall system;
b) by way of joists, partitions and board subfloor systems;
c) by way of the junctions of partitions and exterior walls;
d) through false walls and dropped ceilings;
e) around bathtubs, cupboards, cabinets, and closet walls located on the exterior wall.

Hidden air leakage pathways end at final entry points.

4.4.3 **Surface Air Leaks,** including final entry points on interior partitions, are commonly found in every type of house. They are generally cracks or gaps, often barely visible, in many locations, including the following:

a) exposed floor zone leaks into the basement;

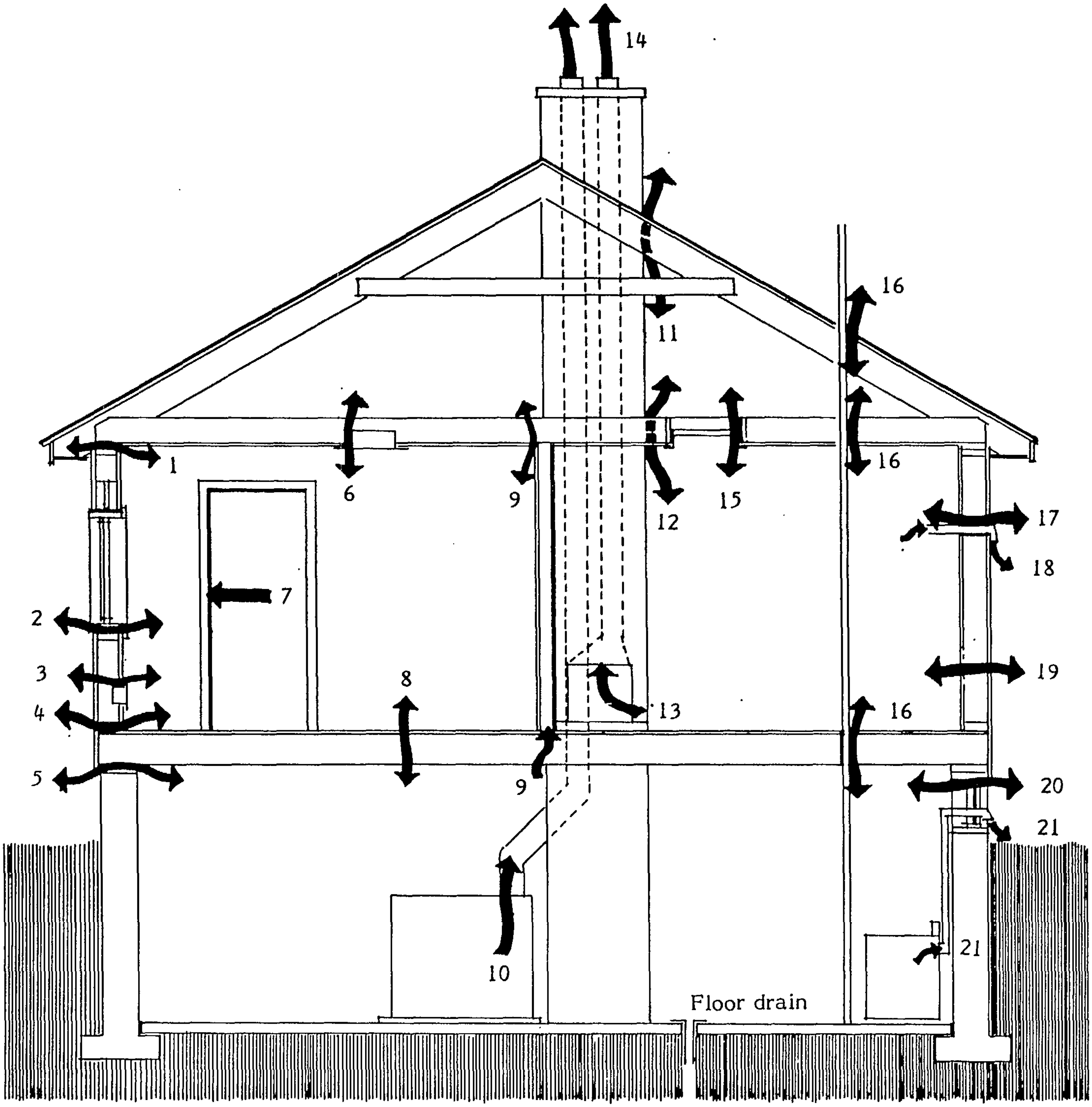
b) electrical outlets and switches;

c) at and behind the trim of windows, and doors, baseboards, dadoes and cornice;

d) cracks through the interior finish;

e) junction of the sill plate and foundation;

f) holes where pipes, vents or wires enter the wall.



1. Joints between wall and ceiling
2. Joints at windows
3. Electrical boxes
4. Joint between plate
5. Joint between joists and foundation
6. Ceiling light fixtures
7. Cracks at doors
8. Air leak from basement
9. Joints at interior partitions
10. Furnace flue
11. Chimney penetration of roof
12. Chimney penetration of ceiling
13. Fireplace flue
14. Chimneys leak air from house continuously
15. Joints at attic hatch
16. Plumbing stack penetration
17. Around vents
18. Through vents
19. Holes through vapour barrier
20. Joints at basement windows
21. Vent from clothes dryer

FIGURE 4.8 AIR LEAKAGE SPOTS IN CONVENTIONAL CONSTRUCTION

SECTION B: UNDERSTANDING CORRECTIVE MEASURES

4.5 REDUCING FORMALDEHYDE LEVELS

- 4.5.1 Formaldehyde Gains and Losses
- 4.5.2 Reducing the Generation of Gas
- 4.5.3 Sealing the Hidden Air Leakage Pathways
- 4.5.4 Sealing the Surface Air Leaks
- 4.5.5 Ventilating the Living Environment
- 4.5.6 Removing the UFFI and Other Contaminants

4.5 REDUCING FORMALDEHYDE LEVELS

4.5.1 **Formaldehyde Gains and Losses** (Figure 4.9). The air in the living environment is a mixture of air from the following sources:

a) gas-laden air infiltrating through UFFI-filled cavities;

b) other infiltrating air, including through doors, windows and vents.

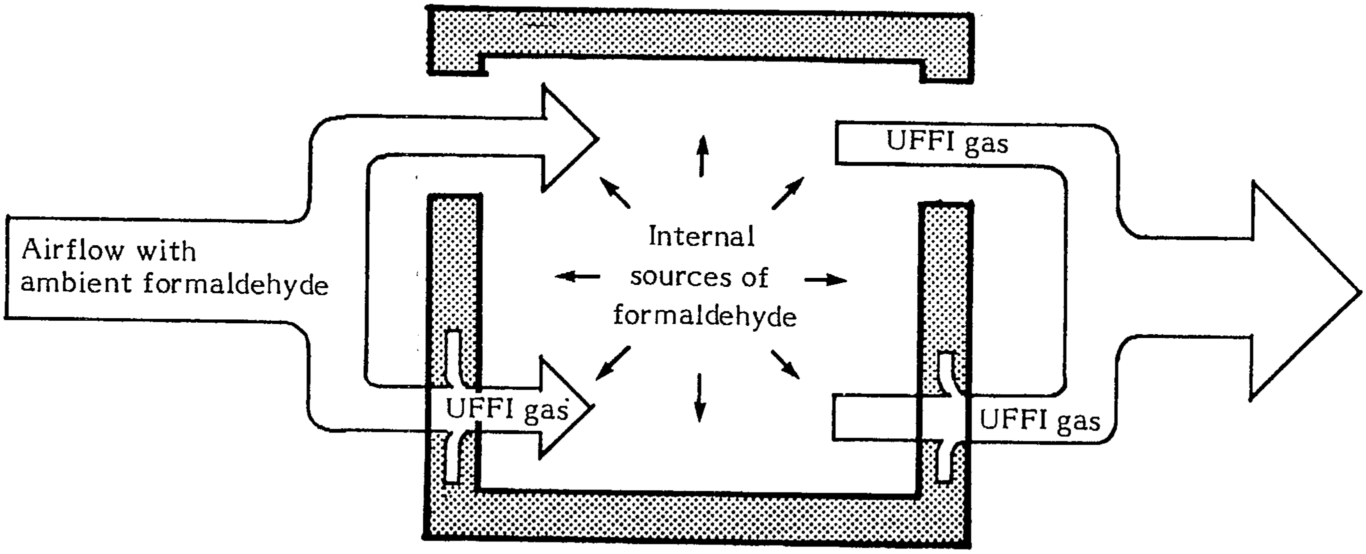


FIGURE 4.9 SCHEMATIC OF UFFI GAS GAINS AND LOSSES

Formaldehyde from other sources may be present in the air inside the house. In UFFI homes having a gas concentration higher in the living space than in the surrounding (ambient) air, the UFFI gas concentration is diluted by outside air brought in by natural and forced ventilation.

Air has a saturation point for formaldehyde as well as for moisture. When the saturation point is reached, the formaldehyde is adsorbed by other substances. When the concentration of formaldehyde in the air falls below the saturation point, this adsorbed formaldehyde will re-enter the air to slow the decrease in concentration.

4.5.2 **Reducing the Generation of Gas.** Wetting the UFFI accelerates the generation of gas. A very effective measure to reduce the generation of gas, therefore, is to dry out the UFFI-filled cavities, if necessary, and keep them dry.

4.5.3 **Sealing Hidden Air Leakage Pathways** is a more extensive method of sealing. The objective is to seal air leaks leading from the insulated cavities into the floor and partition spaces, at wall junctions with the floor and partitions and at joints in rough flooring.

4.5.4 **Sealing the Surface Air Leaks.** Air infiltrating through the UFFI-filled cavities bring in UFFI gas. Warm moist air, exfiltrating through the cavities, accelerates gas generation. Hence, sealing off these pathways will prevent a large portion of the infiltrating air from entering the living environment and much of the warm moist air from exfiltrating. It will reduce both the amount of gas entering and its generation. The openings leading from the cavity to the inside, as well as all holes, cracks and gaps in the finish of the gypsum board or lath and plaster walls should be sealed.

4.5.5 **Ventilating the Living Environment** increases the flow of outside air directly into the home, either by selective window openings or by blowing outside air into the living environment.

Ventilation should not change the air pressure difference within the house to the point where the exfiltration is greatly increased. It should only reduce the negative air pressure differences in the home, thereby modestly decreasing infiltration from the UFFI cavities, while at the same time diluting the concentration of UFFI gas.

Ventilation with heat recovery attempts to recover some of the heat that is lost. This allows a much greater exchange of air for the same energy usage, or requires less energy for the same air exchange.

4.5.6 **Removing UFFI and Other Contaminants.** This corrective measure is intended to remove the major source of UFFI gas by removing the UFFI. All the UFFI is located and removed, each cavity is cleaned thoroughly, treated with a neutralizer and reinsulated, air and vapour barriers are installed and the interior or exterior finish restored. Sealing the interior carefully, as discussed in Chapter 6, increases significantly the resistance to air flow through the building envelope.

CHAPTER 5

KEEPING THE CAVITIES DRY

Contents

5.0 INTRODUCTION

In conjunction with sealing or ventilating a home, it is necessary to take measures to keep cavities dry over a long period of time in order to avoid moisture problems. One measure recommended to reduce the level of formaldehyde in the home is to dry out the wall cavities and thus reduce the generation of UFFI gas. To achieve this, the contractor and homeowner must be aware of the sources of humidity in the home and the steps that can be taken to reduce excessive generation of moisture in the cavities.

5.1 HUMIDITY LEVELS

Humidity levels in Canadian homes vary according to:

- age;
- structure;
- climate;
- living habits of occupants;
- type of heating system;
- degree of air tightness;
- moisture producing activities;
- the operation of doors and windows;
- the operation of ventilation systems.

Unless indoor humidity is kept below 10%, **it is impossible to avoid some condensation** from occurring when air leaks into the walls or ceiling. Since 10% relative humidity is unrealistically low, the solution to condensation problems within the structure is to **reduce the number of air leaks.**

When the rate of ventilation or air leakage is insufficient to carry away the moisture quickly, some amount of condensation is bound to occur. Condensation in a home is produced by water vapour coming into contact with cold surfaces when the rate of moisture flow to the surface is higher than the flow away from the surface. Such surfaces may be glass windows, wall sheathing, roofing, or anywhere within the building envelope. Condensation always occurs to a certain extent; we are only concerned with problems arising from its **accumulation.**

5.2 REDUCING MOISTURE PRODUCTION

This technique entails locating the major sources of moisture production and taking appropriate steps to reduce it. For example:

a) **humidifiers** and their supply of water should be turned off;
b) **bare earth floors** of cellars or crawl spaces should be covered with polyethylene film (0.1 mm or thicker) and then covered with a layer of sand or other material to prevent puncturing;
c) **basement floors and walls** that are unusually damp may need a damp-proof treatment. The outside drainage should also be checked and eavestroughs installed where necessary with water routed away from the foundation;
d) **clothes dryers** must be vented outdoors;
e) **kitchens and bathrooms** may need exhaust fans installed. While these fans can ventilate heavy concentrations of moisture from drying clothes, cooking, washing, baths and showers, they should be used sparingly because they will tend to depressurize the home and increase the infiltration. Open a window a little to minimize the depressurization;
f) **leafy, tropical plants** may have to be reduced in number or exchanged for terrariums;
g) **storing or drying of firewood indoors** should be curtailed;
h) **a dehumidifier** may have to be installed, especially in the basement, for use from early summer to late fall;
i) plant growth at exterior walls (e.g., climbing ivy).

5.3 MOISTURE IN THE WALL CAVITIES

Moisture in UFFI accelerates the deterioration of the insulation and the emission of UFFI gas.

Reducing the amount of moisture in the cavities is an effective measure in reducing the generation of UFFI gas, fungal growth and the concentration of UFFI gas in the living environment.

The homeowner should be aware of signs suggesting moisture in insulated cavities which may include: stains, seepages, blistering paint, peeling, damp spots or mildew on interior or exterior surfaces, and musty "mushroom" odours close to the insulated cavities.

5.4 MAINTAINING DRY CAVITIES

It is important to ensure that the wall cavity does not retain excessive moisture since this can cause damage to the structure, decrease the insulation value and, if UFFI is present, increase the emission of UFFI gas. To avoid this, any water leakage from the outside must be found and corrected. To avoid condensation problems:

a) ensure that humidity levels in the home are as low as comfort permits (reduce moisture production and ventilate);
b) seal all air leaks and ensure as good a vapour barrier as possible at the interior surface of the building envelope;
c) ensure that any moisture which enters the building envelope dissipates to the exterior or is diluted harmlessly by means of adequate roof ventilation and exterior cladding that can breathe;
d) ice ridging due to lack of attic ventilation and/or insufficient insulation.

If these steps are competently done, the problem of walls which may presently hold excessive moisture will be corrected in time. There may be some conditions where walls must be dried before sealing is undertaken and this may be done by use of warm dry air, at a pressure difference which will move such air throughout the cavities. However, the important consideration is to maintain dry cavities over the longer term.

Chapter 6

SEALING AIR LEAKS

Contents

6.0 INTRODUCTION

Sealing all the cracks and leaks in and around the interior finish is a simple and inexpensive step to help reduce the transfer of UFFI gas from the UFFI insulated cavities to the living environment. Sealing also reduces the transfer of excessive moisture into the insulated cavity and causes heat loss due to air leakage, which will diminish the effectiveness of the existing insulation (degradation of insulation).

The work is straightforward, safe, easily maintained, effective and beneficial for any home. Sealing is recommended as the starting point for most of the other corrective measures. Once this is completed, many homeowners may find that no further action is necessary. (Refer to 4.4 for identification of leakage points.)

6.1 SITE PREPARATION

6.1.1 **Health and Safety.** Residents and workers may have adverse reactions to caulking or sealing materials during the curing stage. Proper ventilation may be required depending on the types of materials used. **Workers (including residents who will be doing the work themselves) may have a history of allergies. If odours or fumes from the sealants or materials to be used are objectionable to workers, they should vacate the site or use alternative materials. Residents should test their reactions to small cured samples of the proposed caulking or sealing materials.**

Caution should be taken with respect to sealants that are used for UFFI corrective work. There is concern about the possible toxicity of the products on the market. Sealants are now undergoing extensive study to determine their safety and effectiveness. Current information suggests that water-based acrylic or vinyl latex sealants pose the fewest problems from the off-gasing of chemicals. For the safe use of these materials, or commonly used silicone based sealants, follow the manufacturer's instructions and ensure proper ventilation when caulking indoors. **Petroleum solvent-based sealants and mono acrylic-based sealants should not be used indoors.**

Remove obstructions from work areas and use normal safety precautions when working with ladders, sharp instruments or close to electrical outlets.

6.1.2 Material Required. Ensure that sufficient materials and appropriate tools are available on site.

Have appropriate coverings available to protect carpeting and furniture in the immediate work areas. Furnishings, clothing and household utensils may have to be removed to prevent damage. They may also obstruct workers.

Have the following sealants or caulking materials available:

a) oakum or plastic foam rope fillers for packing large cracks;
b) polyethylene to use as air barrier over large test holes;
c) plaster to fill in wall finish cracks;
d) gaskets for electrical outlets and switches;
e) child-proof plugs to block extra outlets;
f) appropriate caulking materials (Table 6.1).

TABLE 6.1
CAULKING AND SEALING COMPOUNDS

CAULKING AND SEALING COMPOUNDS	CHARACTERISTICS											
	RECOMMENDED	PRODUCT OR APPLICATION STANDARD	COST	EASE OF APPLICATION	VISIBILITY	PAINTABILITY	DURABILITY	FLEXIBILITY	SHRINKAGE	ADHESION	MOISTURE RESISTANCE	AVAILABILITY
* Silicone Seal	YES	19-GP-18M	H	M	L	***N	H	H	L	M	H	H
* Latex Based	YES		M	M	H	Y	M	M	M	H	L	H
* Latex Acrylic	YES	19-GP-5M	L	M	H	Y	M	M	M	H	H	H
** Butyl Rubber	YES		M	L	H	Y	H	M	H	H	H	M
** Acoustical Sealant	YES	19-GP-21M	M	H	H	N	H	H	L	H	H	M
Oil or Resin Based	NO	19-GP-6M	L	M	H	Y	L	L	H	L	L	H
Nitrile Rubber	NO		M	L	H	Y	M	M	H	M	H	M
Neoprene Rubber	NO		H	L	H	Y	M	M	M	M	H	M
Polysulphide	NO	19-GP-13M	H	L	H	N	H	M	L	M	M	L

* recommended for visible
** recommended for hidden
*** pre-coloured

The product or application standard numbers in the Table are CGSB numbers.

L - LOW
M - MEDIUM
H - HIGH

Y - YES
N - NO

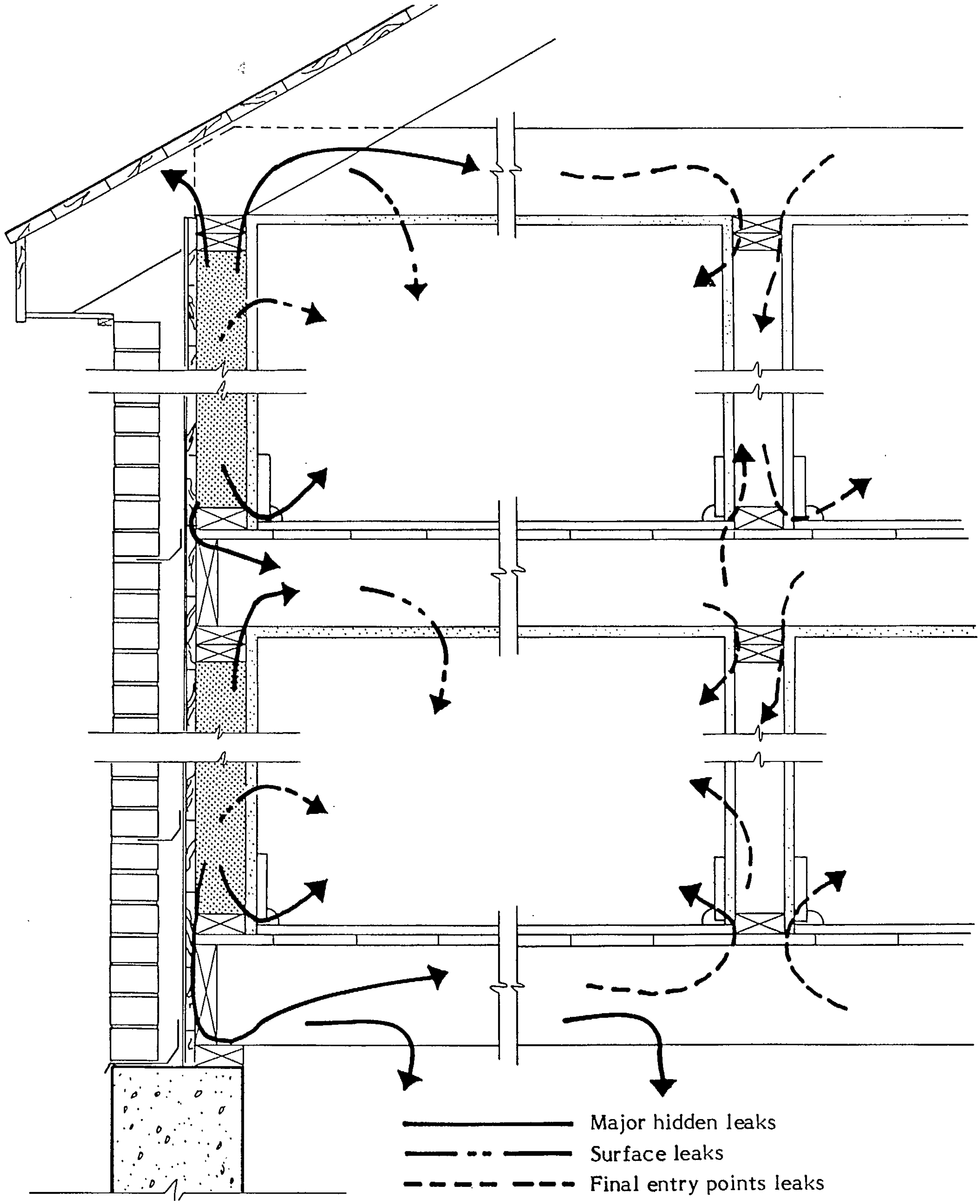


FIGURE 6.1 POSSIBLE UFFI GAS PATHWAYS

Have the following tools and equipment available at the work site:

a) caulking guns;
b) screwdrivers;
c) ladders;
d) staple gun;
e) wire brush;
f) utility knives;
g) scrapers or putty knives;
h) cleaning fluids;
i) cleaning cloths.

6.2 MATERIALS AND PROCEDURES FOR SEALING

6.2.1 Caulking Material. The best caulking is one that remains flexible, undergoes little shrinkage and is compatible with materials being caulked. Movement or cracking is a natural result of changing moisture and temperature conditions which cause materials to expand, contract, or shift, often at the junction of unfinished wooden surfaces or where two very different materials join (see Table 6.1).

The chemical composition of caulking compounds can vary enormously. They are therefore grouped here according to their basic component:

a) **silicone-based compounds** exhibit excellent resistance to aging, temperature extremes and water, but are very expensive and cannot be painted over. They adhere well to glass, metal and ceramic surfaces, are elastic and can flex without permanent deformation. Primer is needed to enhance adhesion and durability on porous surfaces, particularly concrete and wood;

b) **latex-based compounds** are very easy to use. They work well on small joints and non-moving parts and can be cleaned with water. However, they can be applied only at temperatures above 4°C (40°F), and are not effective for use on permanently damp surfaces;

c) **acrylic latex-based compounds** are easy to apply, usually dry quickly and last a long time. They are medium-priced and the most popular. Although they can be applied to damp surfaces, they are not effective in permanently damp environments;

d) **acoustical sealants** are long-lasting and remain flexible. They are excellent for sealing plastic vapour barriers and for any application (such as basements and attics) where caulking is out of sight and touch.

6.2.2 **Caulking Procedures.** Success depends on the quality of the product and how carefully it is applied. If applied poorly, the compound will not last as long as expected. The following procedures will produce the best results:

a) **prepare the surface:**
- ensure that the surface to be caulked is absolutely clean and dry;
- completely remove any old sealant or paint using a screwdriver or putty knife;
- use a solvent specially sold for this purpose to clean very dirty surfaces;

b) **thoroughly clean joints** to be caulked:
- remove loose materials using a paint scraper and wire brush;
- wash the joints with detergent, rinse, and permit them to dry;

NOTE: Make sure detergents are compatible with caulking. Read the instructions regarding caulking, since some compounds require the area to be primed before applying the caulk;

c) **pack joints** wider than 10 mm with oakum caulk, plastic foam rope filler, or pieces of compressed insulation batts before sealing with caulk;

d) **repair areas** to be caulked:
- replace badly deteriorated wood;
- nail loose boards tight;
- complete other necessary work;

e) **application.** Cut the end of the spout at a 45° angle. Some specialists recommend cutting the spout a second time at a 90° angle which stops the product from accumulating at the end of the spout.

After inserting the tube into the gun, pierce the seal by forcing a pointed object down the spout of the cartridge. Keeping the gun at a 45° angle to the surface, apply the product slowly and evenly, making sure the compound has enough time to penetrate the crack. Do not stop when the crack is only half-filled as it is difficult to start again from where you left off. Gently squeeze the trigger of the caulking gun and either push or pull slowly and evenly along the joint to be sealed. Pushing usually works best on tight cracks and smoother surfaces. The gun must be pushed at a speed which maintains a bead of caulking just slightly ahead of the nozzle. This helps to force the caulking into cracks and leaves a smooth finish. Pulling the caulking is a better technique for wide or bumpy cracks.

Release the pressure on the tube BEFORE reaching the end of the crack, otherwise the compound will continue to come out. It is useful to have a cloth handy to wipe the end of the spout every now and then.

Where appearance is important, use masking tape on either side of the crack and remove it immediately after caulking. Smoothing the surface with a wet finger or tool will result in a concave joint, which does not provide as good a seal.

Caulking gives off relatively strong fumes, some of which are inflammable. Good ventilation is important when caulking indoors.

It is important to wait at least a day or two before painting. This will give the product time to complete most of its shrink cycle.

NOTE: The use of a pneumatic gun, rather than a manual gun, will produce a more consistent bead. This becomes extremely important when the bead is installed in visible areas. In such areas transparent or paintable caulking should be used;

f) **clean the caulking gun,** using cloths and the appropriate solvent. Latex-based caulking can be cleaned with toluene or a standard paint remover or solvent.

6.2.3 **Correct Temperature.** The ideal time to caulk outdoors is when the temperature is between 15° - 20°C. When it is too hot, smaller cracks are not visible to the naked eye because of the expansion of materials, and the compound may run. In cold weather, the compound becomes thick, is difficult to squeeze out of the cartridge, and works poorly.

6.3 SEALING SURFACE AIR LEAKS

The following steps should be taken:

a) seal all cracks or gaps between the interior plaster and trim. Not all visible cracks or gaps are real leaks. While some cracks do not lead all the way through to the insulated cavities, the best approach is to assume that they are leaks and seal all that can be found. Consider the following steps when sealing cracks and gaps:
   - repair major openings in walls (e.g., inspection openings). Insulate the area behind the opening, install a vapour barrier and repair the interior with a suitable finish such as gypsum or panelling. Then paint with a finish coat, wallpaper or panel;
   - repair wide cracks and small holes by packing them with oakum or flexible insulation and seal with caulk;
   - repair minor cracks in the wall finish with appropriate material;

b) seal all electrical outlets, cover plates, switch plates and fixtures; seal all electrical receptacles on the exterior walls. Soft plastic gaskets are now available in most hardware or supply stores. Electrical receptacle slots can be blocked with "child-proof" plugs (Figure 6.2). Use transparent caulking or double-sided tape to seal the gasket perimeter to the wall if any gaps remain;

c) seal openings where pipes, vents or wires enter the wall to the UFFI-filled cavity; if the rough opening is considerably larger than the pipe, first tightly stuff or pack the space with a resilient packing: steel wool, oakum, jute, fiberglass, mineral wool or plastic rope filler. Caulk over the packing, or, if the rough opening fits the pipe more snugly, caulk directly without packing (Figure 6.3). Similarly, pack all wires, cables, exhaust vents, fans and other penetrations where necessary and then caulk;

d) seal cracks in the interior finish. When necessary, pack cracks in the interior finish with appropriate materials, seal with plaster, and paint with a finishing coat, wallpaper or repanel as necessary;

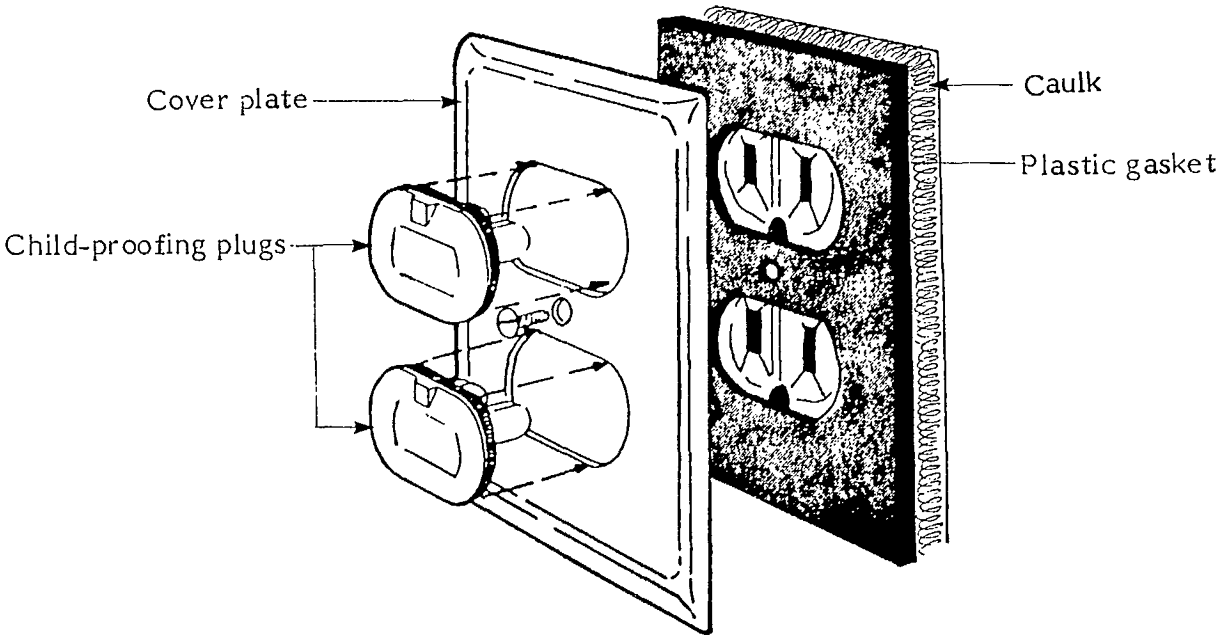


FIGURE 6.2 SEALING ELECTRICAL RECEPTACLES

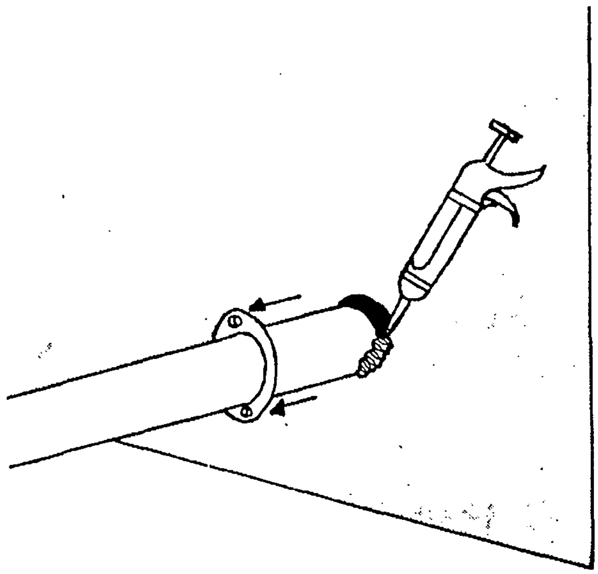


FIGURE 6.3 CAULK ALL OPENINGS

e) baseboards must always be thoroughly sealed, since the interior finish terminates behind them with a large hidden crack leading into the wall cavity. If baseboards are not to be removed, caulk along the edges next to the wall and the floor. Cracks and gaps wider than 10 mm must be packed and caulked. Take care to caulk the vertical joint at the corners (Figure 6.4). Use a transparent or paintable caulking;

where the baseboard is loose or has sprung away from the wall at the top, inject caulking well into the gap and then secure and tighten the baseboard against the wall;

if the bottom of the baseboard is against tile, sheet linoleum or plastic flooring, or against a tight hardwood or parquet flooring, then it is easy to seal all leaks at this zone. Tightly seal the junction of the baseboard with the flooring material (Figure 6.5). If a shoe mould is in place, remove it and caulk generously between the baseboard and floor. Reinstall the shoe mould firmly into the caulking material;

if the floor is carpeted, sealing is somewhat more difficult. Remove any shoe mould holding the carpet in place (Figure 6.6). If the carpet is cemented down, protect the carpet edge with wide masking tape, pushing the edge down into the gap between the carpet and the baseboard. Lay caulking in the gap between the tape and the baseboard, pressing down well against the underlay and the baseboard. When the caulking dries, cut and remove that part of the tape covering the rug. Replace the shoe mould;

if the carpet is held with a tack strip, free the carpet and turn it back from the baseboard to expose the junctions between the baseboard and the tack strip, and between the tack strip and the floor underlay. Lay caulking in both junctions and let it dry. Replace the carpet and the shoe mould;

if the carpet is held only with the shoe mould, remove it and turn back the carpet to expose the junction of the baseboard and the floor underlay. If the gap is wide, pack it with oakum or flexible insulation before sealing it with caulking. When dried, replace the carpet and the shoe mould;

f) seal window trim, door trim, cornices, dadoes, or other decorative mouldings that are set into the plaster or other interior finish in the same way as baseboards. Where they are found to be applied on top of unbroken interior finish, no sealing is necessary. Caulk cracks in window frame or door trim (Figures 6.7 and 6.8);

g) seal under the exterior wall at the top of the foundation.

NOTE: If there is no basement ceiling, seal this surface zone where the UFFI-filled cavities can leak gases downward through the floor and into the basement or cellar. If there is a basement ceiling, this work can be ignored unless serious problems exist. The floor under the exterior wall is usually plywood or individual boards. (see Figures 6.9 and 6.10).

NOTE: In balloon frame construction there may be direct access between the wall cavities and the basement, since the subfloor frequently does not extend to the outer finish. This gap must be blocked and sealed as required.

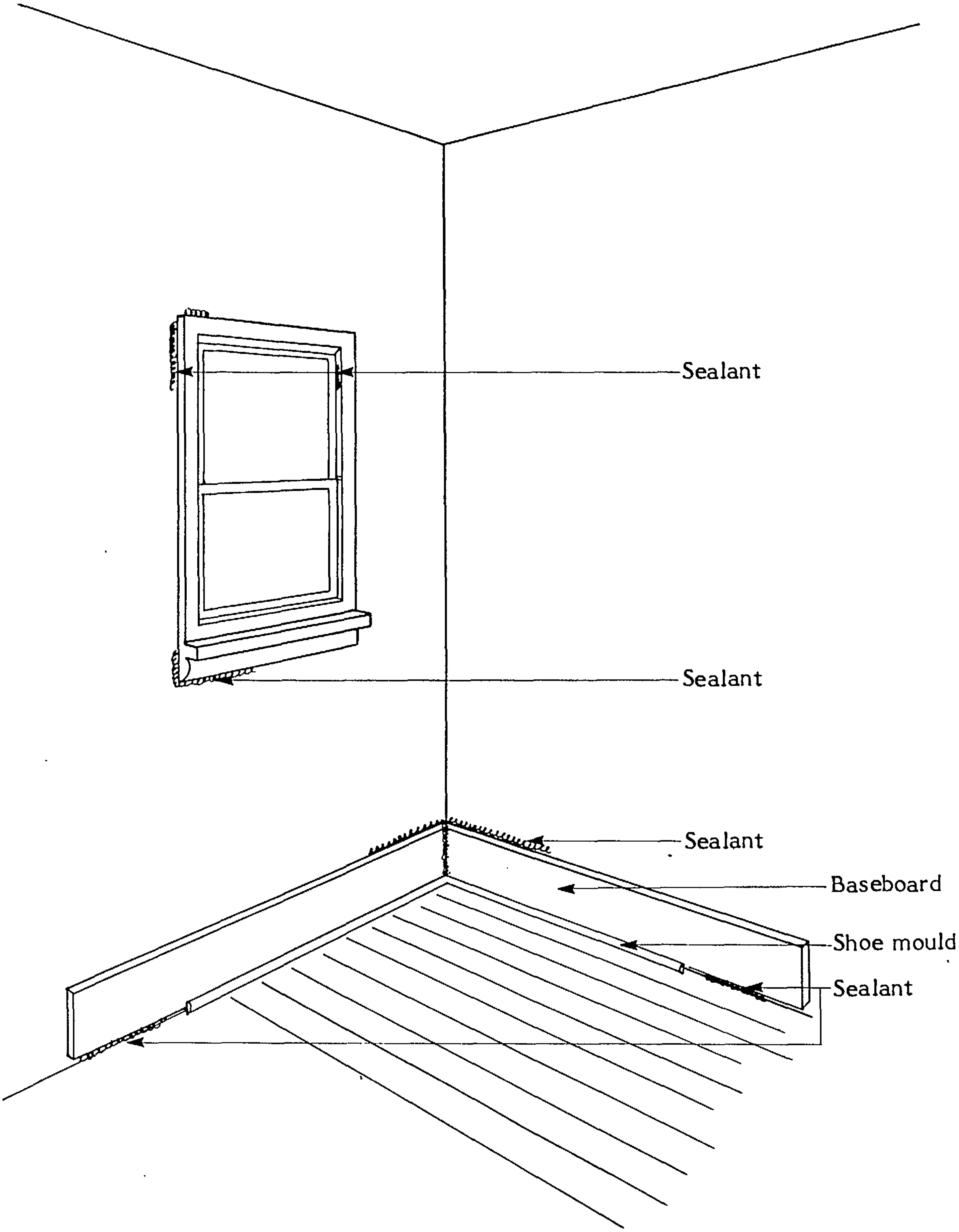


FIGURE 6.4 SEAL BASEBOARDS AND WINDOW TRIM

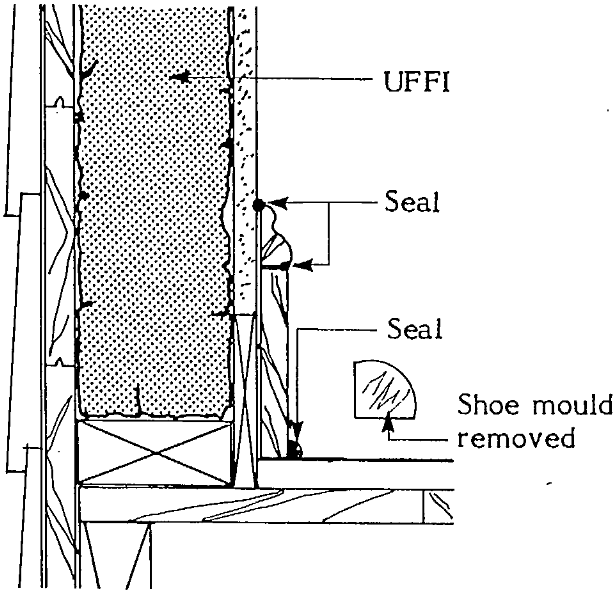


FIGURE 6.5 BASEBOARD (Finished Floor)

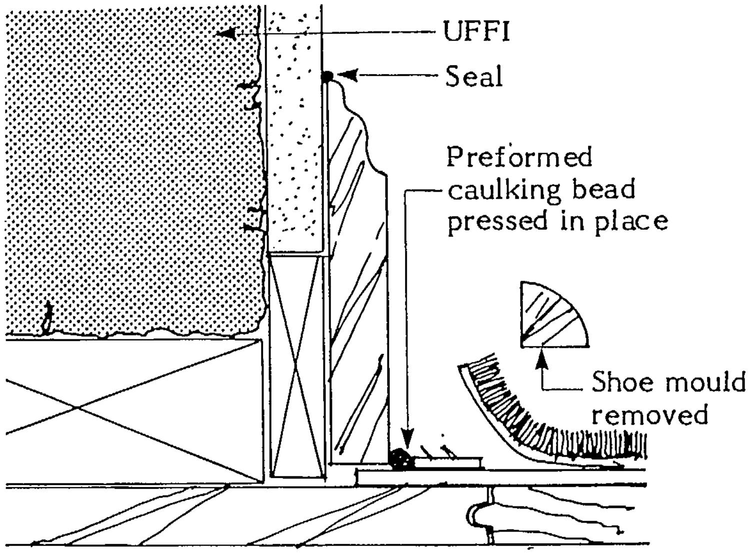


FIGURE 6.6 BASEBOARD (Carpeted Floor)

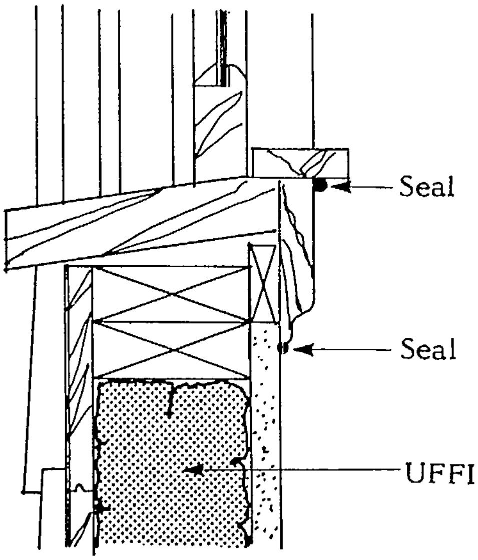


FIGURE 6.7 WINDOW FRAME

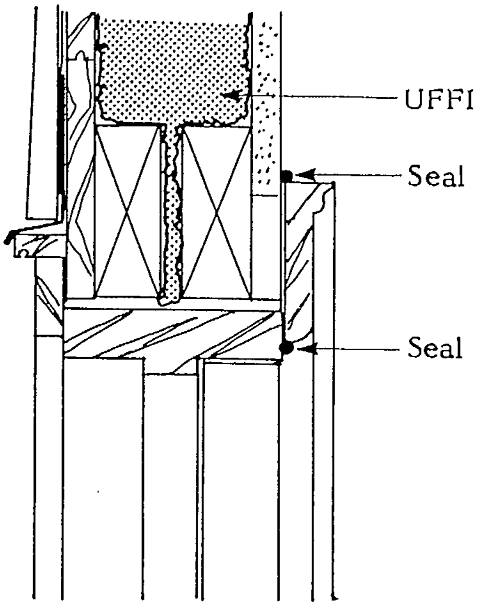


FIGURE 6.8 DOOR TRIM

SEALING SURFACE AIR LEAKS

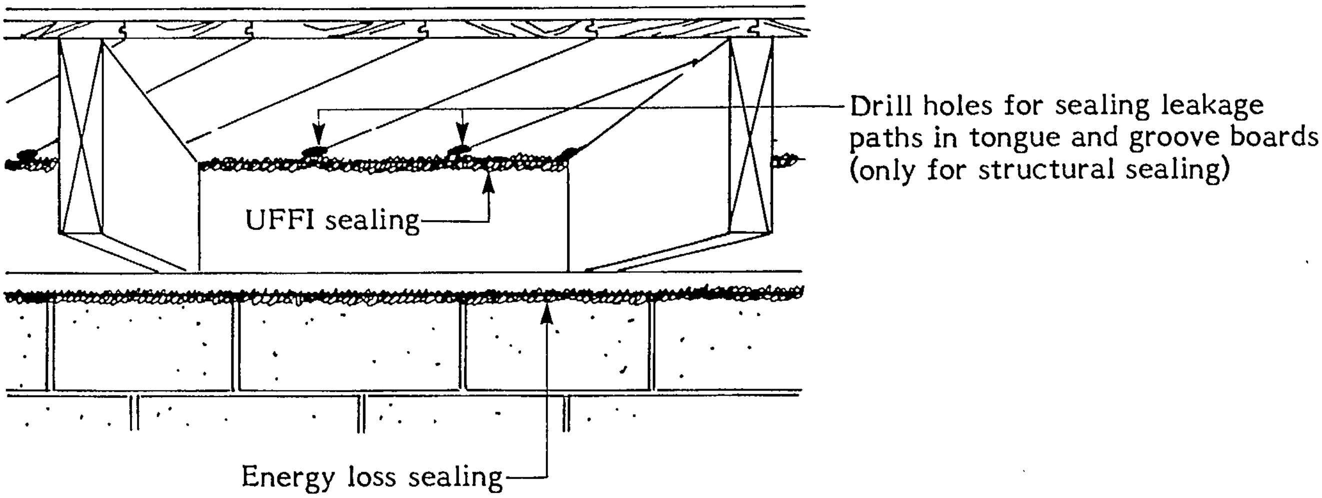


FIGURE 6.9 BOARD SUBFLOOR (Joists Atop Foundation)

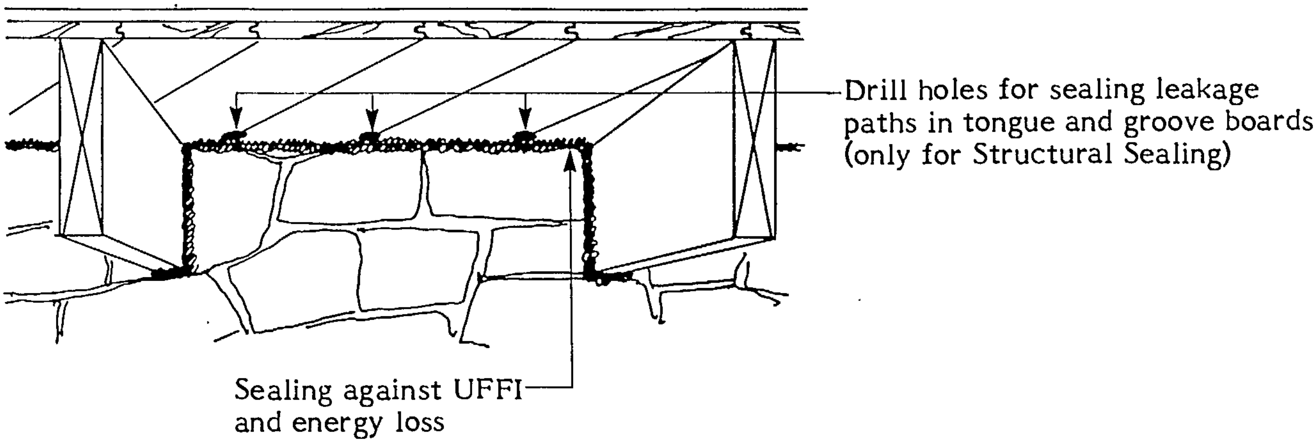


FIGURE 6.10 BOARD SUBFLOOR (Joists Set Into Foundation)

6.4 PROCEDURES FOR SEALING HIDDEN AIR LEAKAGE PATHWAYS

6.4.1 **Structural Sealing** seals the major air leaks where they begin -- at the exterior envelope (Figure 6.11). It therefore requires that some sort of access be gained to the structural junctions of the UFFI-filled exterior walls with the interior partitions and floors. There are two types of Structural Sealing: Open-Access sealing and Drill-and-Spray sealing.

6.4.2 **Open-Access Sealing** will generally be done under the following circumstances:

a) where extensive UFFI has penetrated unintended cavities which cannot be covered or sealed off and removal is impossible;
b) where large gaps require additional blocking or stuffing in addition to sealants;
c) where troublesome tunnels in floor board (tongue-and-groove) cannot be sealed by sprays alone.

Direct access to the structural junctions is usually gained by removing a strip of the interior finish. At the floor joist zones, a strip of floor or ceiling can be removed. It is especially easy to remove and replace the floor if it is finished with wall-to-wall carpeting which can simply be rolled back; otherwise it is usually easiest to remove the ceiling using a shrouded "dustfree" circular saw connected to an industrial vacuum. In some cases, open access is available without any effort (e.g., structural junctions behind kneewalls which already have access hatches). The procedures are as follows:

a) cut away strips of interior finish using a dust-free saw to gain direct access to hidden zones. For partitions, the cut-away strip will normally be the full width of a stud cavity. For ceilings, the width of cut will depend on the framing pattern, but should be at least 300 mm;

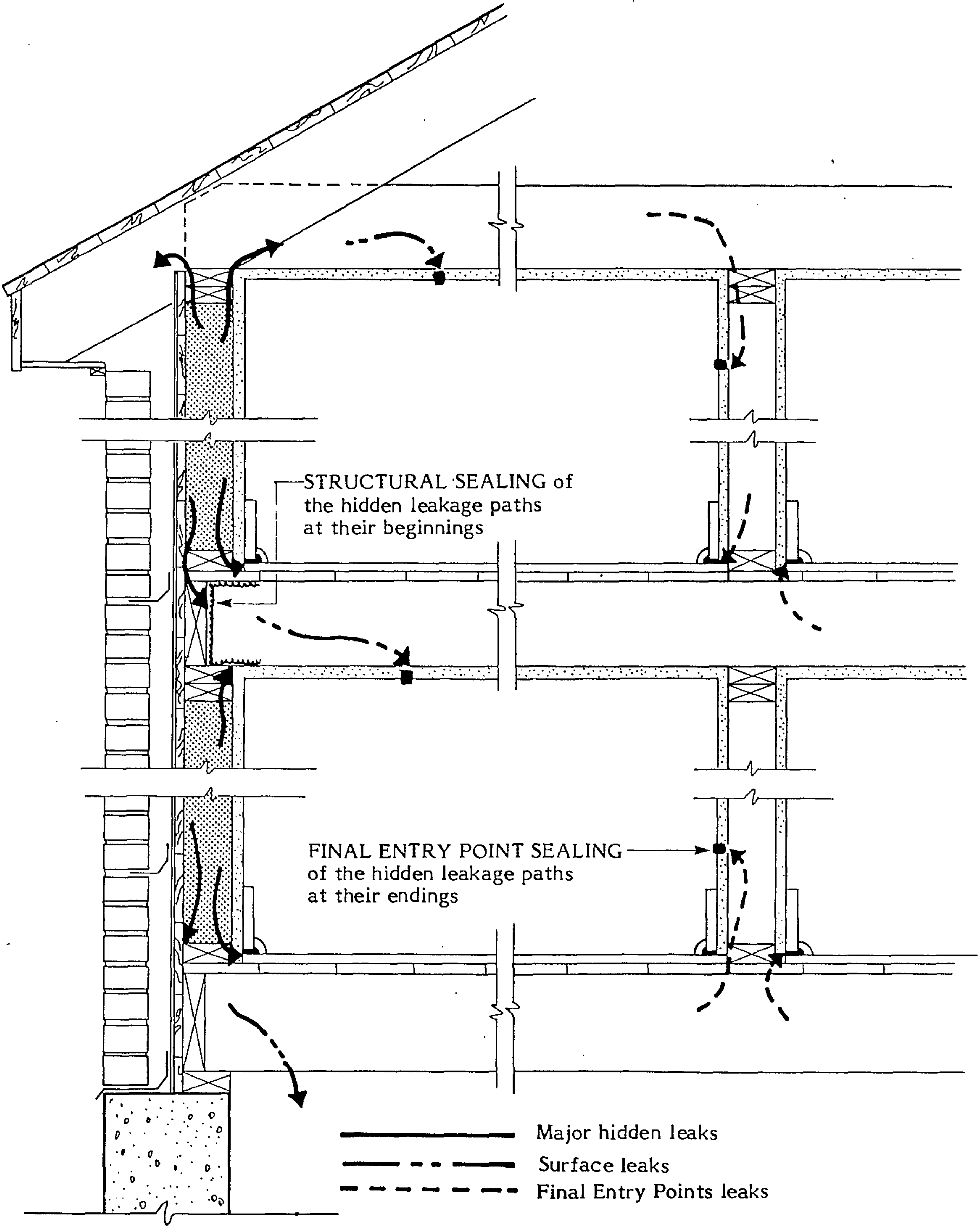


FIGURE 6.11 ADDITIONAL SEALING

b) block large gaps in the framing (e.g., missing firestops in balloon framing);

c) plug smaller gaps (e.g., strapping spaces) by stuffing with mineral wool insulation;

d) drill and plug troublesome shrinkage gaps created by subfloor joints with butyl caulking over the width of the wall above. If the subfloor boards are tongue-and-groove (Figure 6.12), it may be necessary to drill each gap to allow the joint to be plugged through to the indoor edge of the baseboard or to the finish flooring above (Figure 6.13). The same procedure should be undertaken in open basements (Figures 6.9 and 6.10). When the remainder of the joints are sealed, then the two downward leakage cracks from the UFFI cavity are blocked;

e) remove any UFFI found in partitions and floor systems;

f) spray and seal all cracks, packing and blocking with spray sealant;

g) replace cut-away finish materials with compatible new materials and make good to a state that is ready for repainting.

6.4.3 Drill-and-Spray Sealing will generally be done under the following circumstances:

a) where the subfloor consists of plywood or square-edged boards;

b) where little or no UFFI has penetrated into partitions and floor systems and can be readily covered;

c) where large gaps do not require additional blocking;

d) where other existing insulation can be covered;

e) where only shrinkage gaps exist in the framing, that is, where blocking is not required.

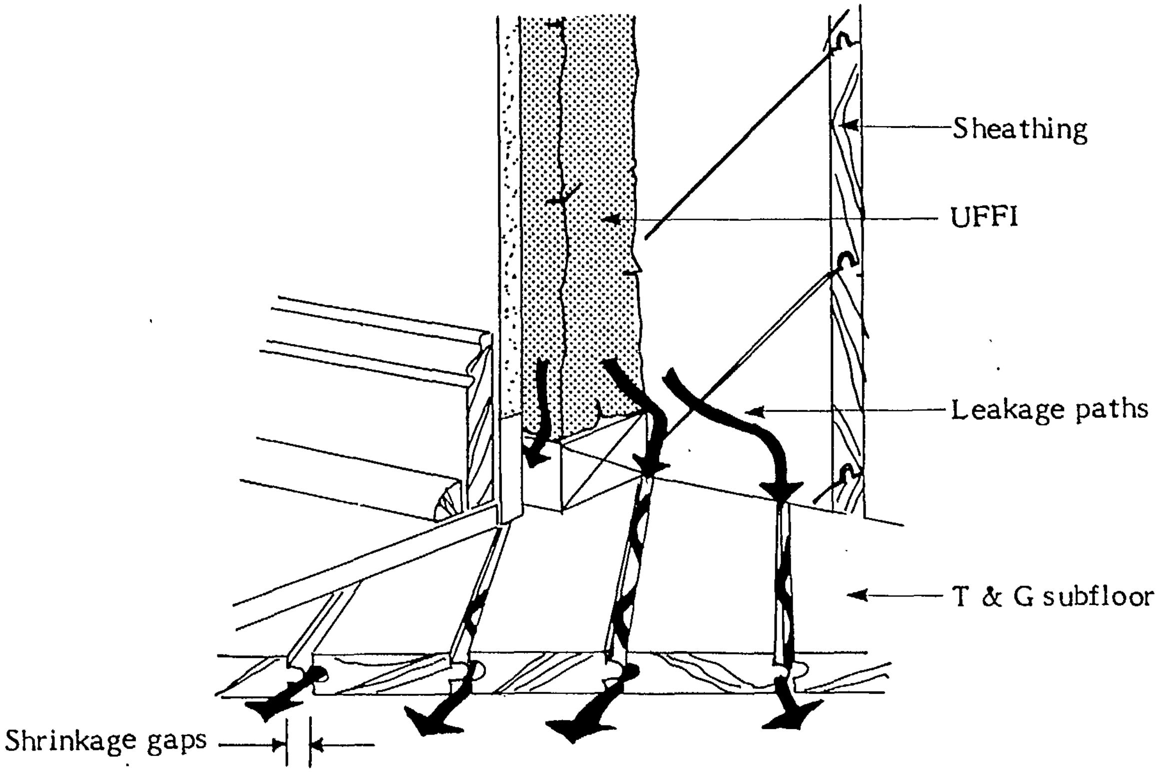


FIGURE 6.12 SHRINKAGE GAPS AND UFFI GAS LEAKAGE PATHS THROUGH TONGUE AND GROOVE JOINT TUNNELS

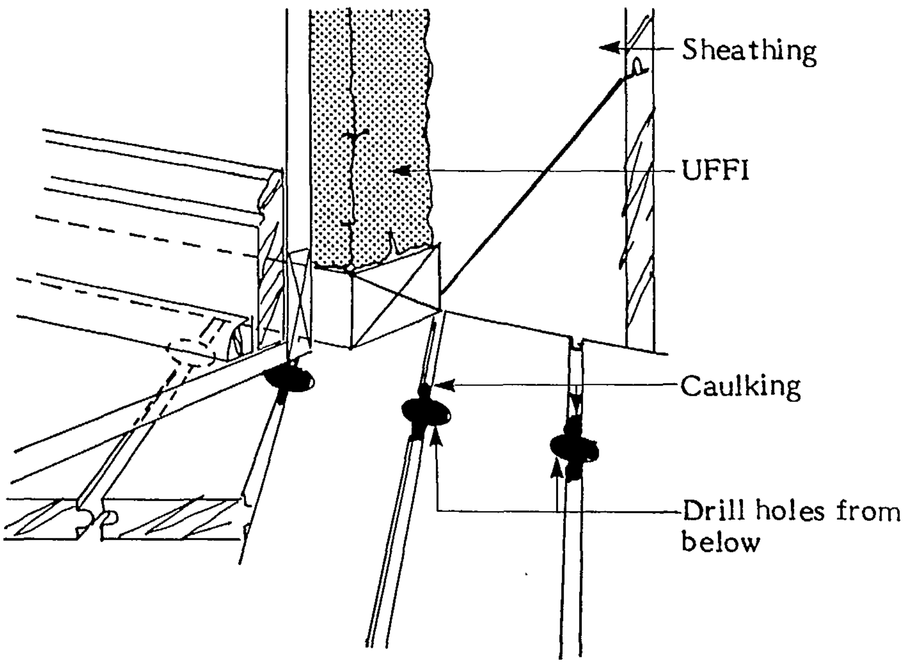


FIGURE 6.13 PLUGGING TUNNELS WITH CAULKING

If you are considering the use of this method of sealing, you will require an optical probe and specialized spraying equipment. The sealant you use should be one that will adhere to building materials and which will bridge a gap measuring at least 3 mm. During trials of this procedure, a polyvinyl acetate- based sealant was found to be effective.

The procedures are as follows:

a) drill holes (35 mm diameter) through the interior finish to gain access to hidden zones (minimum two per ceiling/floor joist space and four per partition/wall stud cavity junction, unless spraying through the bottom of the partition from the basement);

b) seal the leaks by spraying them with a liquid sealant capable of building a thick, impermeable and elastic film which will adhere to the building materials and bridge the cracks;

NOTE: Sealants have been developed especially for this process which can be applied using airless spray painting equipment with a variety of spray tips and wands for difficult-to-reach locations.

c) check sealed cavities with optical probe (Section 2.6.3) and respray if necessary;

d) repair the holes to a state that is ready for repainting.

NOTE: The maximum width which can be bridged with confidence by the spray sealant is about 3 mm. If inspection reveals larger cracks and gaps, this technique cannot be used.

The type of subfloor presents another limitation to the use of the Drill-and-Spray technique in sealing the ends of floor spaces. If the subfloor consists of individual boards, each joint between the boards acts as a tunnel through which air can bypass an otherwise thorough sealing job. Thus these joints must be sealed as well. If the boards are square-edged, sealing the joints is relatively easy and can be done well enough with the spray sealant, provided care is taken to direct the spray directly into the joint. If the boards have tongue-and-groove joints, the spray sealant will not penetrate the full depth of the joints. The only choice in this case, to obtain an effective Structural Sealing job, is to use the Open Access approach and to drill each joint and fill the hole with tube sealant (Figure 6.9).

6.4.4 **Final Entry Point Sealing.** Rather than blocking hidden air leakage pathways at their beginnings, as in Structural sealing, it is usually easier to block their endings -- --the final points where the air enters the living space. This approach is called "Final Entry Point sealing", and is identical to Surface Air Leak sealing in terms of the sealing techniques used. The only difference is that the interior partitions and floors are sealed as well as the exterior UFFI-filled walls.

Because the final entry points are more accessible than the beginnings of the hidden leakage pathways, this method is less expensive and disruptive than Structural sealing. The disadvantage is that final entry points are more numerous and more spread out than the leakage sources so it is difficult to be sure that they are all sealed. The procedures are as follows:

a) seal all cracks, gaps and openings in both faces of all partitions;
b) seal all cracks, gaps and openings in stairwells, including the landing and ceiling.

6.5 ENERGY SEALING

The methods of sealing outlined in 6.3 and 6.4 will contribute to reducing formaldehyde levels in the living space by blocking UFFI gas emissions. Air leakage into the home through other parts of the building envelope -- cracks at window meeting rails, door perimeters, letter slots, etc., will also help reduce formaldehyde levels in the living space by providing fresh air ventilation. Sealing such air pathways (i.e., undertaking energy sealing) is NOT an eligible UFFI corrective measure, since it does not allow fresh air into the living space, and therefore does not decrease formaldehyde levels.

Although not mandatory, it is strongly recommended that energy sealing be done in conjunction with the installation of a Heat Recovery Ventilator (HRV). With an HRV, energy sealing, including the following steps, is an acceptable part of this corrective measure:

a) caulk basement sills, floor headers and windows;
b) seal light fixtures and leaks in the upper ceiling;
c) tape and/or caulk all partition tops;
d) tightly pack and seal plumbing stacks and chimneys where they pass through into the attic or roof space;
e) apply weather stripping to all openings in the exterior envelope: doors, windows and attic access hatches, etc.

NOTE:
a) an HRV will work with some measure of effectiveness without energy sealing, but it will work much more efficiently when the home has been energy sealed;
b) if the house is energy sealed without an HRV, the air changes per hour (ach) may be drastically reduced, tending to:
   i) trap any formaldehyde inside the house;
   ii) reduce the amount of oxygen to fuel burning appliances, thus drawing air down the chimney and/or causing incomplete combustion.

Both conditions may cause carbon monoxide build-up, and for these reasons suitably designed, separate combustion air intake ducts must be provided for all fuel burning appliances.

6.6 COMBUSTION AIR INTAKE

When energy sealing is performed, separate combustion air intake ducts are to be provided as detailed in Appendix I - Combustion Air Supply.

6.7 SEALING CONCRETE BLOCK

When UFFI has been installed in concrete blocks and sealing is to be undertaken, the preferred method is to seal the interior wall surface so that any gases emitted will exit to the outside.

Paint-type sealants applied to the block surface are not ideal since they will eventually crack, peel, blister, etc.

The best approach is to install a continuous polyethylene vapour barrier or, if that is not possible, to seal the inside surface of the existing wall so that it acts as a functional vapour barrier.

A Heat Recovery Ventilator can then be installed, if desired (see Chapter 7).

Restore as per Figure 8.2.

Ensure, where possible, that the outside surface is more permeable than the inside surface when the job is complete.

Chapter 7

VENTILATION WITH HEAT RECOVERY

Contents

7.0 INTRODUCTION

This chapter contains basic information on the use of a heat recovery ventilation system to reduce high levels of formaldehyde. The sealing procedure outlined in Chapter 6 should always be completed before deciding whether it is necessary to install a ventilation system.

Historically, Heat Recovery Ventilators (HRVs) have been used for commercial operation. More recently, however, there has been a demand for HRVs with smaller capacities (150 L/s or less) for use in residential buildings (see Installation Guidelines for Heat Recovery Ventilators, Appendix H).

In older homes, air comes through cracks and openings in the shell. There is no control of air lost through the leaks. In a well-sealed home, however, mechanical ventilation is needed and can include an HRV to preheat incoming fresh air with heat recovered from air being exhausted.

Ventilation with heat recovery increases the rate of air change, thus diluting UFFI gas in dwellings where there are relatively high concentrations of formaldehyde. Installation of an HRV provides improved air quality and protection of the insulated structure against damage due to condensation and moisture in the walls.

7.1 USE

HRVs can be installed in most homes, regardless of structure, geographical location or severity of weather and may eliminate the need to remove UFFI, unless the foam classification and location are such that removal is necessary. However, additional ductwork may be required in homes not presently equipped with adequate air distribution systems, such as a forced air furnace.

Installation of an HRV and/or removal are each acceptable UFFI corrective measures. However, when a house contains E-class foam, **it should be removed** according to procedures in Chapter 8. To determine the class of foam, Full Scale Testing must be undertaken. Also, an inspection of the house should always be performed to find the exact location of the UFFI. In other cases, sealing and ventilation may suffice.

7.2 PREREQUISITES TO INSTALLATION

To keep the cavities dry (Chapter 5) and to reduce infiltration, thoroughly seal all air leakage pathways (Chapter 6).

An HRV will work with some measure of effectiveness without energy sealing, but it will work much more efficiently when the home has been energy sealed. **It is strongly recommended that energy sealing be done in conjunction with the installation of an HRV.**

Under some conditions in a tightly sealed home, carbon monoxide may build up. Suitably designed, separate combustion air intake ducts must specifically be provided for furnaces. If the house is energy sealed without an HRV, the air changes per hour (ach) may be drastically reduced, tending to:

a) trap any formaldehyde inside the house;
b) reduce the amount of oxygen to fuel burning appliances, thus drawing air down the chimney and/or causing incomplete combustion.

7.3 RESPONSIBILITIES OF THE CONTRACTOR

The contractor is responsible for designing and installing the system, starting it up and making the initial adjustments. The registered contractor must use personnel who have been trained and accredited by the manufacturer to install the system in accordance with Appendix H, UFFI Centre Installation Guidelines for Heat Recovery Ventilators. The contractor must accept responsibility for all work done, and ensure that it conforms to those guidelines and all codes for combustion air supply as indicated in Appendix I, Combustion Air Supply.

7.4 OBJECTIVES OF AN HRV SYSTEM

The following objectives pertain to heat recovery ventilation measures for UFFI homes based on current state of the art knowledge, and are subject to future changes arising from research and development in the field of residential ventilation.

The objectives for this corrective measure are to:

a) provide sufficient ventilation to reduce the concentration of formaldehyde in UFFI homes;
b) reduce the infiltration of air through cavities containing UFFI;
c) recover some of the heat normally lost through uncontrolled exfiltration and exhausted air;
d) control or decrease the possibility of moisture condensation in the building envelope;
e) avoid contributing substantially to negative or positive air pressure difference in the house;
f) minimize the resistance to air flow in ductwork so that the unit will be able to perform at its optimum capacity.

7.5 THE PRINCIPLES OF AN HRV SYSTEM

7.5.1 **Air Dynamics.** The walls and ceilings of many UFFI homes have many air leakage pathways. Infiltration of air and UFFI gas through them, particularly into lower levels of the home, is common, especially in winter. Sealing the leaks as outlined in Chapter 6 can control infiltration and exfiltration. Before proceeding with either of the following measures, an estimate of the air leakage rate after sealing will determine how much fresh air should be provided to dilute the indoor formaldehyde concentration to a desired level (ideally below 0.05 ppm).

If fan depressurization tests for airtightness are to be conducted on the home, they should be performed before and after sealing is done.

Depending on air pressure differences, the rate of air change in the living area will vary. Over a period of time, the process will change all the air within the envelope. This process is called air change and the rate is designated as the number of air changes per hour (ach).

Reduction of the UFFI gas concentration can be achieved by increasing the air change rate. For example, if the target concentration is to one-third (1/3) of the measured concentration of formaldehyde, the air change rate must be tripled. In practice, this will not be attained for various reasons.

UFFI gas concentrations will be reduced if mechanical ventilation by means of an HRV is introduced. An air change rate of 0.5 is recommended. This may be achieved by a combination of natural and mechanical ventilation.

7.5.2 **Calculation of Heated Volumes.** Although measurements for heated volumes should be taken from the **inside surfaces of the exterior walls**, it is often simpler to take the external measurements of the house and subtract the thicknesses of both exterior walls. Approximate measurements are sufficient.

All spaces that are heated to temperatures of at least 15°C are considered as part of the living space and should have their volumes included in the total volume calculation. Any spaces within the air/vapour barrier of the insulation are considered part of the heated volume, including interior partition walls, cupboards and closets.

The heated volume of a home is usually given in units of litres or cubic meters in the metric system and cubic feet in the English system. The appropriate conversion factors are:

$1\ m^3 = 1{,}000\ L = 35.3\ ft^3$

$1\ ft^3 = 28.3\ L = .028\ m^3$

$1\ L = .035\ ft^3 = .001\ m^3$

The volume of any square or rectangular building is found by multiplying its three dimensions together. Example A: A house with a length of 12 metres, a width of 8 metres and a height of 2.1 metres would have a heated volume of:

V = L x W x H

V = 12 m x 8 m x 2.1 m

= 202 m^3 (rounded)

For irregular shapes, such as the upper floor of a 1-1/2 or 2-1/2 storey house, the most accurate way of measuring the volume is to determine the cross-sectional area of an end wall and then to multiply this value by the length.

Figure 7.1 shows sample dimensions for calculating the volume of a half-storey.

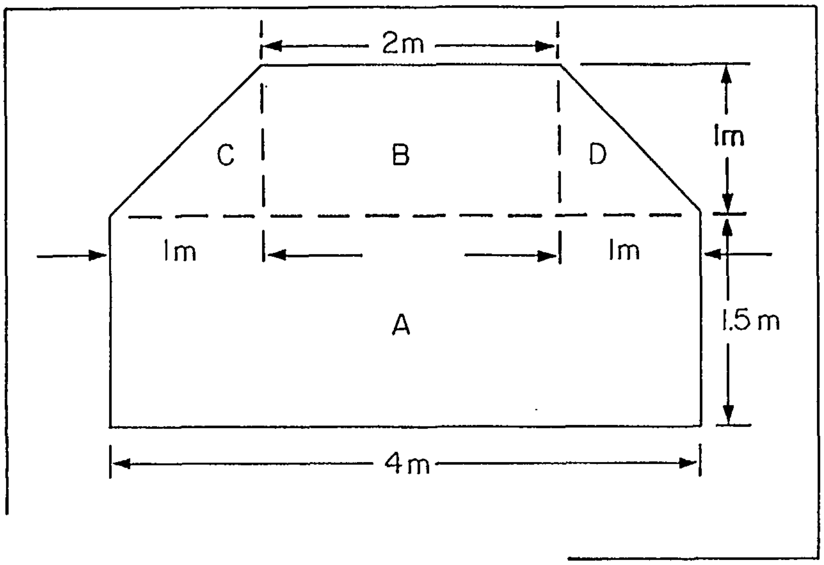


FIGURE 7.1 SAMPLE DIMENSIONS OF A HALF-STOREY

Simplify the calculation of the cross-sectional area by dividing it into squares, rectangles and triangles. Add together the areas of these simpler components, then calculate to give the total cross-sectional area. In the example, the total area is divided into two rectangles and two triangles. The formula and calculation procedure for the four areas is given below.

$A = 4\ m \times 1.5\ m = 6\ m^2$
$B = 2\ m \times 1\ m = 2\ m^2$
$C = 1\ m \times 1\ m \times 0.5 = 0.5\ m^2$
$D = 1\ m \times 1\ m \times 0.5\ m = 0.5\ m^2$

The total area of the half storey is:

$$A_t = A + B + C + D$$
$$= 6 + 2 + 0.5 + 0.5$$
$$= 9\ m^2$$

By multiplying this total cross-sectional area of 9 m^2 by the length, 12 m, we find the total volume of 108 m^3.

7.5.3 **Target concentration level (K)** may be expressed as a fraction of the actual level, thus:

$$\text{Target Concentration (K) Level} = \frac{\text{Target level of concentration in ppm of measured concentration}}{\text{Measured level of concentration in ppm}}$$

7.5.4 **Heat Transfer.** Heat (one of the most common forms of energy) is transferred by the random motions of molecules. The more rapidly they move and vibrate, the more heat they transfer.

When describing the heat energy in a quantity of air, two forms of heat must be considered: sensible heat and latent heat. These two forms of heat are additive and the sum is usually referred to as the total heat or enthalpy.

Sensible heat is the heat which raises temperature (e.g., air). Latent heat is the heat absorbed or radiated during a change of phase at constant temperature and pressure. The energy required to change the state of water, for example, from a liquid to a gas is referred to as latent heat. Or, when evaporated water is condensed into a liquid, the latent heat is converted into sensible heat.

Heat flows from high temperature areas to low temperature areas. Conduction is the transfer of heat through a solid material by direct contact between molecules. Thus, the heat on the warm side of a solid material will naturally tend to flow or be transferred to the cooler side by means of conduction. Cold outside air passing through an HRV unit will be warmed by the heat transferred from the warm air being exhausted.

The method of heat transfer used in some HRV units recovers both sensible and latent heat; others do not. Sensible heat is transferred by conduction through the solid heat exchange material which separates the air streams in the unit. Latent heat can be transferred directly or indirectly: it is transferred directly by water vapour passing from one air stream to the other. Some units transfer sensible heat by raising the temperature of the incoming air stream, and also moisture from one air stream to the other. Some heat exchange materials, such as various types of paper, permit the movement of some water through them in the vapour state.

Most models transfer latent heat indirectly. This occurs when the temperature of the exhaust stream is lowered below its dew point as it moves through the core and condensation begins to occur. The result is the conversion of latent heat into sensible heat which is transferred through the walls of the heat exchanger core. In this case, some latent heat is recovered, but no moisture transfer occurs (Defrost device required: Section 7.6.3).

7.5.5 **Rate of Ventilation.** To arrive at the total rate of ventilation, both the mechanical and natural rates are combined. Formaldehyde reductions in UFFI homes will occur if ventilation is supplied at the rate of one-half (1/2) air change per hour. The mechanical rate of ventilation for the HRV shall not be less than one-quarter (1/4) air change per hour. The natural air change rate after sealing should be measured by the fan depressurization method, CGSB draft standard 149-GP-10M. The resulting figure will be used to determine the size of unit required to provide the proper ventilation rate. If the air change rate after sealing cannot be measured in this way, it can be estimated by a secondary method (see 7.7.3, Method 2).

The operation of an HRV system must not substantially increase the positive or negative air pressure differences within the home:

a) **excessive positive air pressure difference** could cause condensation damage in the walls and upper ceiling due to a greater outflow of warm, moist air;

b) **excessive negative air pressure difference** may cause two very undesireable results:

- increased infiltration may draw in UFFI gas past unsealed points of entry, negating the objective of sealing;
- back drafting, pulsations, or sooting can occur in homes without adequate combustion air supply for fuel-fired furnaces, fireplaces and appliances (see Appendix I for further information).

Balanced air flows, a defrosting mechanism and/or a fail-safe device are mandatory for use in the UFFI Program.

NOTE: Other means of ventilation (natural and mechanical) in the home may temporarily unbalance the air flows of the HRV.

7.5.6 Calculating Effectiveness. Manufacturers' values have been calculated by differing methods, so cannot be directly compared. Such factors as air flow rates, humidity, temperature differences and defrost cycles vary. CSA is preparing a performance standard for residential HRVs which establishes the criteria for rating HRVs and provides an acceptable method of comparing various units.

For example, the effectiveness of a unit may be represented by an inside termperature of 20°C (T_1) and an outside temperature of T_2 - 20°C. For example, the outside temperature after passing through the HRV rises from -20°C to 10°C (T_3), an increase of 30°C.

The effectiveness of this HRV is the ratio between the actual temperature rise, 30°C (54°F), and the maximum theoretical temperature rise, 40°C (72°F).

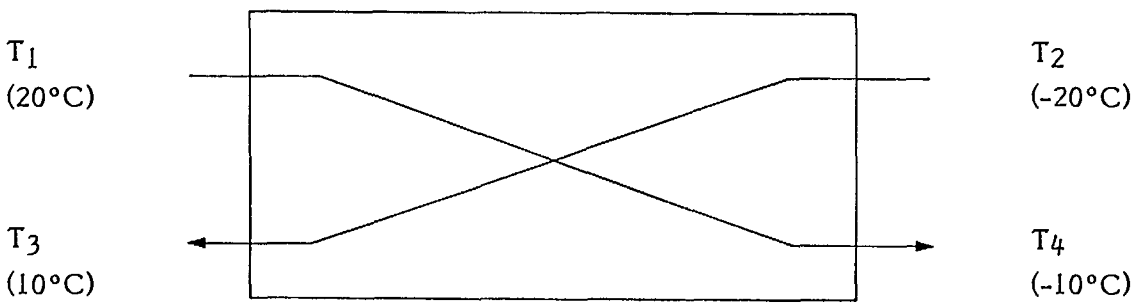


FIGURE 7.2 CALCULATING THE EFFECTIVENESS OF AN HRV

The effectiveness (E) may be expressed mathematically as follows:

$$E = \frac{T_3 - T_2}{T_1 - T_2} \quad \text{or} \quad \frac{T_1 - T_4}{T_1 - T_2} = \frac{20 - (10)}{20 - (-20)} = \frac{30}{40} = .75$$

$$= \frac{10 - (-20)}{20 - (-20)}$$

$$= \frac{30}{40}$$

$$= .75 \ (75\%)$$

This effectiveness value defines only the sensible heat recovery. The effectiveness calculation where condensation occurs is somewhat more complicated. When condensation occurs, latent heat is converted to sensible heat. Effectiveness values under these conditions are higher than values where no condensation occurs.

This calculation procedure assumes balanced exhaust and supply air flow rates. Considerably higher effectiveness values can be obtained if the exhaust air flow rate exceeds the supply air flow rate; however, infiltration is induced through the building envelope -- a condition to be avoided in UFFI installations.

Effectiveness curve values charted under actual conditions are not constant but can vary with the air flow rate, humidity and temperature difference.

7.5.7 **Measurement of Air Flow Rate.** A measure of both the exhaust and supply air flow rates is required to determine the contribution to the overall air change rate and to allow balancing of the system. Most measuring devices do not determine the flow rate directly but give an indication of the average air velocity. To determine the air flow rate (Q), multiply the cross-sectional area of the duct (A) by the average velocity (V) of the air, using the following formula:

$$Q = V \times A$$

where

Q = air flow rate, m^3/h or ft^3/min

V = average air velocity, m/h or ft/min

A = cross-sectional area of the duct, m^2 or ft^2

Some devices for measuring the average velocity are:

a) air flow meters;
b) vane anemometers;
c) Pitot traverse devices;
d) velocity pressure measuring devices.

Instructions for each type are provided and some require a fair degree of skill and patience to produce accurate results.

7.5.8 Conversion of Air Flow Rate to Air Changes per Hour. Air flow rates are usually given in three different forms: two are metric and one uses British system. To convert quickly from one to another, use the following relationships:

1 L/s	= 3.60 m^3/h	= 2.12 ft^3/min
1 m^3/h	= .28 L/s	= .59 ft^3/min
1 ft^3/min	= .47 L/s	= 1.70 m^3/h

For example, to convert an air flow rate of 35 litres per second to cubic feet per minute, multiply 35 x 2.12, which yields a value of approximately 74 ft^3/min.

Air exchange rates are normally expressed in air changes per hour (ach). If a house has an air change rate of 1.0 ach, this means that the total volume of air in the house has changed every hour. For 0.5 ach, one half of the house air is changed every hour.

The air change rate can be expressed more precisely in the form of cubic meters per hour (m^3/h) or litres per second (L/s). For example, if a house has an air change rate of 0.5 ach and the volume of the house is 600 m^3, then:

Air change rate = V x ach
= 600 x 0.5
= 300 m^3/h
= 300,000 L/h
= 5,000 L/min.
or = 83 L/s

To convert an air flow rate (e.g., litres per second to air changes per hour), use the following relationship:

$$\text{ach} = \frac{\text{L/s} \times 3.6}{\text{volume } (m^3)}$$

For example, a heat recovery ventilator with balanced flow rates of 50 L/s installed in a home with a total volume of 600 m^3, would have an air change rate of:

$$\text{ach} = \frac{50 \times 3.6}{600}$$

$$= .3 \text{ ach}$$

7.5.9 **Balancing Air Flows.** Measurement can only be accurately taken once the system has been completely installed. To ensure balanced air flows, readings must be taken in the duct system when laminar (streamline) flow exists. It is most important that turbulent air flow does not affect the readings. To ensure laminar flow, the measurements should be taken downstream from an elbow, the distance from the elbow being three times the diameter of the duct.

When measurements indicate that one air flow is greater than the other, the necessary adjustments must be made to increase the lesser air flow such that it is in balance with the greater air flow.

In all cases, balancing of air flows must be done in accordance with ACGIH manual, "Ventilation Testing System" from "Industrial Ventilation", available from the Committee of Industrial Ventilation, Lansing, MI, U.S.A.

7.6 BASIC EQUIPMENT

7.6.1 Considerations. Some problems or limitations of the HRV can be: condensation, icing, frosting, drainage, noise, cross-contamination, and temporary odours from sealants used during manufacture. HRV units must incorporate balancing, defrost and fail-safe features.

Certain units, such as capillary blowers, rotary type and those with permeable paper cores, transfer some moisture. Since the moisture will retain some formaldehyde, greater air flow rates may be required if one of these types of HRVs is installed.

In cold weather, as the temperature of the exhaust air in the unit decreases, condensation and frost buildup may occur in the exhaust air stream. For this reason, most residential HRVs have a condensate drain and provision for a defrost cycle.

Do not install the HRV in locations in the house where temperatures may fall below 5°C. A heated enclosure may have to be built.

CAUTION: Fire hazards. Some HRVs contain significant amounts of combustible materials, such as plastics, and should be installed away from potential fire hazards, such as electrical panels, furnace flue pipes, and storage cabinets.

Selection criteria may be based primarily on factors and features such as the following:

- air flow capacity in relation to requirements;
- thermal effectiveness;
- defrost operation;
- ease and simplicity of maintenance and cleaning by the owner;
- noise and vibration level;
- control options;
- costs for purchase, installation and maintenance.

All HRV units must be designed and installed in accordance with the guidelines in Appendix H.

7.6.2 **Potential Problems** include:

a) **cross-contamination** both by gases and particulate matter or organic material (e.g., fungi spores) from one airstream to another;
b) **failure to deliver necessary air flows** after duct systems are installed;
c) **unbalanced supply and exhaust air flows** which, besides affecting performance, can cause excessive pressurization or depressurization of a home;
d) **icing and potential clogging** of the exhaust air stream under extreme winter temperatures;
e) **control of noise and vibration** of fans;
f) **inadequate access to the core**, for regular inspection and cleaning.

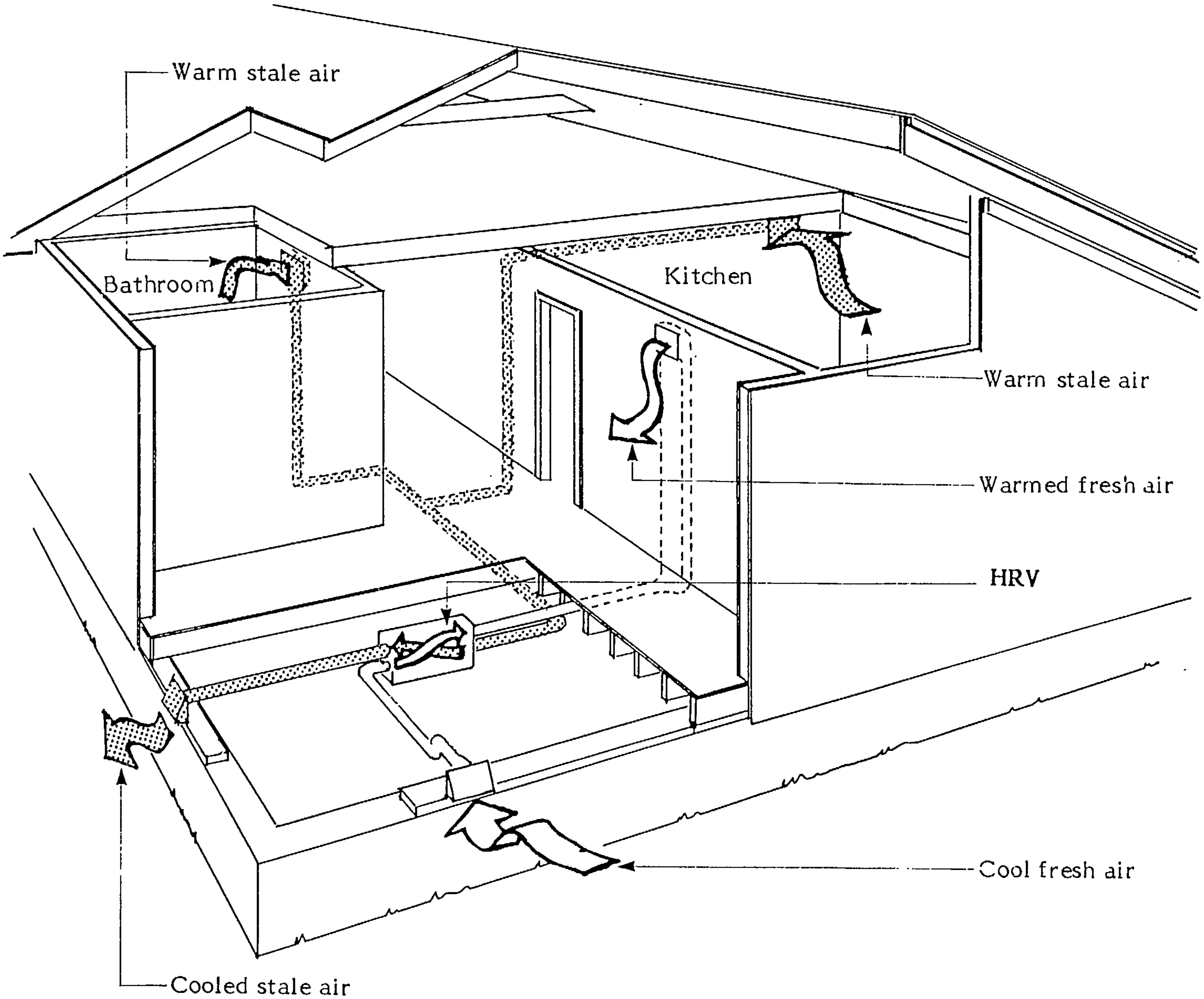


FIGURE 7.3 HEAT RECOVERY VENTILATOR (HRV) SYSTEM

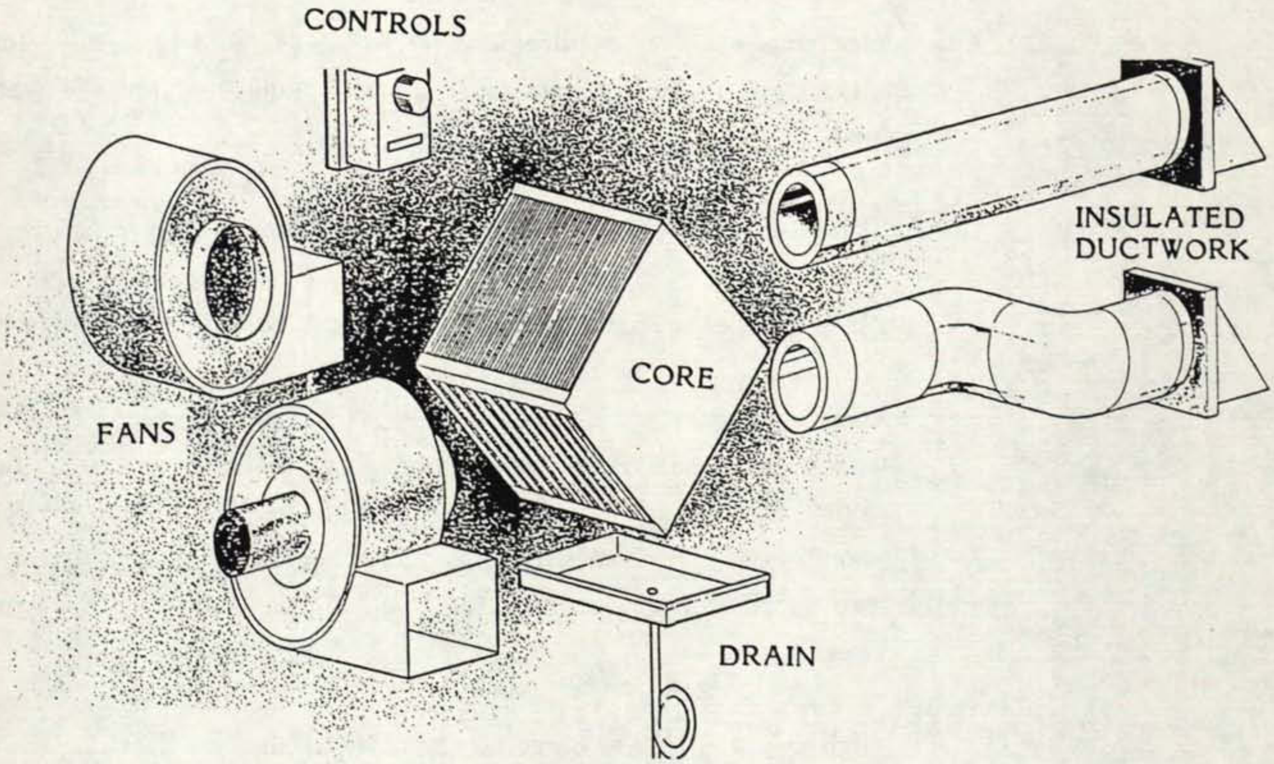


FIGURE 7.4 HRV COMPONENTS: CORE, CONTROLS, FANS, DUCTS, DRAIN

7.6.3 **Supplementary Heating Devices.** So that the homeowner will not feel it necessary to shut off the unit, the installation must provide the means to bring the supply air to a comfortable temperature. The use of "preheaters" or "re-heat coils" is recommended. Some units are provided with heaters for defrosting or frost prevention.

The electrical power requirements for HRVs are generally low. Normally, the two fan motors on the units require about 250 watts combined.

Defrost heaters normally have a 1 to 2 kilowatt power requirement.

7.6.4 **Controls** must operate in accordance with the guidelines in Appendix H:

a) **two-speed HRV operation.** An air change rate of 1/4 ach is the maximum ventilation rate normally needed to maintain contaminants and moisture at acceptable levels. Although HRVs should be run continuously, most units are designed to operate at two speeds: high for maximum ventilation and low for normal operation.

High speed normally corresponds to the design ventilation rate of 1/4 ach. Maximum rates will be required occasionally when the laundry room, kitchen or bathrooms are in use. The second, lower speed is adjustable by the installer (where fan motors have variable speed controls) and can be adjusted to suit particular air quality requirements (e.g., smokers may require higher ventilation rates than non-smokers).

Low speed is used for normal ventilation during the greater part of the day.

Controls operated by a humidistat or manual switch in the kitchen, bathroom and/or laundry room can be used to run the unit at maximum speed when required. In addition, an automatic timer can activate high speed fan operation.

b) **fail-safe sensor** provides automatic warning when the HRV is not working properly and can detect, in a variety of ways, an abnormal pressure drop, flow imbalances, or a stopped fan.

This device is usually a differential pressure switch which senses both the air pressure in the home and in the supply air stream. If the air supply is significantly reduced, both the exhaust and supply air fans are turned off.

c) **automatic defrost mechanisms.** Under some conditions, frost can build up in sufficient quantity to raise the air flow resistance and reduce the exhaust air flow. If the reduction becomes significant, it is necessary to defrost the unit.

One method for defrosting is to use a pre-heating coil installed at the cold air intake. The heating coil can be controlled in two ways: it can be activated when the fresh air temperature falls below a certain temperature, to avoid frosting. It can also be started when a sensor indicates that the unit is frosting up. Both methods avoid a negative air pressure difference (see also 7.6.3).

An alternative method of defrost is to shut off the supply fan and to divert the exhaust flow back into the home. Other methods are acceptable providing they do not contribute to indoor negative pressure.

d) **condensate drain.** In cold weather, condensation may form on surfaces inside some units. If required, a drain provided on the HRV for condensate removal should be piped to a floor drain in much the same way as condensate from an air conditioning cooling coil. A trap must be incorporated in the drain. The drain must not be installed in locations where the surrounding air temperature falls below freezing.

e) **noise control.** Acoustical silencers should be installed in the supply and exhaust ducts between the HRV and the interior of the house. Silencers are usually sections of duct about 1 m long, lined with a sound-absorbing material (see Figures 7.5 and 7.6).

f) **vibration control.** Noise generated from the operation of an HRV can be aggravating. This problem can be reduced with proper installation methods:

  i) where fans are integral components, the unit should be mounted with vibration isolators so that vibrations from the fans are not transmitted through the house (see Figure 7.5). Small pieces of fabric duct should be used to isolate the unit and the fans from the distribution ductwork;

  ii) fans which are not integral components and are located in the ductwork should be mounted with vibration isolators to prevent transmission of noise through the house (see Figure 7.6). Small pieces of fabric duct located on either side of the fan should be used to isolate the fan from the distribution ductwork.

  When the unit is to be located below a quiet room such as a bedroom, it may be preferable to mount it on the concrete basement wall or on a stand on the basement floor rather than suspending it from the floor joists.

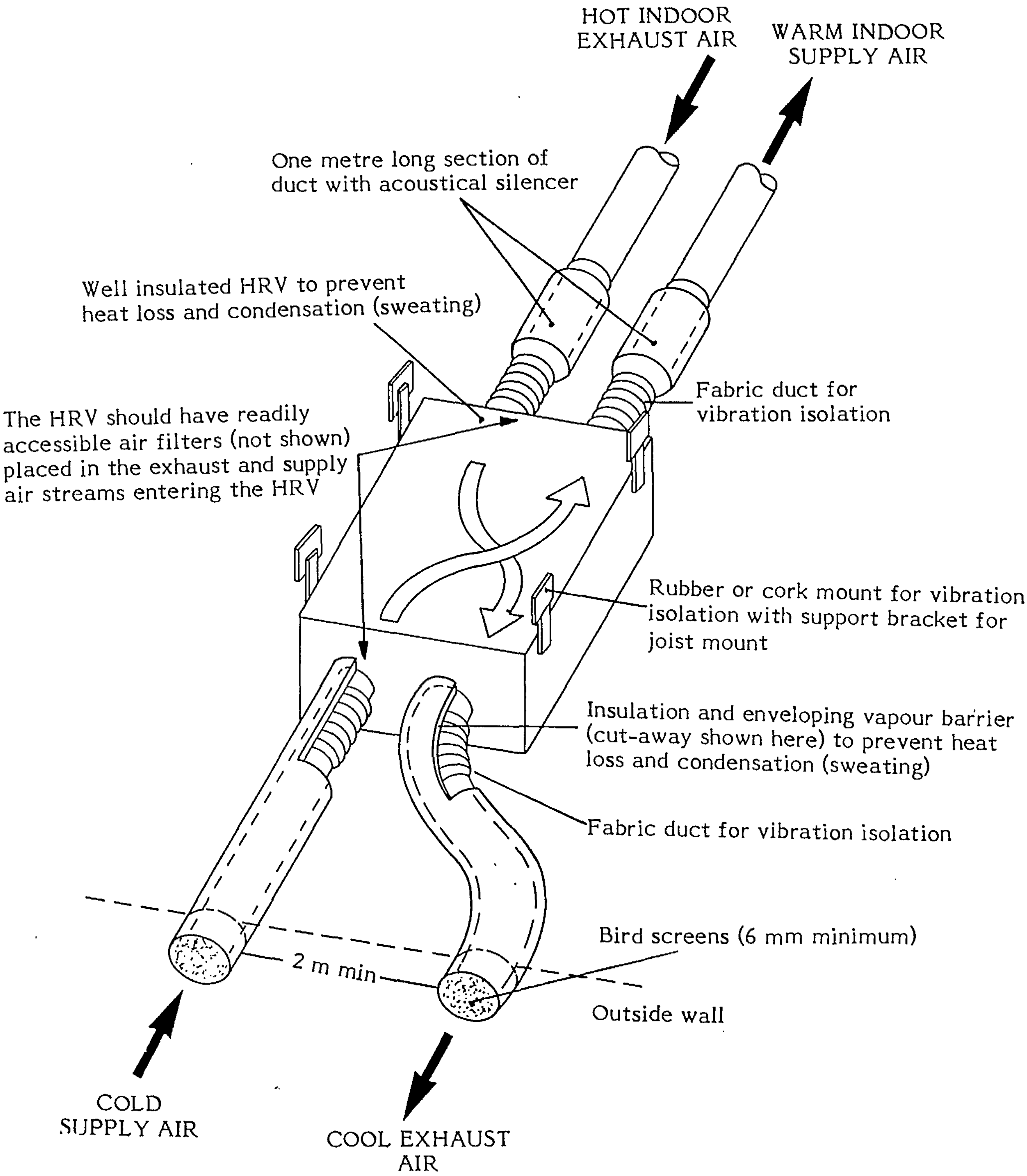


FIGURE 7.5 NOISE AND VIBRATION ISOLATION FOR AN HRV WITH INTEGRAL FANS

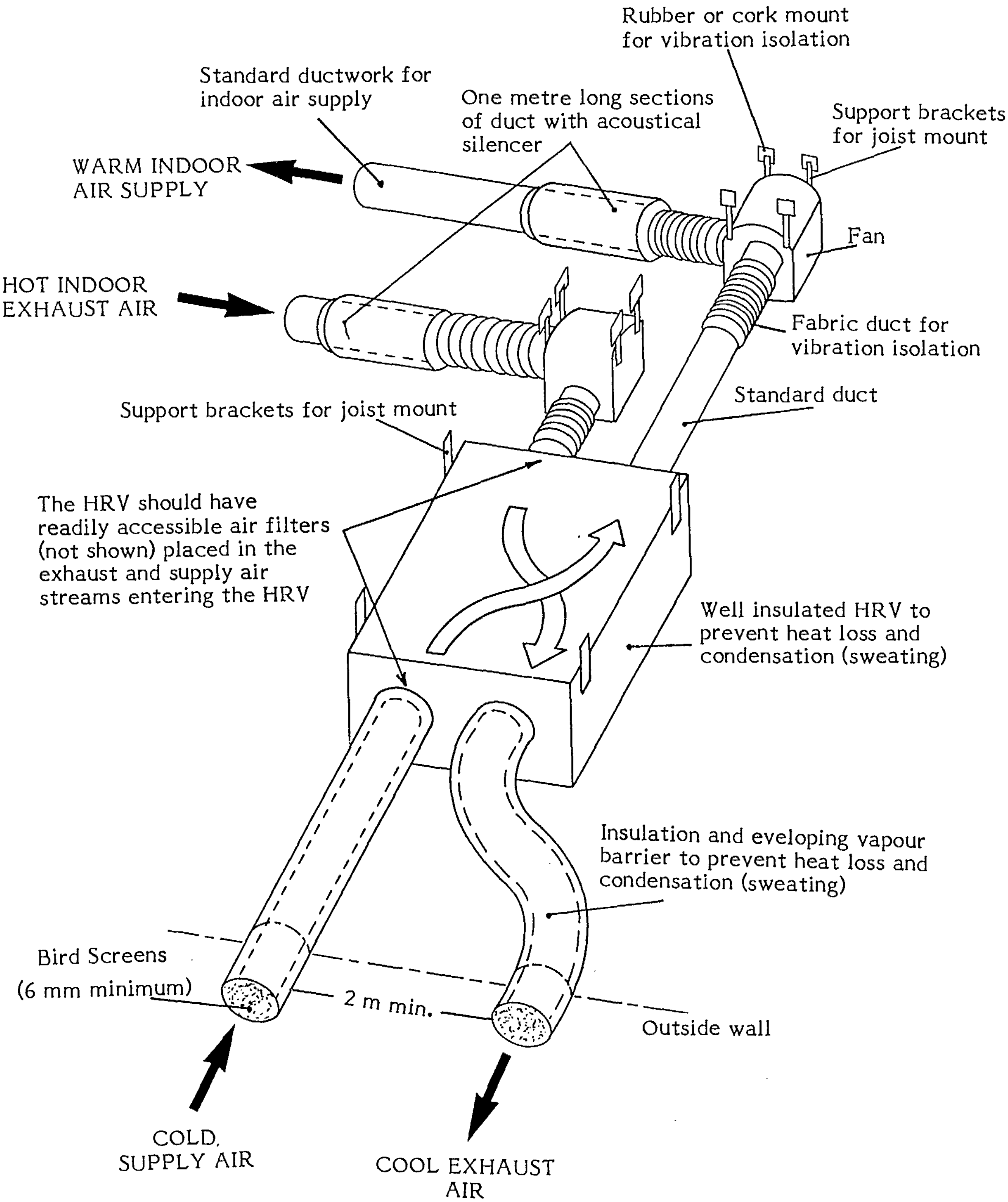


FIGURE 7.6 NOISE AND VIBRATION ISOLATION WITH FANS LOCATED IN THE DUCTWORK

7.6.5 Ducting. All ductwork must be installed in accordance with the guidelines in Appendix H. If any doubt exists about proper installation procedures, the services of a qualified sheet metal contractor should be employed.

The minimum duct diameter should not be less than the size of the flange on the HRV. A 15-18 cm (6" or 7") duct is appropriate for most air flows encountered in typical homes.

The pressure drop through an air distribution system increases with the number of elbows and the duct length. As the fan capacity for most HRVs is reduced dramatically with increased drop in pressure, it is extremely important to minimize elbows and duct lengths.
(1 - 90° bend = 2.6 metres of duct)

Use special care when sizing the air distribution system; once installed, check the HRV system to ensure that it is balanced and that acceptable air flow rates are provided.

What constitutes an acceptable installation of ductwork is sometimes open to interpretation, however, there are some simple rules to follow. These are: minimum length of ductwork, minimum number of bends, minimum sagging, and proper connections.

The supply and exhaust ducts between the unit and the exterior must be insulated and sealed with a vapour barrier to minimize heat loss and to prevent condensation on the outside of the duct. Ducts carrying the cold fresh air and exhaust air should be kept as short as possible to reduce insulation requirements.

7.6.6 Fresh air intake. Since intake air will be at outside temperatures, supply (and exhaust) ducts must be insulated, sealed with duct tape, and covered with a vapour barrier to prevent condensation. The intake vent should be located where it will not be blocked by grass cuttings, leaves or snow and away from driveways where automobile exhaust fumes are generated. It should be equipped with a bird screen made of coarse mesh. Fine mesh (such as window screening) will become blocked with insects, cutting off the fresh air supply to the home. An air filter for trapping insects and other small particles should be located in the fresh air duct, and be readily accessible for cleaning or replacement.

7.6.7 **Fresh air distribution.** The fresh air leaving the unit must be ducted to distribution points throughout the house. If the home is equipped with a forced air heating system, fresh air can be discharged near a return grille of the heating system (Figure 7.6). When the furnace ductwork is utilized, it is recommended that the furnace fan motor be two-speed. The furnace operates at normal speed when the thermostat calls for heat and at low speed at all other times. The fresh air duct should not be connected directly to the furnace return air system; intermittent operation of the furnace fan would cause an unbalanced flow in the HRV.

In houses with hot water or electric baseboard heating, the supply air should be ducted to individual rooms. A more powerful intake fan may be required because of the more complex distribution system.

Some manufacturers recommend that the fresh air be discharged near ceiling level, so that it mixes with the warm air at the top of the room. This avoids cool drafts and makes use of potentially available passive solar heat. It can also help destratify air (i.e., much warmer air near the ceiling than the floor) which is likely where there are cathedral ceilings.

NOTE: Supply and/or exhaust air ducts must be provided for each storey of the house.

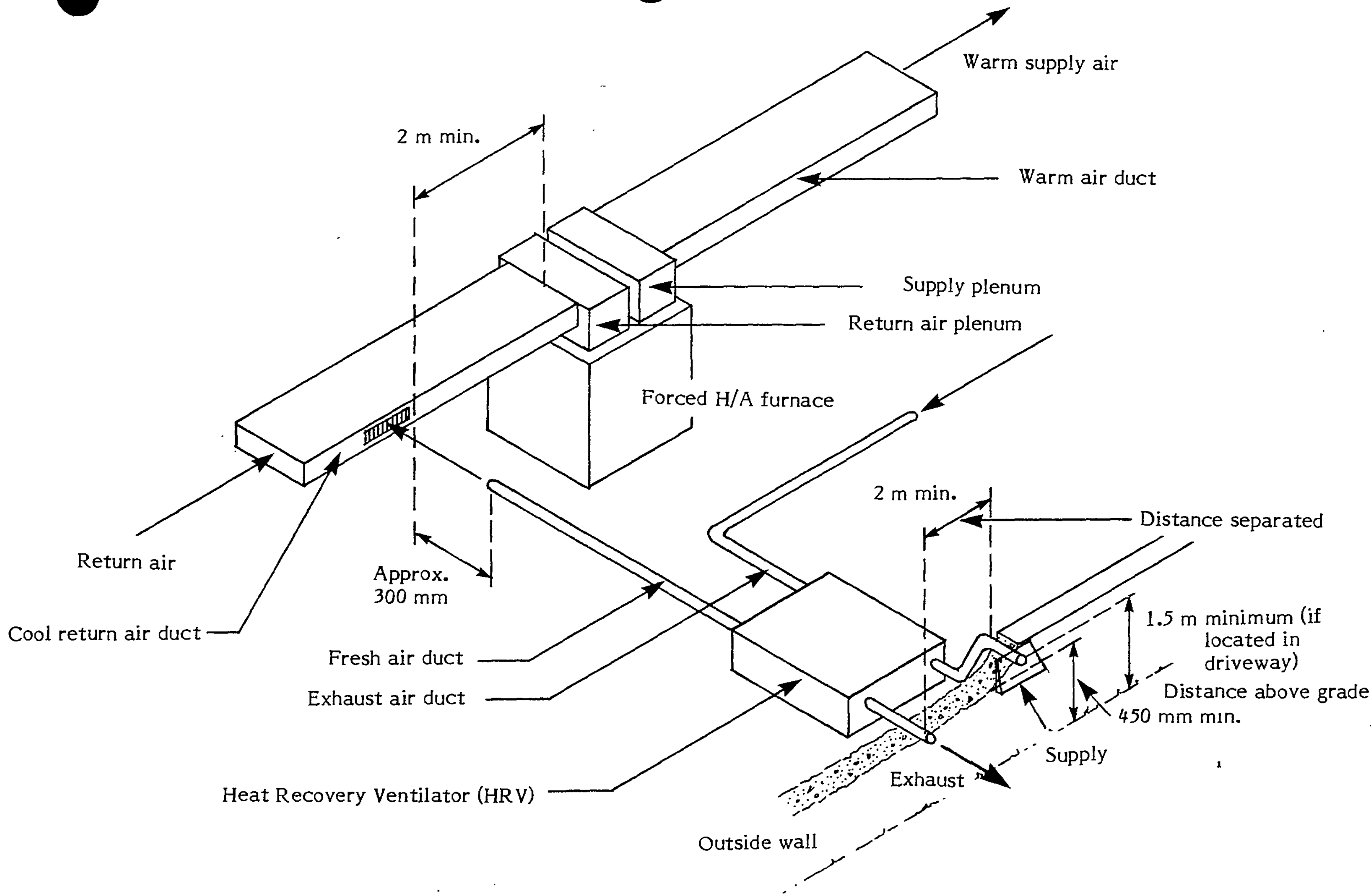


FIGURE 7.7 INDIRECT CONNECTION TO RETURN AIR DUCT OF WARM AIR HEATING SYSTEM
(HRV - UFFI GUIDELINES ARTICLE - 5.24 REV.)

7.6.8 Exhaust air collection. The exhaust air should be taken from points as far away as possible from the supply vents, so as to provide good overall ventilation, leaving as few stagnant areas as possible.

Hood vents are not to be connected directly to the exhaust system, since the greasy exhaust may build up on HRV surfaces. Range hoods which recirculate the air should be used.

Clothes dryers shall not be connected directly to the exhaust system, since lint may also collect on the unit's surfaces. Electric clothes dryers can be vented through lint filters, and a separate intake installed from the laundry room to the HRV. Gas dryers should never be vented indoors.

Central vacuum systems must not be connected to the HRV system.

Wall cavities must not be used as ductwork. Special ductwork which is used in wall cavities must have sealed joints.

Where ductwork cannot be installed in partition walls because of obstructions, rectangular ducts may be run against the wall and boxed in with wood and drywall.

Floor registers may also be used as alternatives to wall ducts.

Readily accessible filters should also be installed in the exhaust air ducts leading to the HRV. Instructions for inspection, cleaning and/or replacement of the filters should be supplied by the manufacturer.

7.6.9 Exhaust air outlet. Spacing the vents at least 2 m apart is necessary to avoid mixing the flows from the exhaust air outlet and supply air inlet. They should also be located away from driveways, above snow levels and accessible for occasional inspection and cleaning.

7.7 VENTILATION SYSTEM REQUIREMENTS

7.7.1 **Introduction.** Use an accepted HRV and ensure that the system is installed in accordance with the guidelines in Appendix H.

CSA requires that manufacturers of exhaust and supply ventilation equipment provide air movement ratings for all fans. Fan performance should be checked with manufacturers to ensure that adequate air flow rates can be achieved in conjunction with the duct system.

7.7.2 **Sizing the HRV.** HRVs are designed to operate within a certain range of air flows. Selection of the unit will depend on the required ventilation rate and on the pressure drop through the air distribution network (the longer and more complex the ductwork, the higher the pressure drop and corresponding required fan capacity).

A ventilation rate of 1/2 ach by combination of mechanical and natural ventilation is the minimum required to reduce formaldehyde concentrations to an acceptable level. The mechanical rate of ventilation shall not be less than 1/4 ach.

An example of how to calculate the required capacity of the HRV follows. A typical house with a floor area (including basement) of 200 m^2, and a ceiling height of 2.5 m, has a volume of 500. Based on 1/4 ach minimum mechanical ventilation rate, the maximum required flow would be 125 per hour, or 35 litres per second or 70 cfm (see Section 7.5.2).

7.7.3 **Calculating the ventilation rate.** After energy sealing has been completed (see Chapter 6), the ventilation rate required to ensure adequate dilution of the gas concentration is calculated as follows:

a) NIOSH tests or dosimeter readings are taken in each room to give the measured formaldehyde concentration.

The results of these tests are used to calculate the average value of the concentration from all samples. This will be designated by the symbol C_i, the mean formaldehyde concentration.

b) the post-sealing natural air change rate of the house is estimated and the required ventilation rate is calculated. The required air changes can be calculated by one of the two following methods:

Method 1: Fan Depressurization and Calculation

Analyze the airtightness data from fan depressurization test to give the air leakage rate in m^3/h at a pressure differential of 50 Pascals. This is the standard analytical method given in the CGSB Draft Standard 149-GP-10M. The 50-Pascal air leakage rate will be designated as Q_{50}.

Divide Q_{50} by 20. This will give the best estimate of the natural infiltration rate of the house. The natural infiltration rate will be designated as Q, and will be expressed in m^3/h.

The total required ventilation rate will be calculated from the following equation:

$$V_R = 1.5 \times Q \times \frac{(C_i - C_o)}{(C_t - C_o)}$$

Therefore, the increase in the required ventilation rate is derived from the following equation:

$$V_X = V_R - Q$$

where:

* V_R is the total required ventilation rate (m^3/h)

** Q is the natural infiltration rate (m^3/h)

*** V_X is the increased air necessary for the HRV system dimensions (m^3/h)

C_i is the mean formaldehyde concentration for the inside air

C_t is the target concentration for formaldehyde inside and has a value of 0.05 ppm

C_o is the formaldehyde concentration in the outside (ambient) air and is to be selected from Table 7.4

* Equivalent to RAC in Method 2
** Equivalent to AAC in Method 2
*** Equivalent to IAC in Method 2

Reasonable margins of error are included in this calculation for:

- formaldehyde measurement;
- air leakage measurement;
- normal ductwork losses.

Table 7.4

SELECTION OF VALUE OF C_o

House location	Value of C_o (ppm)
House is in an urban area with high traffic levels and extensive local industry	0.02
House is in a suburban area with little local industry, and traffic intensity ranges from light to moderate.	0.01
House is in a rural area with no significant local industry and with low traffic intensity	0.005

The testing agency should select the value of C_o that most closely matches the house environment.

Method 2: Approximation

TABLE 7.6

ASSUMED NATURAL AIR CHANGE RATE (AAC)

IN AIR CHANGES PER HOUR

FOR HOMES SEALED AS IN CHAPTER 6

If the age of the house is	Then winter average air change (AAC) ranges between:
Pre-1945	0.5 to 1 air change/h
1945-60	0.33 to 0.67 air change/h
1961-80	0.25 to 0.5 air change/h

Calculate the required air change rate (RAC) by multiplying the assumed natural air change rate (AAC) from Table 7.5 by 1/K:

where **K** $= \frac{\text{desired level of Concentration } (C_t)}{\text{measured level of Concentration } (C_i)}$

RAC = 1/K x AAC, air changes/h

The unit must supply only the increase air change (IAC) to ensure that RAC is met:

IAC = RAC - AAC, air changes/h

NOTE: EQUIVALENT TERMS

Method 1 (calculated)		Method 2 (approximate)
V_X	=	IAC
V_R	=	RAC
Q	=	AAC

7.8 MAINTENANCE REQUIREMENTS.

So that the homeowner can operate and maintain the unit properly, manufacturer's operation and maintenance manual must be provided. The maintenance requirements for an HRV are similar to those for an oil or gas furnace. Fan motors may need lubrication or replacement if they fail. Air filters will need cleaning or replacement on a regular basis. The heat exchanger core will likely require periodic cleaning. Some units have a core which can be removed, however, in some cases, the whole unit must be disconnected and removed for cleaning. The bird screen on the outdoor air intake duct must be checked periodically for blockage.

Once the two air flow rates have been balanced, they should **not** be adjusted except by a qualified technician. It is recommended that the two air flow rates be checked at least once a year and be re-balanced if necessary.

Chapter 8

REMOVAL OF UFFI

Contents

8.16 STEP 6: DISPOSAL OF UFFI AND OTHER CONTAMINATED MATERIAL

8.16.1 Storage on Site

8.16.2 Transporting the Material

8.16.3 Disposal at Site

INTRODUCTION

Complete removal of UFFI is generally the most expensive corrective measure. It is normally only recommended when formaldehyde levels within the walls are high or when health problems exist.

Due to the nature of UFFI removal and the consequences of an unsatisfactory operation, an individual trained in this work must be constantly involved and present on the site during the sealing, removal and neutralizing operations. A knowledge of masonry wall construction and of wall framing characteristics of wood frame construction used in that particular region of Canada (Chapter 3), is essential.

In those instances where removal involves full or partial dismantling of load-bearing masonry walls, advice should be sought from a consultant skilled in such work.

This chapter is divided into four sections which present the procedures in the order in which they logically occur, and which will serve also as a reference.

Section A, Safety procedures outlines the steps to follow when working with UFFI, including sensitivity or reactions of occupants and workers, proper clothing and breathing equipment to be worn and ventilation of the work area.

Section B, Removal of UFFI deals with locating the UFFI, preparations for removal (both interior and exterior) and disposal of the material.

Section C, Restoration describes procedures for chemically treating the cavity to neutralize residues, drying and testing of the cavity, installing insulation and air vapour barrier and applying the finish.

Section D, Clean-up and Disposal prescribes methods to ensure the cleanliness of premises and the environment by proper collection and disposal of the UFFI and other contaminated building materials.

SECTION A: SAFETY

8.0 INTRODUCTION

Because the type of work required to conduct UFFI corrective measures is unique, some health and job hazards may not have been identified. In all cases, workers must follow local occupational health and safety regulations and the basic rules as outlined below.

8.1 BASIC RULES

Contractors must ensure that each member of the work crew is aware of the following basic rules:

8.1.1 **Persons sensitive** to formaldehyde or allergic to other toxic materials **should not work with UFFI** regardless of the protective measures they may follow or the protective equipment they may use.

8.1.2 **Ventilation** of the enclosed work area is necessary at all times when work is in progress by using fans and opening the appropriate windows. Use maximum ventilation when spraying with sodium bisulphite solution. Arrange a fan to blow the gases and dust to the outside away from the work area and the area already exposed.

8.1.3 **Physical Reactions and Medical Advice.** Anyone involved in UFFI corrective work who experiences either internal or external discomfort, or other unexplained symptoms should stop work immediately and seek medical advice. Anyone inhaling sodium bisulphite powder should consult a **doctor or poison control** centre immediately for advice about proper treatment. Before commencing work, the foreman should determine a reliable source of medical advice and inform workers of the **location** and **telephone number.** Workers should be familiar with specific first aid measures, and equipped with a first aid kit.

8.1.4 **Task Rotation.** Worker exposure and possible risk can be lowered by the use of good organization and scheduling techniques which assures that workers are not in the work place without protection. When work requires wearing a respirator, a rotation of two hours on - two hours off is recommended. The degree of exposure may be greater when corrective measures are conducted within an enclosed space.

NOTE: Task rotation alone is not an adequate means of protection for workers involved in UFFI corrective measures.

8.1.5 **Respirators.** NIOSH-approved respirators must be worn at all times while doing UFFI corrective measures:

a) **a formaldehyde respirator** must be worn during removal, cleaning and warm water washing which is capable of protection up to 30 ppm;
b) **an acid gas respirator** for sulphur dioxide gas must be worn during the entire operation through mixing the sodium bisulphite solution and until 24 hours after the last cavity treatment.

A dust/mist pre-filter must be worn with the appropriate respirator at all times.

See Appendix D for selection, use and maintenance of respirators.

NOTE: A dust mask worn alone is not sufficient protection.

8.1.6 **Protective Clothing and Approved Safety Equipment** must be used:

a) where there are high UFFI gas concentrations, contaminated material or dust particles;
b) when mixing, handling or spraying with sodium bisulphite solution.

Required clothing and equipment include:

a) long sleeved shirts;
b) pants with tight cuffs;
c) chemical resistant rubber gloves;
d) non-vented dust-chemical safety goggles;
e) the appropriate NIOSH-approved respirators with dust/mist pre-filters;
f) a hard hat, or other protection which completely covers the head if a hard hat is not required;
h) safety boots.

NOTE: Contaminated work clothing should be separated from ordinary clothing for laundering.

8.2 SAFETY OF RESIDENTS AND THE ENVIRONMENT

The safety of residents and the neighbouring properties are of prime consideration. During removal of UFFI, the following safety precautions are necessary:

a) insist on evacuation of the house and removal of food and furnishings from the work area, unless satisfactory prevention from exposure to UFFI dust and gas, and mist and gas from the sodium bisulphite spray can be ensured;
b) ensure that the premises are thoroughly ventilated and cleaned;
c) a tarpaulin must be installed in such a way as to prevent UFFI dust and particles from blowing around the neighbourhood;
d) UFFI and UFFI-contaminated materials must be contained and disposed of daily (see 8.16);
e) UFFI and UFFI-contaminated materials must NEVER be burned (see 8.16);
f) UFFI-contaminated materials must not be reused unless they can be successfully neutralized;
g) store chemicals in a safe place and do not leave building materials in hazardous locations.

SECTION B: REMOVAL OF UFFI

8.3 INTRODUCTION

8.4 PROBLEM IDENTIFICATION AND DECISIONS ON PROCEDURES

- 8.4.1 Problem Identification
- 8.4.2 Decisions on Procedures for UFFI Removal

8.5 TYPES OF CAVITIES

8.6 GENERAL REMOVAL STEPS

- 8.6.1 Planning
- 8.6.2 Prescribed Steps

8.7 STEP 1: SITE PREPARATION

- 8.7.1 Site Preparation for Removal from the Interior
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- 8.7.3 Site Preparation for Removal from the Exterior

8.8 STEP 2: EXPOSURE AND REMOVAL

- 8.8.1 General Removal Procedures
- 8.8.2 Removal from Masonry Veneer Houses
- 8.8.3 Removal from Inside Masonry Houses
- 8.8.4 Complete Dismantling of Masonry Walls
- 8.8.5 Protection of Masonry Structures During Removal
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- 8.11.1 The Safe Use of Chemicals
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- 8.11.5 Protecting the Cavities
- 8.11.6 The Five-Stud Cavity Test
- 8.11.7 The Equilibrium Box Test

8.3 INTRODUCTION

This section outlines the steps to follow during UFFI removal operations. The nature and source of the problem should be considered thoroughly and the site properly prepared before beginning work. Complete removal of UFFI and thorough cleaning and neutralizing of exposed cavities is essential. Short sub-sections outline special considerations for masonry homes.

8.4 PROBLEM IDENTIFICATION AND DECISIONS ON PROCEDURES

8.4.1 Problem Identification. In determining the extent of the problem and preferred approach to removal, the following are some of the factors which should be considered:

a) the style, age and general condition of the house;
b) the type of structure involved;
c) the total area of the exterior walls, attic space, and roof space where UFFI had been installed;
d) the cavities and spaces insulated with UFFI;
e) any building construction peculiarities as listed in Chapter 6;
f) the nature of the problem as it relates to health, odour, moisture and formaldehyde levels;
g) the moisture content of the wood in the cavity;
h) the formaldehyde concentration in the living environment and in the cavities;
i) the evidence of any stuctural damage due to UFFI;
j) the type(s) and the condition of interior finishing materials, special trim, finish or decorative features;
k) the type(s) and the condition of exterior cladding materials, special trim, finish or decorative features;
l) the sources of high moisture levels in the home;
m) other types of insulation materials within UFFI-foamed cavities;
n) the type and condition of any existing vapour barrier and air leakiness of the building envelope;

o) the possible contamination of interior lath and plaster, gypsum board or other interior cladding material;

p) the presence of UFFI in electrical boxes and/or indications of corrosion of electrical receptacles or equipment;

q) the presence of any type of air conditioning, forced ventilation or air pressurization equipment;

r) overall site conditions as they relate to access, safety and general working conditions;

s) "E class" foam should be removed.

8.4.2 **Decisions on Procedures for UFFI Removal.** If it is decided to remove the UFFI, the following considerations will determine whether the job is done from inside or outside the house:

a) the location of the UFFI. If it is, for example, only on the interior of a load-bearing masonry wall (with or without some spillage in or between adjacent masonry units), removal should be from the inside;

b) comparative condition and restoration costs of the inside finish and outside cladding;

c) the potential for maximizing energy conservation during restoration;

d) the willingness of the occupant to vacate the premises during the work;

e) the cost of preparatory and clean up work;

f) the effect of adverse weather conditions.

8.5 TYPES OF CAVITIES

Because each home and each problem is unique, the contractor must have a knowledge of building structures in his area and be conversant with the National Building Code. Chapter three should be referred to regarding the location and types of hidden cavities.

8.6 GENERAL REMOVAL STEPS

8.6.1 Planning. In planning and estimating the cost of the work, be sure to include:

a) compliance with all provincial and municipal regulations;
b) sealing, pressurizing and ventilating the work area during work;
c) use of special equipment, tests, and the cost of spraying the chemicals;
d) special vacuum cleaners, the extensive washing of walls and furniture, especially the cleaning of upholstered furniture if such arrangements have been made;
e) removing or covering the furniture.

8.6.2 Prescribed Steps. The prescribed steps, listed below, are the same whether removal is from the interior or exterior.

STEP 1. Site preparation
STEP 2. Exposure and removal
STEP 3. Chemical treatment following UFFI removal
STEP 4. Reinsulation and restoration (Section C)
STEP 5. Clean up (Section D)
STEP 6. Disposal of contaminated materials (Section D)

8.7 STEP 1: SITE PREPARATION

8.7.1 Site Preparation for Removal from the Interior:

a) remove from the work area, all household furniture, furnishings, and food;

b) isolate the work area as effectively as possible from adjacent living areas and spaces;

c) assure that adequate ventilation of the work area is provided;

d) assure that the electrical circuits serving the work area have been disconnected;

f) assure that all exhaust fan grills, and heating supply and return registers have been effectively covered and sealed.

8.7.2 Interior Preparation Prior to Removal from the Exterior:

a) in the event of health problems or acute sensitivity, occupants should vacate the premises until the UFFI removal, chemical treatment and cavity drying operations are completed;

b) all furniture, carpets, draperies, clothing, linen, food or other household items must be removed or protected with suitable disposable or washable covering;

c) an essential step which must be taken to limit infiltration of UFFI dust and gas is sealing and pressurization:

   i) **seal** the interior finish of the exterior walls prior to proceeding with removal from the outside. This will prevent UFFI gas and dust particles from transferring through the UFFI-insulated cavities to the living environment, and will reduce heat loss in the future;

   ii) **pressurize** the house against leaks through invisible cracks. If air is passing through the wall, it should flow from the inside to the outside. This will reduce the tendency for UFFI gases and dust, stirred up during the removal, to filter in through cracks in the wall.

To pressurize, close all normal air outlets in the house (fireplace dampers, kitchen vents, dryer vents, windows, etc.). Open a window as far as possible from the work area to prevent drawing in any outdoor UFFI dust. Place a large fan in the window to blow air into the house from that one opening. If necessary, use an electric heater to warm the incoming air.

The critical wall is the one from which UFFI is being removed. A false door may be built with a fan mounted in it to blow air into the room. Leave a window slightly open in that room to prevent over-pressurizing, which could cause air to flow **out** of the room and into the rest of the house.

(d) ensure that electrical circuits serving the work area wall are disconnected.

8.7.3 Site Preparation for Removal from the Exterior:

a) it is essential that a tarpaulin-type drop sheet be erected to protect the exposed framing assembly, to avoid work stoppages due to adverse weather and to contain UFFI dust. Leave the protection in place until replacement of sheathing materials is complete;

b) from the interior, seal the work area from other areas of the home to prevent contamination through windows, doors, air-conditioning intake ducts and attic vents;

c) take measures to protect workers from electrical or other external hazards;

d) provide a safe facility for storage and mixing of chemicals on site;

e) provide covered disposal containers in a safe, accessible location for deposit of UFFI and contaminated material;

f) provide workers with all necessary safety equipment and supplies;

g) ensure that workers do not engage in such activities as eating, drinking or smoking in the contaminated areas;

h) ensure that some provision is made to enable workers to vacuum their clothing and to wash up before entering non-contaminated areas;

i) protect any roof which:
   - is used as a working deck;
   - supports scaffolding;

j) provide a secure storage area for new materials;

k) ensure daily site clean up.

8.8 STEP 2: EXPOSURE AND REMOVAL

8.8.1 General Removal Procedures:

a) disconnect electrical circuits serving the removal area, remove any cladding, trim and sheathing materials as necessary to reveal hidden or accidentally foamed cavities, to provide access for the removal of the UFFI. All UFFI located in the cavity must be removed. Take precautions so as not to weaken the structure during removal.

   If reinstallation of materials is being considered, remove them from the immediate work area. If they have not been in direct contact with UFFI, such material may safely be reinstalled following the prescribed treatment. It is also important that the supporting capacity of any load-bearing walls be fully restored. If, for example, wood sheathing is removed which served a structural purpose such as forming (or being part of) a lintel or beam over a window or door opening, then adequate wood members must be used as replacements, especially if the wood sheathing is being replaced with another material (e.g., insulating sheathing) of no structural value.

If removal is to take place from the **interior**, carefully remove all trim and decorative wall cladding materials such as baseboards, door and window casings, and other similar materials. Place scrap material in the on-site container;

b) take necessary precautions to protect workmen and to prevent damage during removal of UFFI to any electrical wire, plumbing pipes, or ductwork present in the cavity;

c) remove all UFFI and any other materials such as batt insulation from the cavities. Place this waste in industrial disposal canisters, sealed polyethylene sheets or bags as it is stripped from the cavities and put it into the on-site container;

d) check window and door shim spaces, lintels and adjacent framing details for hidden cavities;

e) avoid weakening or damaging the structure when removing UFFI from the cavities;

f) brush and vacuum all surfaces of the cavities to assure removal of all residual UFFI particles and stains. Avoid excessive damage to the plaster key of the lath and plaster interior cladding during removal from the exterior. Control dust by vacuuming narrow cavities. Vent the vacuum to the exterior or bubble exhaust through water in a container, or both. Sandblasting may be an alternative or complementary operation to brushing, especially when removal is from the outside (see Appendix F). Types of brushes and vacuum cleaners are described in Appendix E;

g) brush residues from electrical wiring so as not to damage insulation, if wiring is not to be replaced;

h) report to the owner any significant defect in, damage to, and/or deterioration of, the exposed framing or any mechanical equipment in the cavity;

i) check exposed electrical wiring, receptacle boxes connectors or other components for damage or corrosion. Report any such deterioration or damage to the appropriate authority. Have a licensed electrician make required repairs or modifications;

j) check all openings for UFFI while the wall framing is exposed.

NOTE: All UFFI in the dismantled section must be removed.

8.8.2 Removal from Masonry Veneer Houses

a) **removal from inside the masonry veneer house.** In situations where UFFI was injected into the framed insulation cavities and none has been found in the air space between the veneer and the sheathing, proceed as outlined in section 8.4.1.

b) **removal from outside the masonry veneer house.** If UFFI has been injected into the space behind the veneer as well as the wood frame cavities, removal from the outside is then appropriate. See Figure 8.6 for components within a cross-section of a brick or masonry veneer house (platform frame):

   i) dismantle veneer, starting from the top down;
   ii) remove all UFFI from the space between the veneer and the sheathing;
   iii) remove building paper and dismantle sheathing;
   iv) clean UFFI from all cavities and places where it may have travelled inadvertently. Brush or sandblast wood components. Treat the wooden components as per Section 8.11.

c) **removal from both inside and outside** may be necessary in brick veneered plank frame construction where UFFI has been located on both sides of the plank. In this case, the brick veneer will have to be dismantled in order to remove UFFI from the space between the brick and the plank. The interior finish must also be removed in order to remove the UFFI enclosed by the furred places, the planks and the plaster, and to clean between the horizontal joints in the planks.

8.8.3 **Removal From Behind Interior Finish in Masonry Houses** involves dismantling the interior finish:

a) remove trim, baseboards and interior finish (gypsum board, lath and plaster or other). The interior wythe of masonry may have to be dismantled if UFFI has also been injected in the cavity or in some of the hollow units (Figure 8.1);
b) remove all UFFI found behind the interior finish (Figure 8.2). Remove UFFI from all cavities (see Chapter 3);
c) remove UFFI from fixtures and wiring. Electrical wiring may have to be unfastened from the wall in order to avoid mechanical or chemical damage.

8.8.4 **Partial or Complete Dismantling of Masonry Walls.** If it has been decided to partially or completely remove masonry walls injected with UFFI, **the advice of a consultant should first be sought.**

a) prepare site as indicated in section 8.6.1;
b) install temporary structures using shoring system as described in section 8.7.5. Make sure that these will provide adequate support for all the loads (Figure 8.3(A)). These structures must be adequately braced to resist wind forces which will tend to lift the roof;
c) dismantle walls, one section at a time;
d) clean UFFI from ceilings, roofs and foundation walls;
e) reconstruct the wall. The consultant may recommend replacement of a masonry wall or wythe by a stud wall.

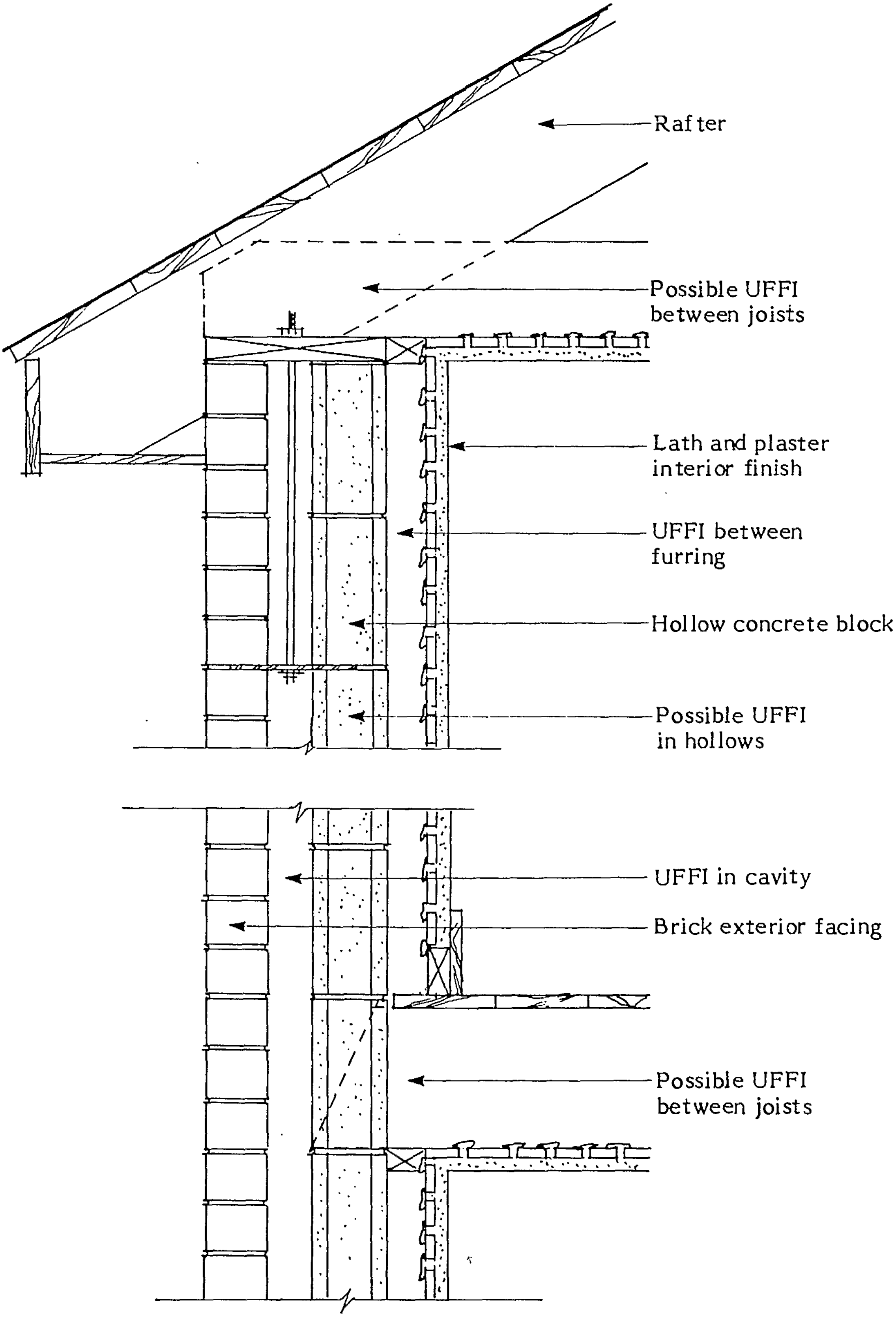
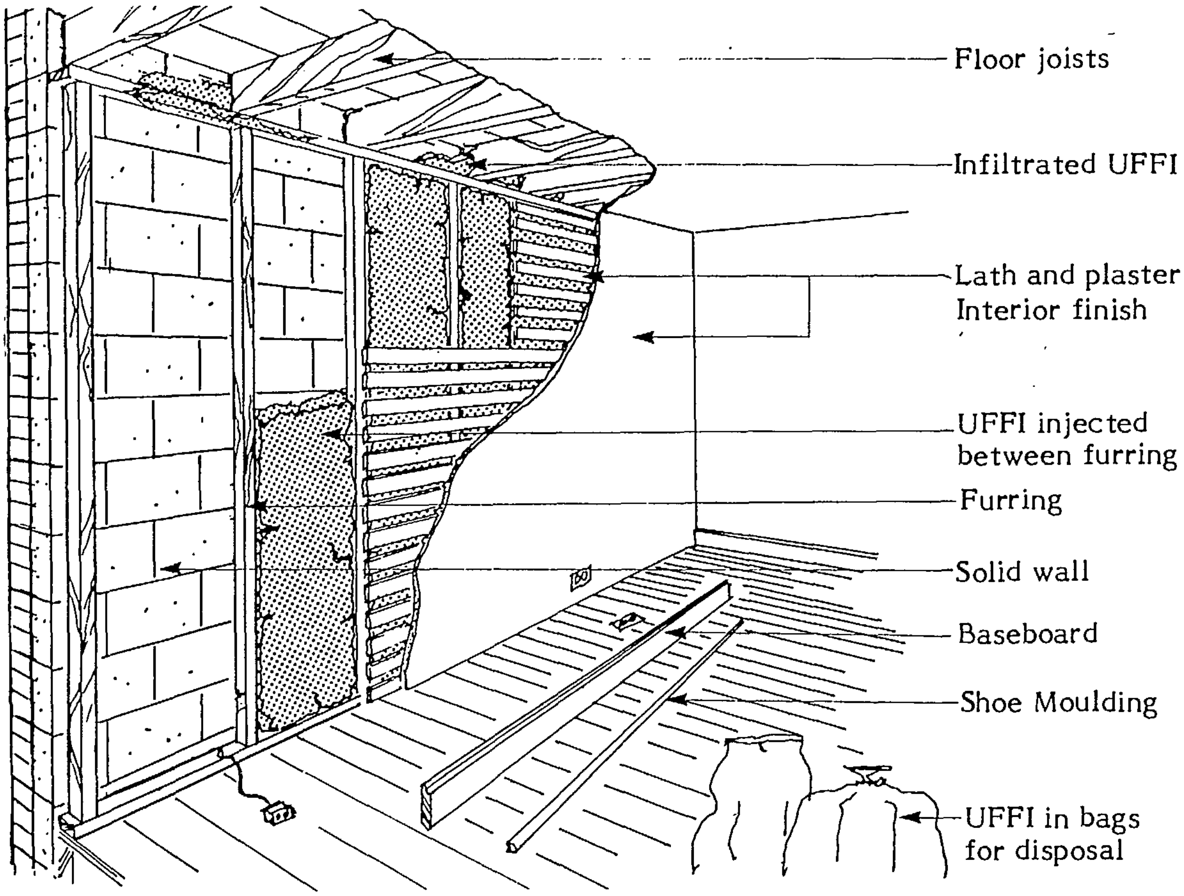
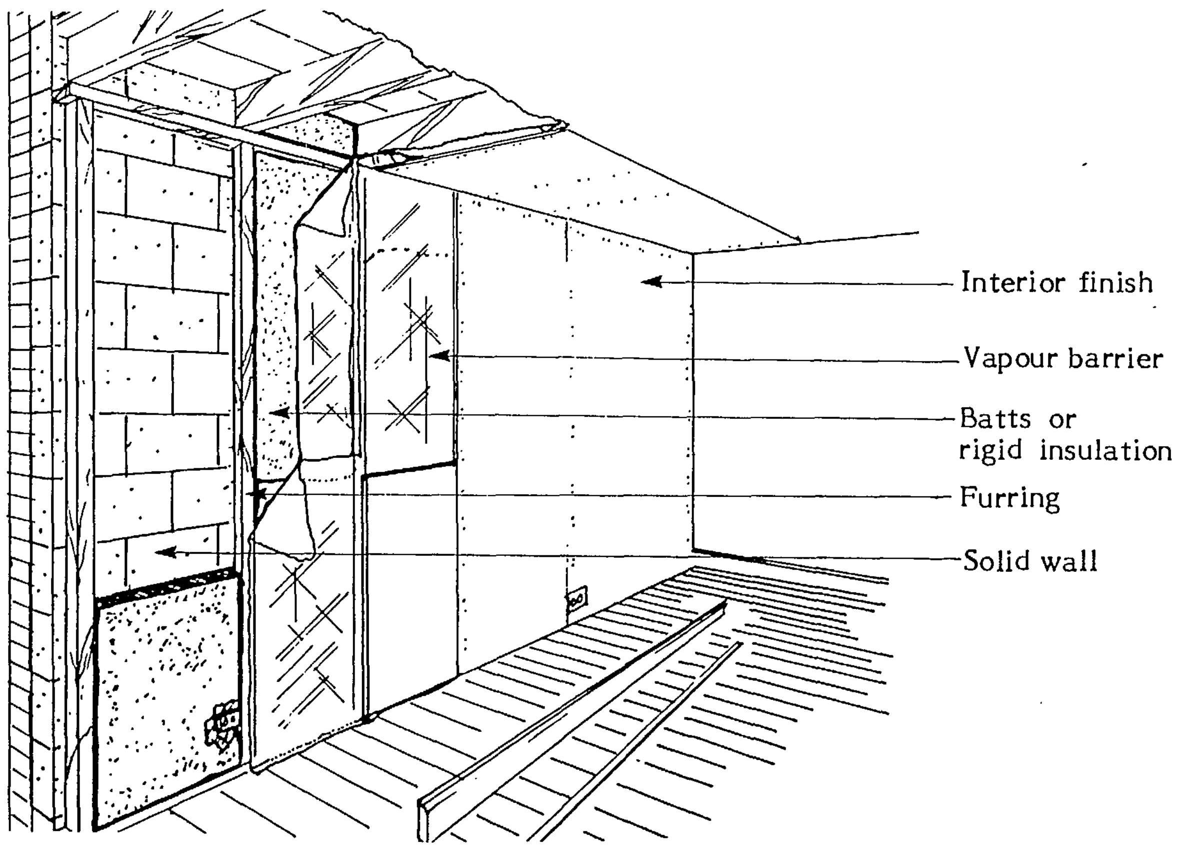


FIGURE 8.1 UFFI IN A BRICK/BLOCK WALL



A. REMOVING THE UFFI



B. RESTORING THE INTERIOR FINISH

 FIGURE 8.2 UFFI REMOVAL FROM SOLID MASONRY CONSTRUCTION

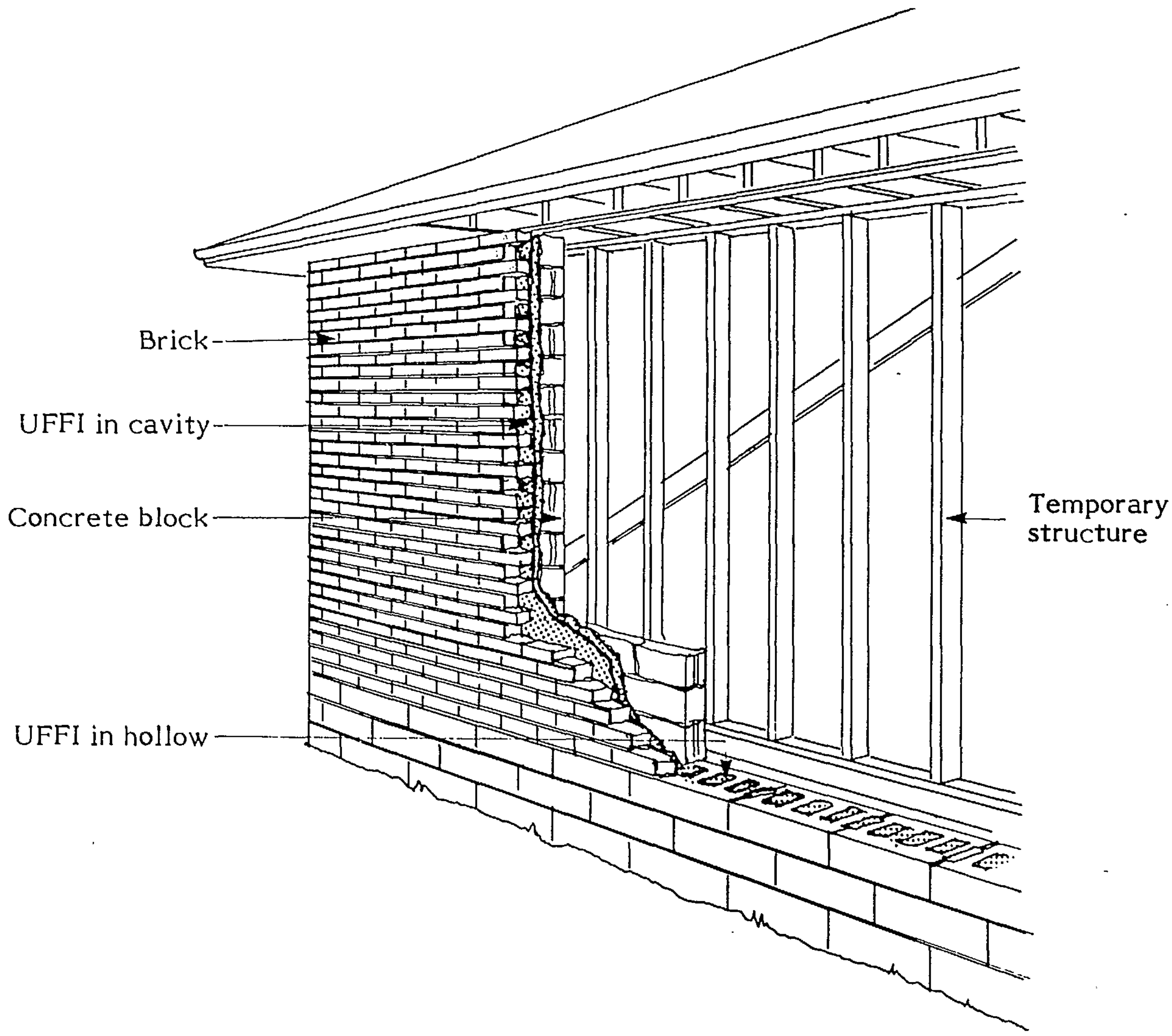


FIGURE 8.3(A) TOTAL DISMANTLING OF CAVITY WALL, SHOWING TEMPORARY SUPPORT STRUCTURE

8.8.5 Protection of Masonry Structures During Removal. In all cases where the masonry wythes are an integral part of the structure (the only exception being the veneered walls) and where all or a portion of the wall is to be dismantled, it is necessary to ensure that the house remains structurally sound during this work as well as after completion.

In addition to the weight of the wall itself, there is an accumulation of weight from the floors and roof. These loads must be borne by a temporary structure if portions of the load-bearing wall are to be removed.

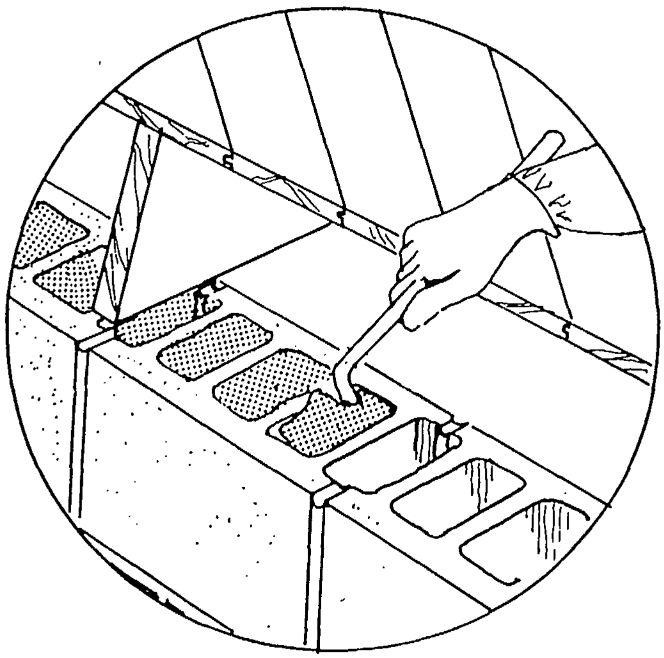


FIGURE 8.3(B) UFFI REMOVAL FROM HOLLOW FOUNDATION BLOCKS

A shoring system, supporting upper floor joists or roof joists, should be capable of transmitting the load from the upper floor or roof to the first floor and via the first floor to the basement (Figures 8.4, 8.5). The upper floor or roof joists should be jacked just sufficiently to permit wall removal by relieving the load from the joists or roof to the wall. Spreader members should be used to distribute the load so that the intermediate wood floor or supported floor members will not be overstressed.

a) adjustable shoring systems, such as steel posts which may be jacked to the desired height, have the advantage of allowing for adjustment of the wood structure onto new masonry walls. A fixed shoring system lacks the flexibility which adjustable posts offer;

b) a simple fixed support can be achieved by constructing a wood frame wall inside the house. The wall must be braced laterally (Figure 8.3(A)). The loads must be transferred to the basement floor. (Part 9 of the NBC provides the necessary information on load-bearing beams and columns.)

8.8.6 **UFFI in Concrete Blocks.** The only recommended method for complete removal from concrete blocks is to replace the blocks. Other methods can damage blocks and reduce the strength and structural integrity of the wall.

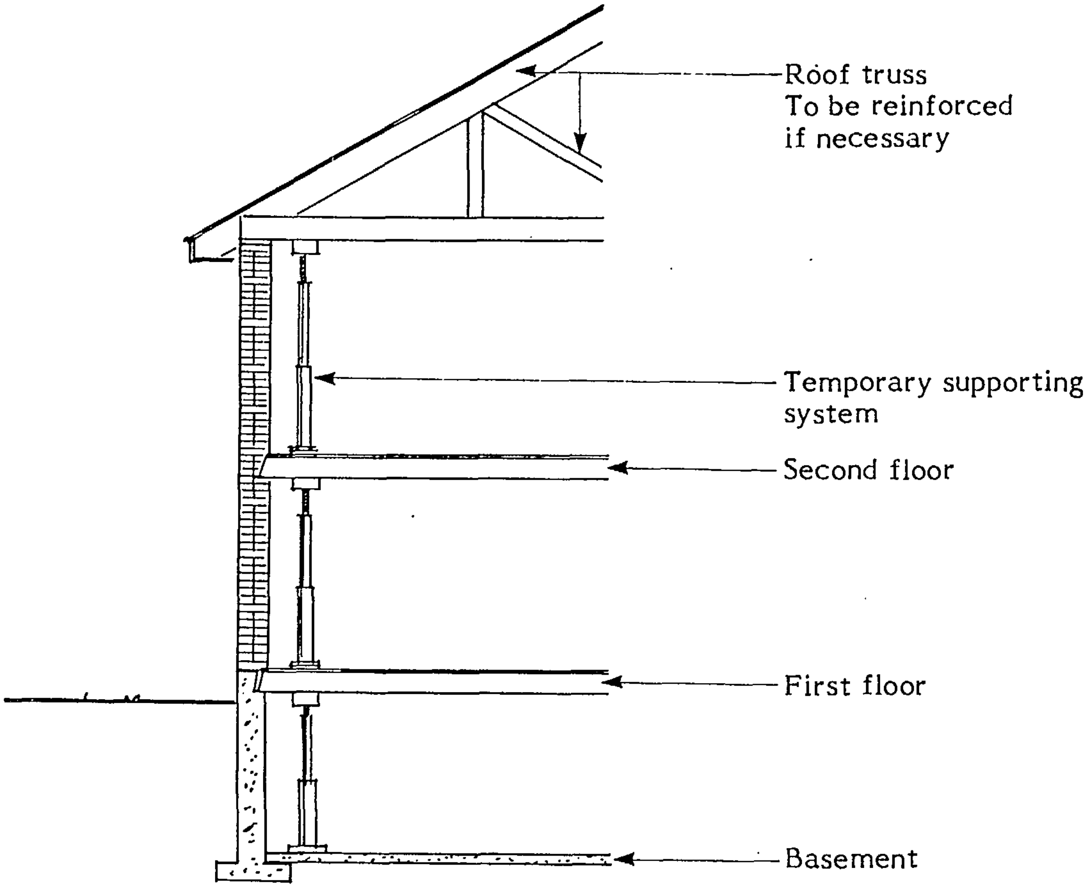


FIGURE 8.4 TEMPORARY SUPPORT FOR WALL REMOVAL

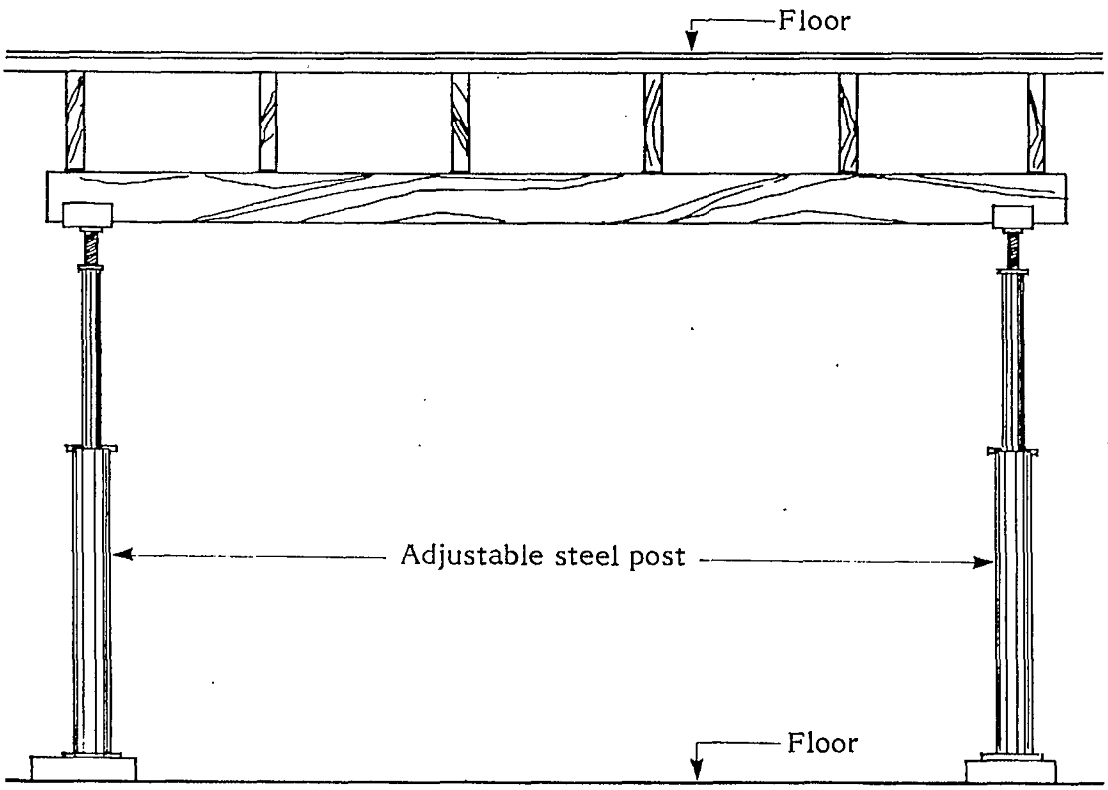


FIGURE 8.5 DETAIL OF JOIST SUPPORT

8.9 UFFI REMOVAL DURING WINTER

If removal during wintertime is being considered, the following must be done:

a) ensure that homeowners are forewarned of any additional costs to them such as heating, as a result of work being carried out over the winter;

b) take the necessary precautions to ensure that the sodium bisulphite solution will not freeze during neutralization treatment and that the cavities are thoroughly dried.

NOTE: Do not add antifreeze of any kind to the solution.

There is a need to take precautions when UFFI is removed during the winter. The sodium bisulphite solution used to neutralize contaminated wood surfaces will freeze at temperatures below 0°C, and will be rendered completely ineffective. Additionally, at temperatures falling near 0°C, formaldehyde emissions from contaminated materials are significantly lower, also reducing the effectiveness of the neutralization treatment and the validity of the Cavity Test.

It must be ensured that the air temperature in the wall cavities is continuously maintained above 5°C from the start of the neutralization procedure until the satisfactory completion of the test or until the end of further required treatment and any additional testing.

Inspectors will not undertake the test unless they are satisfied that suitable precautions have been taken.

NOTE: Contractors are cautioned against the use of portable heating units which use hydrocarbon fuels and which have no separate venting to carry off combustion products. Such units produce a considerable quantity of moisture and may not be appropriate for drying cavities.

8.10 FUNGAL GROWTH ON UFFI

Under certain conditions, fungus will grow on a variety of building materials, including wood, plasterboard, insulating materials, ceramic tile grouting, upholstery, and carpeting. The main condition which promotes fungus growth is moisture. Given sufficient moisture, UFFI is also a suitable material for fungi to grow on.

To safely deal with the possibility of exposure to fungi or the spores which they release, workers involved in the removal of fungi-contaminated UFFI must follow the necessary safety procedures. In particular, the dust/mist pre-filter must be attached to the respirator and changed frequently in order to prevent the inhalation of the tiny spore particles which can cause allergic reactions in sensitive persons.

Fungal growth on UFFI can often be identified as patches of discolouration on the foam; in some cases it may not be noticeable at all except to a trained technician. For this reason, it is essential that dust/mist pre-filters be attached to the respirators at all times.

There is no special fungicide or treatment to be done, but it should be brought to the homeowner's attention that fungus is present. **The only effective prevention of fungal growth is to eliminate the moisture,** which may originate from a structural/mechanical problem, excessive humidity in the home or trapping of condensation within the cavity. The following corrective steps should be taken:

a) carefully remove UFFI, being sure to wear protective clothing and respirators equipped with dust/mist pre-filters;
b) replace any other badly contaminated building materials (e.g., if studs are rotten, repair or replace them);
c) if some source of moisture is present, fix it (e.g., check for leaking or sweating water pipes and leaks in the roof or siding);
d) clean the cavity and treat with sodium bisulphite;

e) dry the cavity thoroughly (a minimum of 24 hours between treatments). The only effective prevention of fungal growth is to eliminate the moisture;

f) restore, taking steps to ensure that the cavity stays dry. If removing from the exterior, ensure that interior surfaces are properly sealed, papered and/or painted, so as to become an effective vapour barrier (see Appendix C). If removing from the inside, ensure that a polyethelene vapour barrier is installed.

Ways of reducing moisture production in the home are discussed in Chapter 5.

If you are concerned about any fungal growth that you have found, samples of the fungus-contaminated materials can be sent to your local Agriculture Canada office for identification, but it will take some time before an answer can be provided.

Removing contaminated materials and eliminating sources of moisture are the only recommended ways to prevent the problem from recurring.

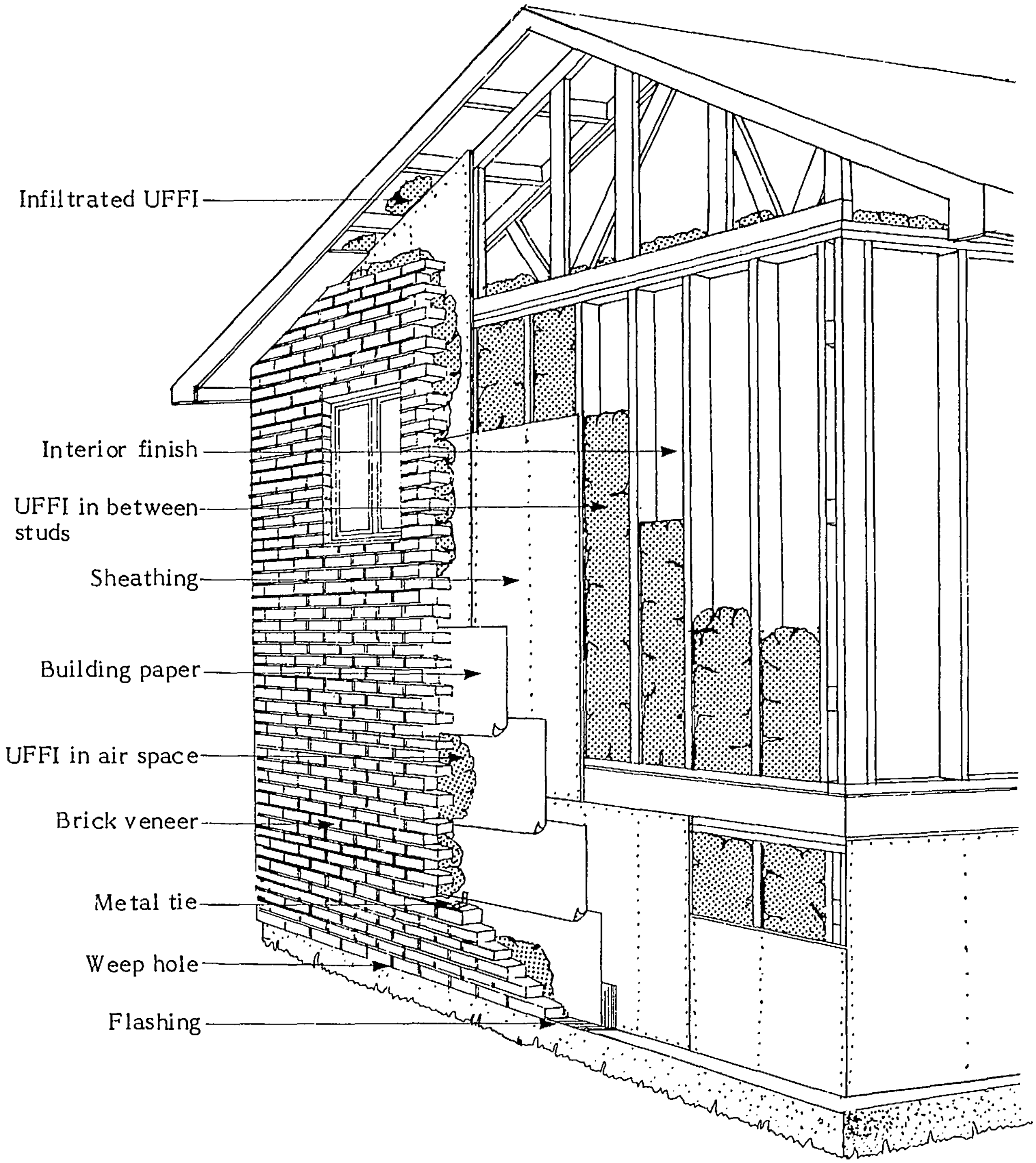


FIGURE 8.6 DISMANTLING OF BRICK VENEER WALL

8.11 STEP 3: NEUTRALIZATION FOLLOWING UFFI REMOVAL

Neutralization is the process by which an active chemical is made inactive by another chemical.

Formaldehyde is neutralized by sodium bisulphite. The combination of these two chemicals produces a stable chemical (does not react), once the water in the solution evaporates (dries).

Neutralization will occur in the thin film of water on the wood surface only as long as both formaldehyde and sodium bisulphite are in water. It will not take place in the air, or if the water turns to ice.

UFFI is made of tiny "blocks" (called polymethylolureas). These "blocks" were adsorbed by the building materials which were in contact with the UFFI.

The first step in neutralizing is to flush the "blocks" from the wood, and to lessen their potential to emit formaldehyde.

Formaldehyde emission will increase with a rise in temperature and moisture. However, it is a slow-release process. Warm water washing accelerates the release of formaldehyde. Because it takes a long time for formaldehyde to travel from within the wood to its surface, there must be a waiting period of at least 24 hours before the sodium bisulphite solution is applied so that the formaldehyde which has reached the surface can be neutralized.

8.11.1 The Safe Use of Chemicals. Proper protective equipment and safety measures as outlined in Section A are essential to safe handling and use of the concentrated chemicals and solutions.

If the neutralizing solution is to be mixed at the job site adequate measures must be taken to ensure correct proportions and protection for the workers doing the mixing. Reliable personnel to do the mixing and adequate first aid must be available to the job site. Special care should be taken to avoid any contact of the powder or solution with the eyes. If the solution should come in contact with the eyes, immediately wash the eyes with large amounts of clean water. Following first aid, the injured person should be transported immediately for medical attention.

Safety measures must be strictly enforced during the entire process of treating the cavity. It must be ensured that the workers wear protective clothing and respirators.

Work areas must be ventilated with large centrifugal fans. Dispose of any unused chemicals.

In homes where occupant health or chemical sensitivity problems are involved, advise occupants to consult the family doctor concerning possible reactions before using any chemicals.

8.11.2 Warm Water Washing. When the UFFI residues have been brushed or sandblasted and then vacuumed, **wash the masonry surfaces and the affected wooden components with warm water and then leave to dry.**

8.11.3 Prepare a Solution of 3% sodium bisulphite (Na HSO_3) using a ratio of 100 g of sodium bisulphite in 3.5 L of water (1 pound in 3.5 Imperial (4 U.S.) gallons of water).

NOTE: STABILITY OF 3% SODIUM BISULPHITE SOLUTION

1. the solution must be prepared for immediate on-site use;
2. the solution can be stored for a period not exceeding 24 hours providing that the container:
   a) is tightly sealed;
   b) is 100% capacity-filled;
   c) is kept in a cool area;
   d) is non-metallic.

The solution should be discarded if not used within 24 hours.

8.11.4 Neutralization of UFFI Residue. Apply one coat of the solution onto the wood in the cavity with a new or very clean fog or airless sprayer, sponge, or mop and let the cavity dry thoroughly (24 hours minimum). Apply a second coat and let dry thoroughly (24 hours minimum). The second application of sodium bisulphite solution neutralizes any formaldehyde that has been slow to reach the surface and further reduces formaldehyde emissions.

NOTE: Masonry surfaces which have been in contact with UFFI should be washed with water only.

Spray into each cavity until a slight running of the liquid occurs. This should provide sufficient solution to soak the surface layers of the wood materials being treated. Since the solution should not come into contact with masonry components, these materials should be protected during the spraying procedure. Do **not** treat lime base plaster with this solution. Limited wetting of wood lath should not damage the plaster finish. Avoid spraying into electrical outlets. Allow the cavities to dry and arrange for an inspector to measure the concentration of formaldehyde (Section 8.11.6). Results should be near ambient. If the levels are still high, a further treatment may be required, as well as a search for hidden UFFI.

Types of spraying equipment recommended by experienced UFFI contractors as particularly suitable for this purpose are described in Appendix E.

NOTES:

a) If the sodium bisulphite is applied too soon after the warm water wash, the formaldehyde may not have reached the surface of the wood. By the time it has, the water will have evaporated from the sodium bisulphite solution, meaning that the formaldehyde will not be neutralized.

b) Under freezing conditions, very little formaldehyde will be released from the wood, and no reaction will take place in ice.

c) If the wall cavity is closed up with the solution frozen onto the surface of the wood, neutralization will not be effective. Not enough of the solution will be left on the surface by the time the formaldehyde is released. Furthermore, because of higher moisture content in a closed cavity, the structure could be more vulnerable to rot and fungal growth.

d) Saturation must be complete during each application (droplets running down the wood surface).

e) Allow at least 24 hours drying time between each step, and make sure that the cavity is dry before proceeding with the next step.

f) When the moisture content and the temperature increases, so will formaldehyde emission.

g) A minimum temperature of 5°C must be maintained during the entire neutralization and testing procedure (Section 8.11.6).

CAUTION: For reasons of performance, only the following grades of **chemically pure** sodium bisulphite are recommended:

- USP (U.S. Pharmacopia);
- BP (British Pharmacopia);
- CP (Canadian Pharmacopia).

If difficulties are encountered in locating the prescribed product or grade in some areas of Canada, contractors or homeowners should contact the UFFI Centre.

8.11.5 Protecting the Cavities. During the drying of cavities exposed on the exterior, it might be necessary to cover the cavity with a temporary polyethylene cover to protect them against the elements.

8.11.6 **The Five-Stud Cavity Test.** Precautions must be taken as follows to ensure that the Cavity Test accurately measures the formaldehyde concentration. **This test should not be undertaken unless the air in the cavity can be maintained above 5°C.**

a) **Step 1. UFFI Removal.** Ensure that the UFFI removal process, including the removal of residual particles (by sandblasting or brushing and vacuuming, and by searching for hidden pockets of UFFI) has been thorough and comprehensive. Ensure that the water spraying and chemical treatments have been thorough and complete.

b) **Step 2. Air Exposure.** Wait at least 24 hours after completion of the last sodium bisulphite treatment before beginning to prepare the Cavity Test area, and ensure that the walls which are to be sealed for the Cavity Test are thoroughly dry. Otherwise, higher readings may result.

c) **Step 3. Selection of Test Area.** Select an area for the test that is five full stud spaces in width, preferably a full storey in height, without window, door or other openings. Select the area which had the highest formaldehyde readings as recorded on the Full Scale Test reports, or Inspection Visit report. In the absence of such reports or if those reports show no reading above 2.0 ppm, select a test area that has a southern exposure.

d) **Step 4. Preparation of Test Area.** Ensure that the test area can be securely sealed around the perimeter, vertically at the two outer studs and horizontally at the top and bottom plates. If the framing is balloon, or if the soffit of a roof overhang is lower than the top wall plate, blocking may be required in other locations to seal off the test area from any part which cannot be otherwise properly sealed.

Normally, either the outer or inner wall cladding assembly will have been left in place. If both have been removed, sealing the test cavity on both sides will be undertaken as described below. If the interior wall has not been fully sealed, tape or otherwise seal any significant holes in the remaining wall cladding, e.g., UFFI installation holes through sheathing or around electrical outlets.

For the purposes of the test only, replace the wall cladding which has been removed with 6 mil polyethelene, tightly secured with staples around the perimeter and along intermediate framing members. Use a single sheet of polyethelene sufficient to cover the whole test area without joints. If a joint is necessary, it shall be run vertically and lapped over one stud space, and stapled to both studs.

19 mm x 38 mm (1" x 2" nominal) wood strips should be nailed tightly to the perimeter and intermediate framing members, with sponge rubber strips (weatherstripping) under the wood strips to ensure a tighter seal.

Do not use sealants or more than a minimal amount of adhesive tape in sealing the cavity, since these may give off gases which could interfere with the measurement of formaldehyde concentration.

Use new polyethelene for each cavity test; do not re-use this material.

e) **Step 5. Waiting Period.** The test area must be left for at least 24 hours, preferably longer, before testing, to ensure that the formaldehyde level in the air reaches its equilibrium position.

f) **Step 6. Testing.** A small hole is made through the polyethelene into the centre stud space and sealed around the Draeger tube while the test is undertaken. Two Draeger readings should be taken and the average used.

8.11.7 **The Equilibrium Box Test** is performed after UFFI is removed to determine the new formaldehyde levels within the wall cavities. **This test should not be undertaken unless the air in the cavity can be maintained above 5°C.**

a) **Step 1. UFFI Removal.** Thorough removal of UFFI, including residual particles (by sandblasting or brushing and vacuuming, and by searching for hidden pockets of UFFI) must be completed.

b) **Step 2. Pre-testing Inspection.** The inspector will question the contractor and when possible the homeowner, to determine whether the water spraying and chemical treatments have been thorough. If not, the testing procedure will not be performed. The reasons will be explained in the inspection report. The homeowner/contractor will be advised that the test cannot be done and that other arrangements must be made for future testing, if desired.

c) **Step 3. Air Exposure.** Wait at least 24 hours after completion of the last sodium bisulphite treatment before taking the test to ensure that the walls are thoroughly dry. If this is not done, higher readings may result.

d) **Step 4. Selection of Test Area.** The inspector will select test sites on each of two separate walls, at least one of which is at the location of the highest formaldehyde reading recorded on the Full Scale Test report. The second site will be on a south wall, if available. In the absence of a report or there are no readings above 2 ppm, test sites will be selected on each of two separate walls at least one of which is on a south wall. Where two separate walls are not available, both test sites will be on the same wall, as far apart as possible. The polypropylene box should be installed approximately at the mid-point of the flat cavity surface being tested. The grommet hole through which the Draeger reading is taken is sealed with suitable tape.

e) **Step 5. Installation of the Box on the Test Area.** The polypropylene box is placed vertically against the testing surface. Affix the box firmly to the test surface with the attached pins.

f) **Step 6. Waiting Period.** The inspector waits for a period of 15-30 minutes before taking the Draeger reading, to ensure that the formaldehyde level in the box reaches equilibrium.

g) **Step 7. Testing.** A Draeger 0.5/a tube is pushed into the box through the taped grommet hole and take a reading. The two readings are recorded on the inspection report.

h) **Step 8. Washing the Box.** The inside surface of the polypropylene box can collect formaldehyde which could be released during subsequent testing. It is, therefore, important to wash the box after every use in order to obtain reliable results. Clean, hot water should be used to wash the inside surface. The box should be air-dried for 24 hours before re-use.

SECTION C: RESTORATION

8.12 INTRODUCTION

This section deals with details of the basic steps involved in restoring the residence to a state equivalent to that before removal. The steps include proper installation of insulation and an air/vapour barrier. Some background information is included with various procedures. Further information on construction materials and techniques may be obtained from "Residential Standards 1980" and "Wood Frame House Construction" issued by CMHC.

8.13 STEP 4: INSULATION AND RESTORATION

8.13.1 Preparing for Restoration. Materials and construction work must meet the requirements of the applicable building regulations. This may require the inclusion of items omitted during the original construction (e.g., fire stops). Consultants may be needed in some instances to solve individual problems. The following steps outline the general procedures to follow in restoring the structure after UFFI removal:

a) replace any wooden structural members which have been damaged (e.g., by dry rot);

b) block and seal openings passing through wall plates, or blocking from the wall cavity into joist spaces, or from storey to storey;

c) seal the cracks between adjacent parallel framing members (e.g., wall plate and joist header, or between double studs framing a window) and any butt joints in these members. In balloon framing, seal between the sub-floor and the outside finish;

d) seal the junction of interior partitions and the exterior wall;

e) replace deteriorated electrical components;

f) insulate the window and door frame shim spaces;

g) schedule the restoration of any ceilings and interior partition walls to permit the installation of a continuous air/vapour barrier.

8.13.2 **Sequence of Restoration Tasks.** The sequence of tasks depends on whether the removal was done from the interior or the exterior. The tasks must be performed in the following sequences:

a) **interior removal:**

i) install appropriate insulation materials;
ii) provide a continuous vapour barrier;
iii) seal all potential leaks;
iv) install an acceptable interior finish;
v) clean up.

b) **exterior removal:**

i) seal cracks and leaks apparent in the structure;
ii) install appropriate insulation materials;
iii) install sheathing, building paper and cladding materials;
iv) clean up.

NOTE: When removal is from the exterior, the interior surface of exterior walls should be sealed before removal begins.

8.13.3 **Insulating**

a) **Types of insulation.** During corrective measures, since walls have been opened and the interior made accessible, materials that are acceptable for new construction (e.g., mineral fibre batts) should be used. Some rigid board insulations have a relatively high resistance to moisture transmission and should only be used on the outer side of a wall if a very tight, continuous seal against air leakage and vapour transmission is provided on the inner side of the building envelope. (See Appendices A and B for information on insulating materials.)

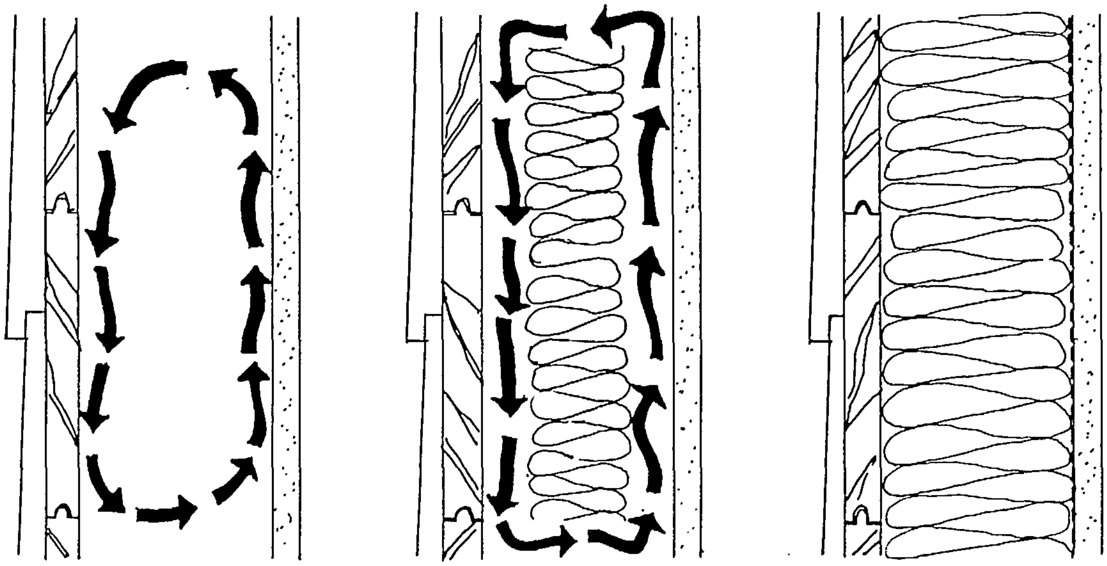
b) **Seal and insulate:**

i) between rough openings and the frames of windows and exterior doors with the appropriate materials;

ii) around pipe entry points and wires passing through the exterior wall, with the appropriate materials;

iii) the interior of exposed header areas with roll batts of mineral fiber, or extruded polystyrene (Figure 8.11 (A) to (D)). This is possible only if the ceiling area along the inside of the exterior walls was removed;

iv) the open cavities in wood frame houses with friction fit batt insulation. Ensure that the batts fit snugly. Gaps and pockets left in or around the batts will permit convective forces to short-circuit the resistance value of the insulation (Figure 8.7).



Convection in an empty stud space

Loose-fitting insulation can be "short-circuited" by convection

Tight fitting insulation eliminated convection

FIGURE 8.7 INSULATION PERFORMANCE IN A STUD WALL

c) **Cut and install insulation to fit:**

i) odd-shaped cavities formed by such structures as bracing and fire stops;

ii) the space between studs. In older homes the spacing of studs may be different from the standard width of insulation on the market;

iii) around the exterior of water pipes, electrical boxes for plug outlets and switches, and plumbing pipes and vents. When batts are used, cut, split, or trim the batts to avoid excessive compression.

Compression reduces the thermal resistance of the batts, but not in proportion to the reduction in thickness. Compression must be kept to a minimum.

8.13.4 Air and Vapour Barriers. A **continuous** vapour barrier is necessary to stop warm moist air from diffusing through the insulated cavity. However, ten times more moisture is transferred by air leaks than by diffusion. Air leaks also account for 20% to 30% of the heat loss from a typical house.

Select a suitable vapour barrier material from the Table "The Resistance to Moisture Flow of Common Building Material" (Appendix C).

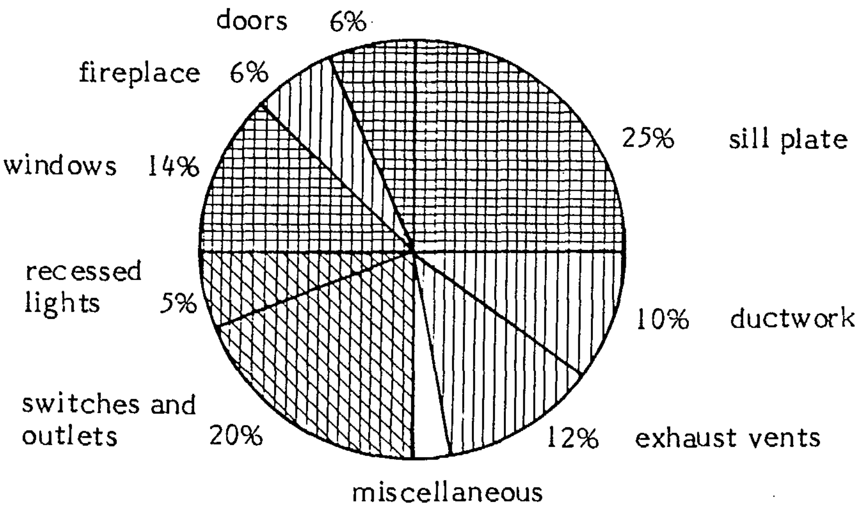


FIGURE 8.8 PERCENTAGE OF AIR LEAKAGE

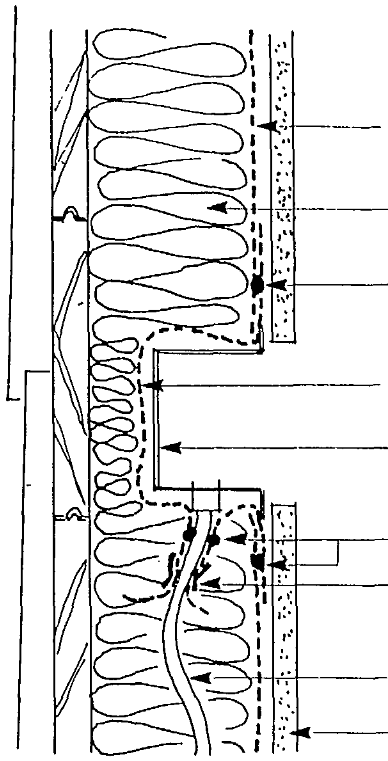
a) **Installation of air/vapour barriers from the interior:**

i) wrap all electrical boxes on exterior walls in polyethylene (Figure 8.9 (A and B)), and tape the poly to the wire where the wire passes through, or use polypans or shells (Figure 8.9 (C to F)), and caulk where the wire enters. Ensure that sufficient thermal insulation is placed behind the box to avoid a thermal bridge.

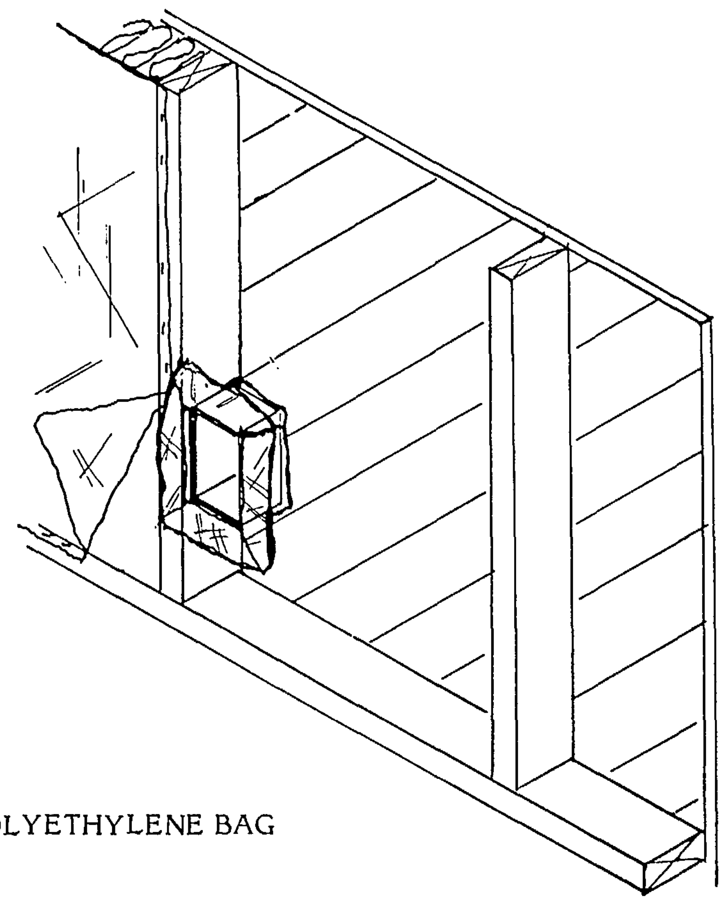
There are no requirements for the vapour barrier when removal is done from the exterior because:

- in the event that some of the interior wall finish had become contaminated, a vapour barrier in this location would cause any formaldehyde emissions to migrate more readily toward the living space;
- the work involved in installing the vapour barrier between the studs is onerous and tedious, which could lead to an incomplete job. Besides, even if the work were thoroughly done, openings would still exist for air/vapour movement beyond the vapour barrier at wall plates, etc.;
- the requirement for basic sealing of the interior surface during removal, together with normal interior wall finishes and surface coatings should provide as effective an overall air/vapour barrier.

It is most important that basic sealing of the interior surface of the exterior wall be thoroughly done BEFORE beginning removal from the exterior. This will serve both to minimize the migration of formaldehyde and UFFI particles to the interior during removal, and will continue to reduce the passage of air and water vapour from the living space into the exterior walls. To further reduce air/vapour movement at the junctions with the exterior wall of interior partitions and floors, gaps or cracks between adjacent structural members be sealed.

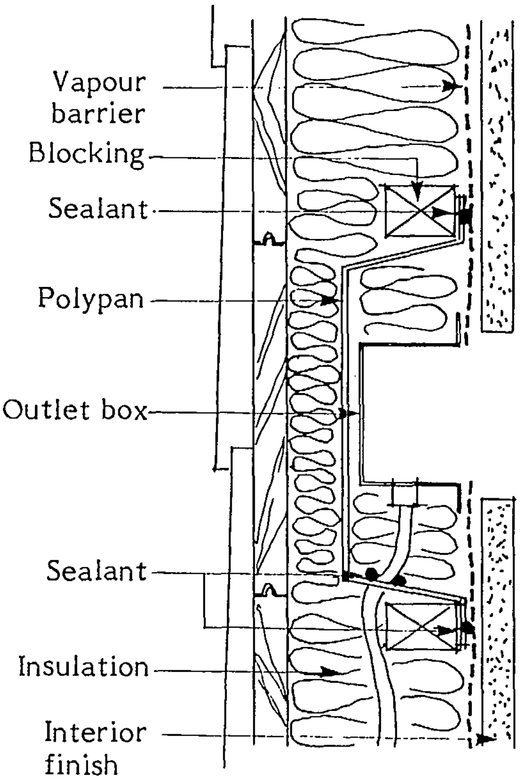


A. SECTION THROUGH POLYETHYLENE BAG

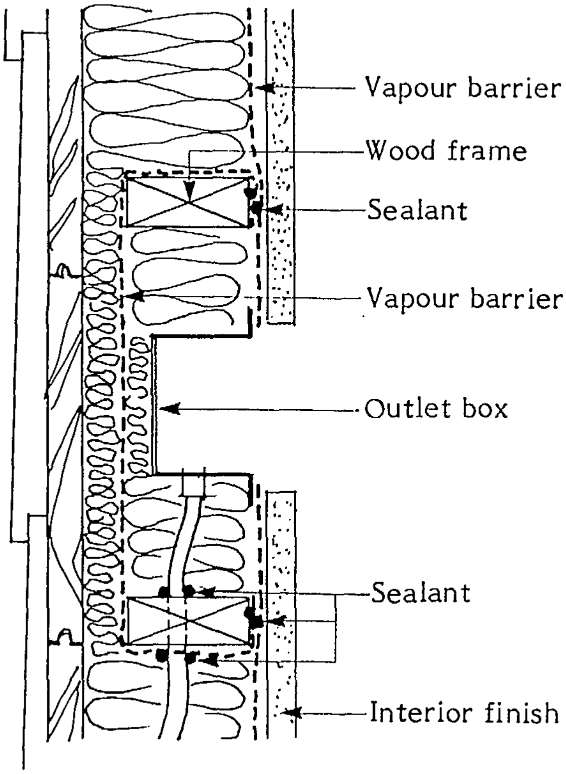


B. POLYETHYLENE BAG

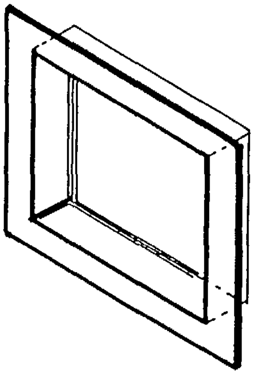
FIGURE 8.9 SEALING AROUND ELECTRICAL OUTLETS



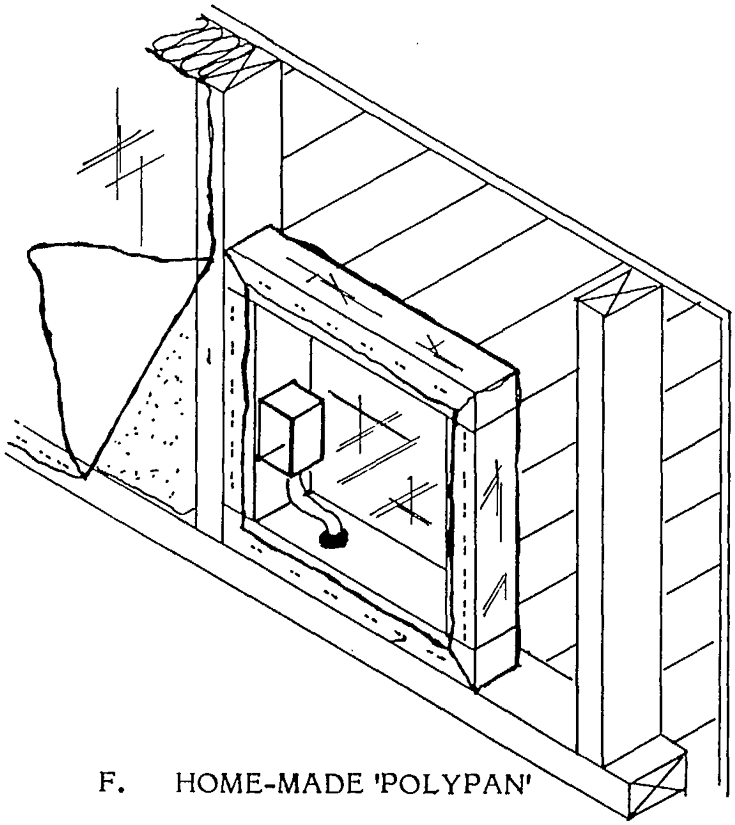
C. SECTION THROUGH PRE-FABRICATED 'POLYPAN'



D. SECTION THROUGH HOME-MADE 'POLYPAN'



E. PRE-FABRICATED 'POLYPAN'



F. HOME-MADE 'POLYPAN'

 FIGURE 8.9 SEALING AROUND ELECTRICAL OUTLETS

ii) using an acoustical sealant, seal the perimeter of each sheet of 0.15 mm (6 mil) poly installed along the interior of exterior walls (Figure 8.13);

iii) overlap the poly at joints between sheets at least 100 mm, and seal each joint with acoustical sealant or overlap one framing space (Figure 8.10);

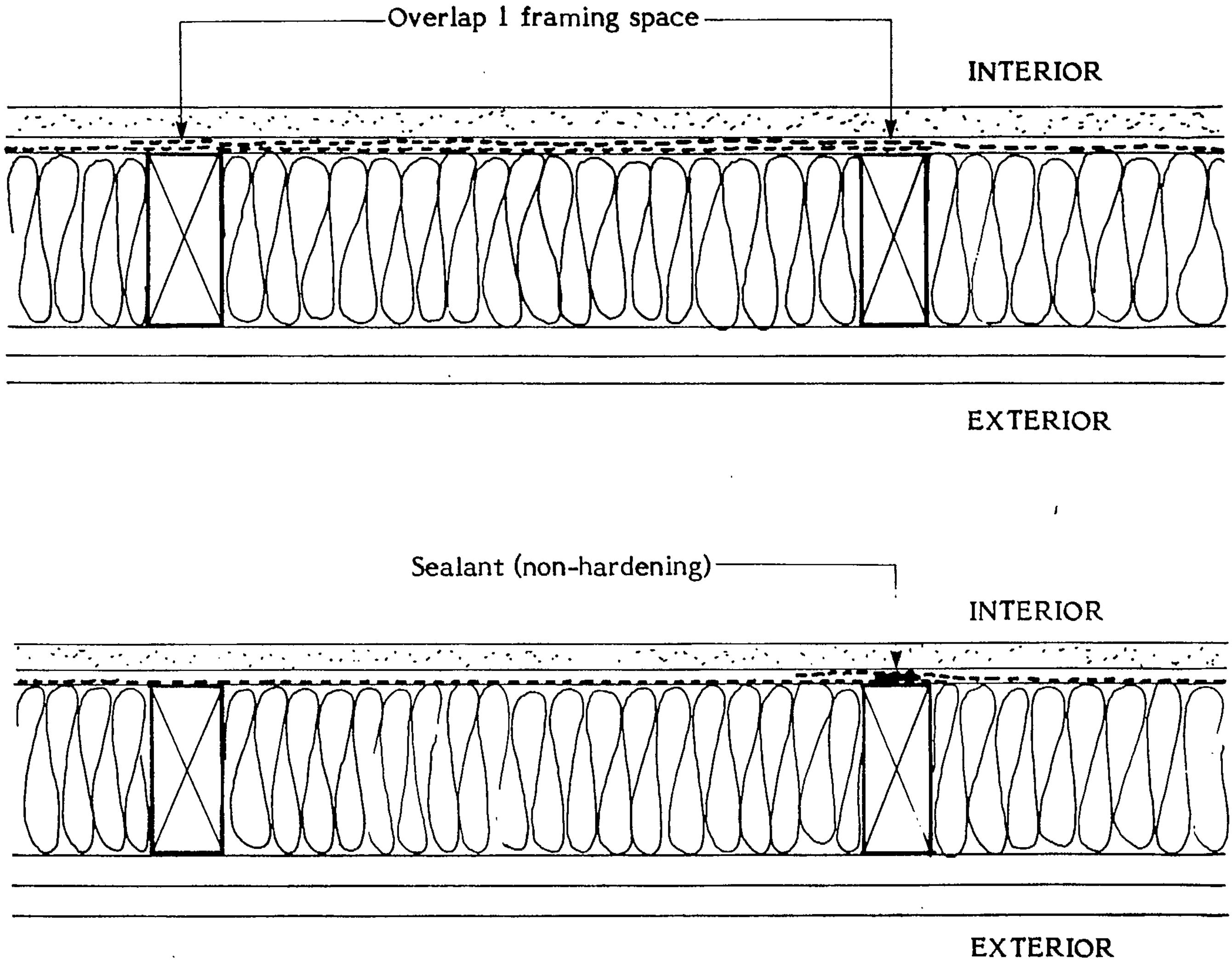
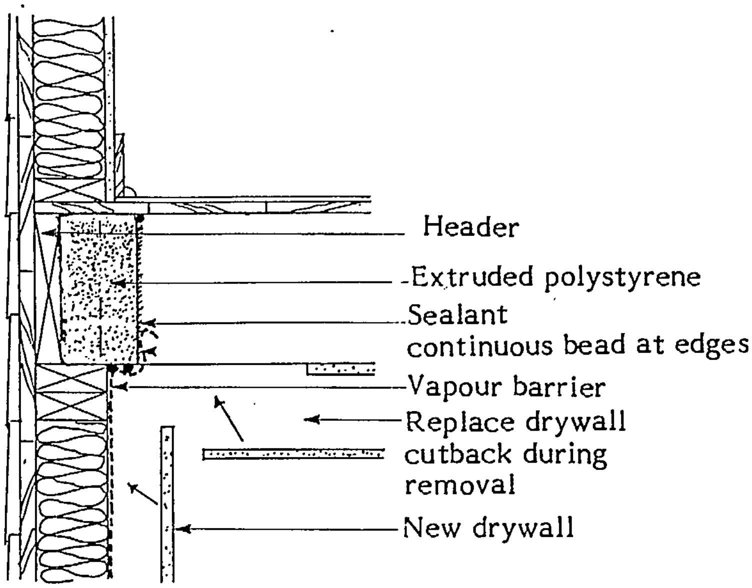


FIGURE 8.10 OVERLAPPING AND SEALING THE AVB

iv) after main vapour barrier has been installed, unfold and tape the edges from inside electrical boxes to the main vapour barrier covering the wall, or if polypans were used, staple the poly around the caulked edges of polypans;

v) seal header areas between floors which have been opened. (Figures 8.11 (A) and (B));



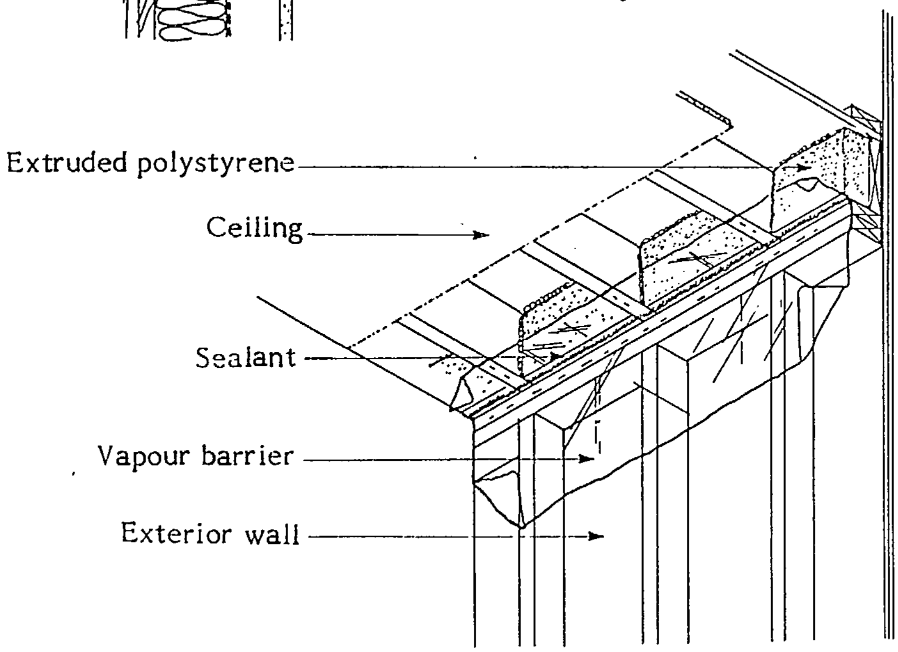
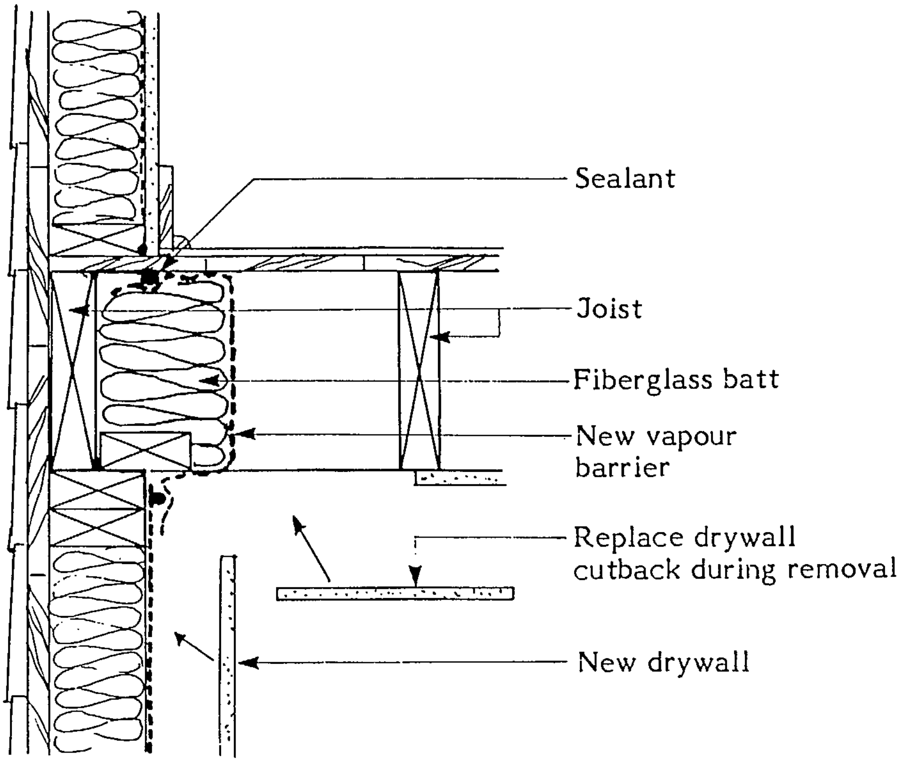


FIGURE 8.11 (A) SEALING THE HEADER AREA (JOISTS PERPENDICULAR)



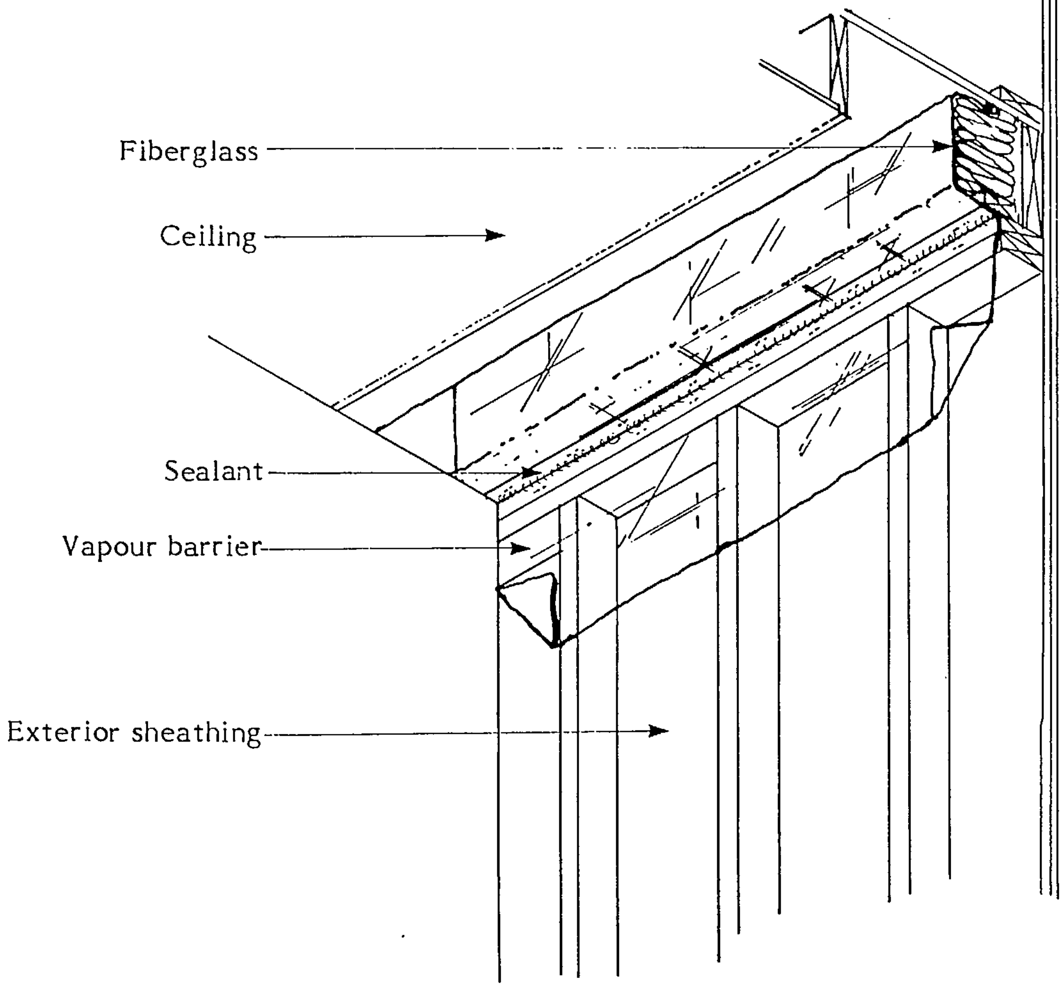


FIGURE 8.11 (B) SEALING THE HEADER AREA (JOISTS PARALLEL)

vi) when the stud space of a partition wall next to an exterior wall has been opened, install polyethylene as in Figure 8.12. Apply a continuous bead of sealant along each vertical joint;

When a wall has been opened from the exterior, seal junction of interior partition and insulate;

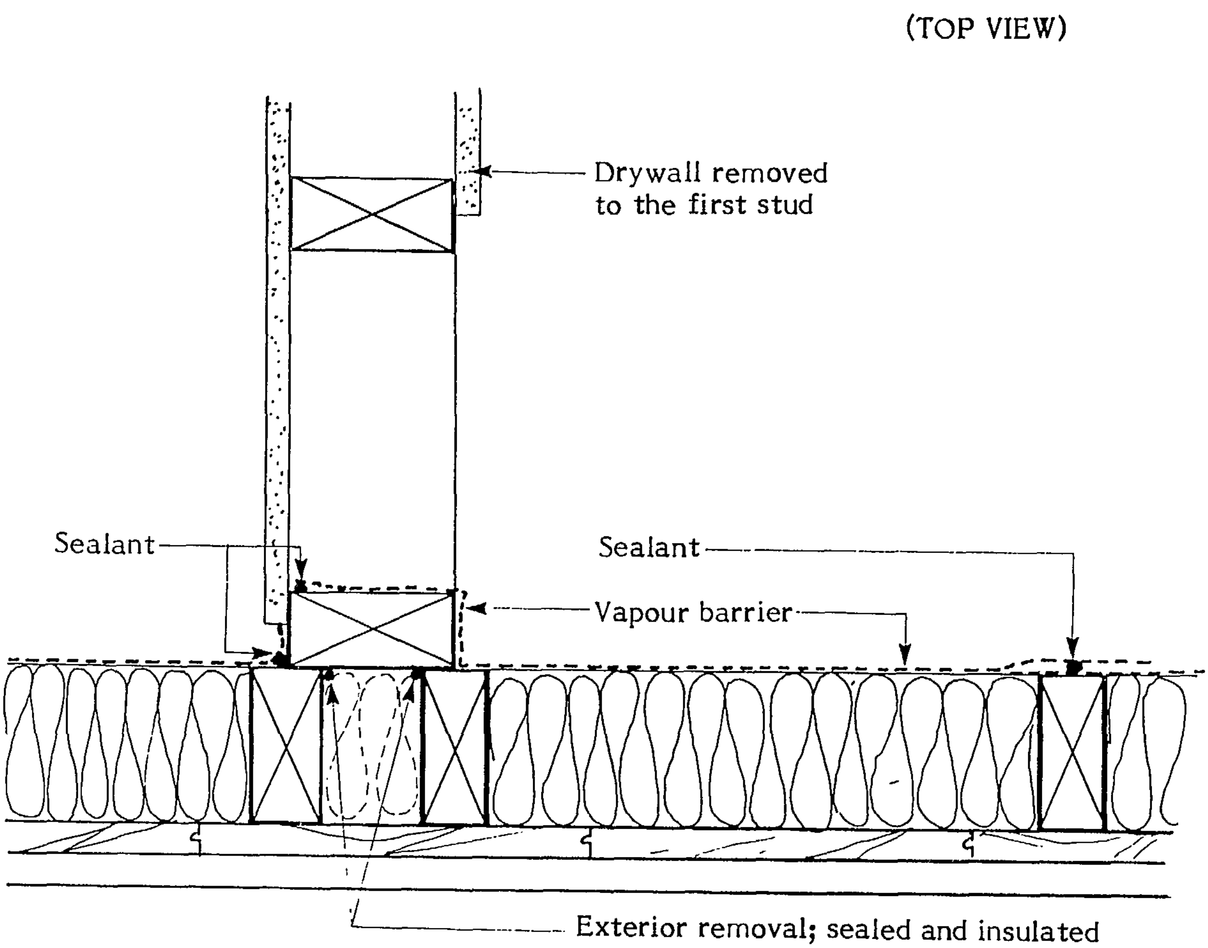


FIGURE 8.12 EXTERIOR WALL

vii) caulk the main vapour barrier around the perimeter of each sheet and frame of each window and exterior door (Figure 8.13);

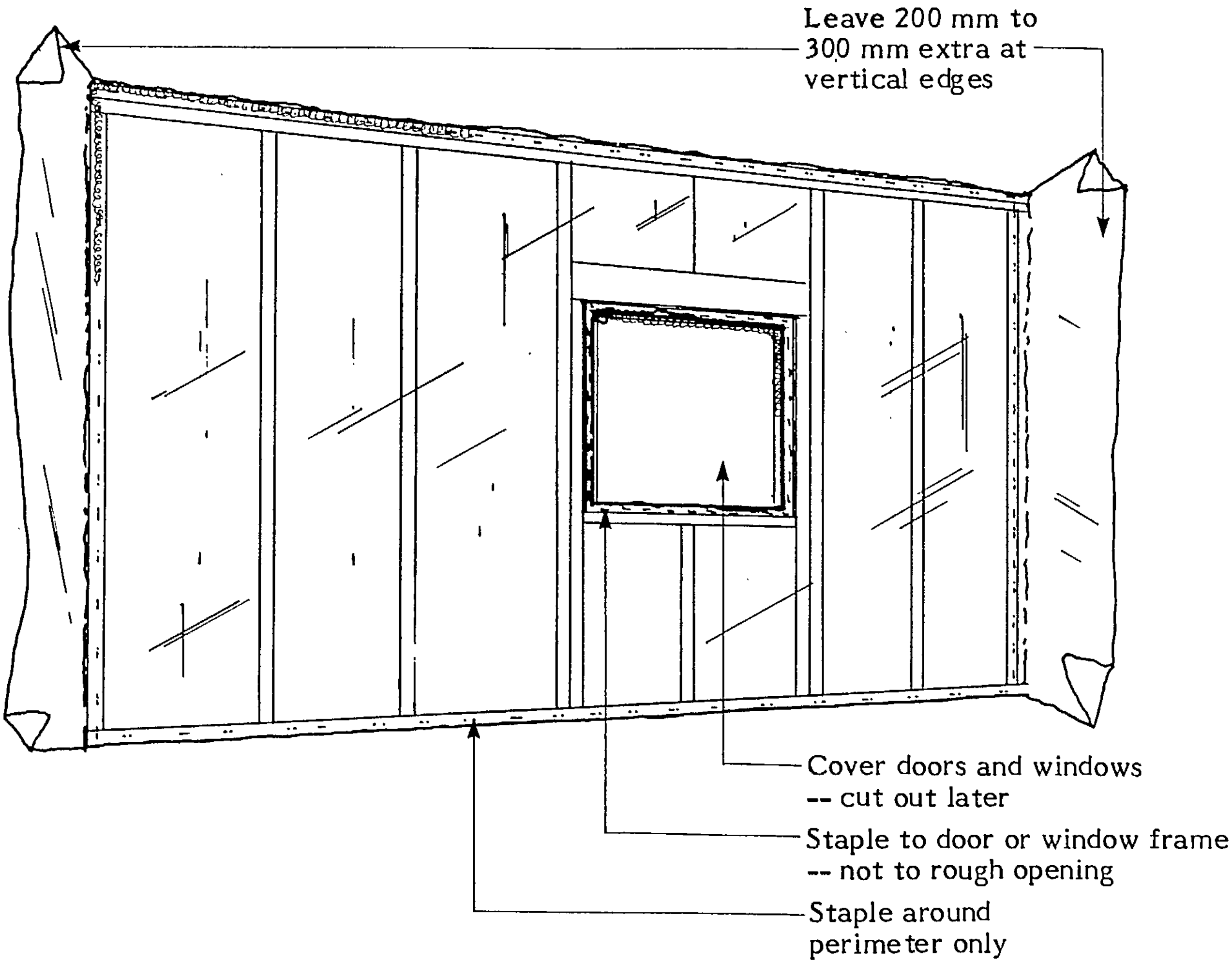


FIGURE 8.13 APPLYING A CONTINUOUS VAPOUR BARRIER

viii) install gaskets behind electrical wall outlets and switch plates, and place "child proofing" plugs in unused outlets (Figure 8.14). Caulk or use two-sided sticky tape to seal the gasket;

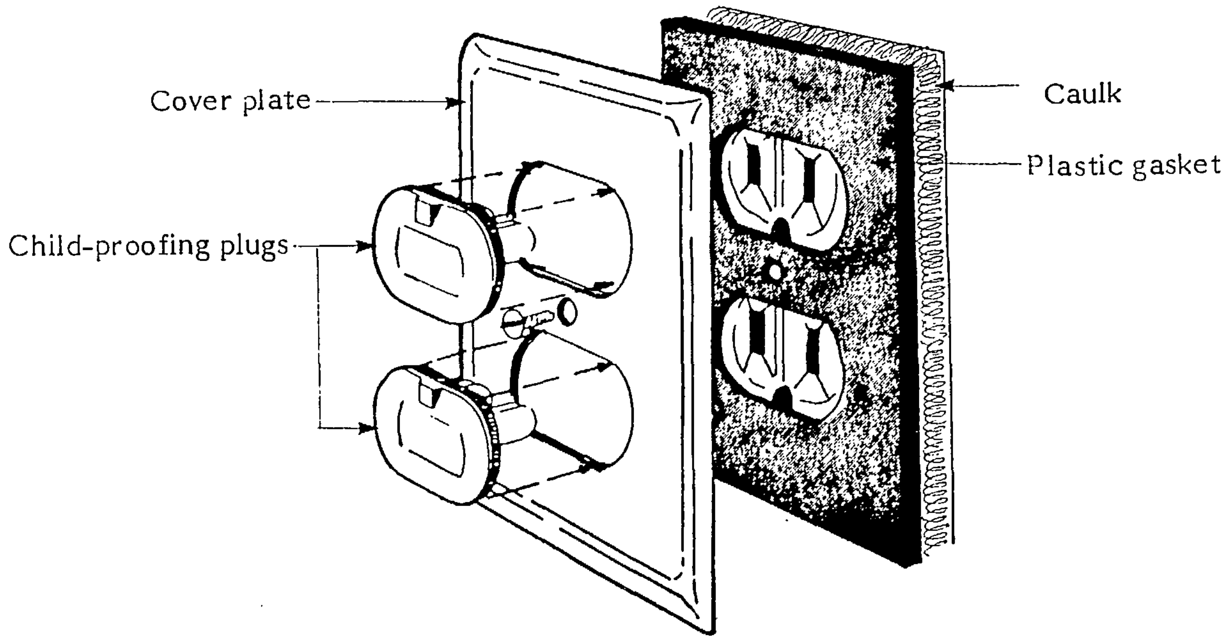


FIGURE 8.14 SEALING THE ELECTRICAL OUTLETS

b) **Installation of an air/vapour barrier from the exterior.** The most important step in preventing air and vapour leakage through the wall when removal is from the outside, is to thoroughly seal the interior surface of the building envelope from indoors. In addition:

i) seal gaps or cracks between parallel adjacent structural members: double plates, double studs, plate and joist header. Sealing may be from the inside where cracks are readily accessible, e.g., where the joist header is open to the basement;

ii) seal the vertical gaps and cracks at the intersection of interior partitions with the exterior wall;

iii) seal any cracks or gaps in the interior finish visible from the exterior.

8.13.5 **Installation of an Acceptable Interior Finish.** Generally, gypsum board (drywall) is chosen as an interior finish. Avoid using materials which may emit formaldehyde. Ensure that the vapour barrier is not punctured during the installation of the interior finish. Take care not to break the air seal at electrical outlets and switches, baseboards, window and door frames, and junctions of partitioned walls and ceilings.

8.13.6 **Installation of an Acceptable Exterior Finish.** Follow the minimum requirements specified in the applicable building code for sheathing and exterior cladding. Contact the municipal building inspector for this information. Use at least one layer of sheathing paper applied horizontally and lapped 100 mm. Ensure proper ventilation of the cladding to the exterior.

a) **Review of general steps involved in exterior removal and restoration:**

1. seal interior surfaces of exterior walls;
2. remove cladding carefully;

3. strip off building paper;
4. remove sheathing material;
5. remove UFFI from all cavities;
6. brush the cavities;
7. vacuum thoroughly;
8. spray wood members with sodium bisulphide solution ($Na HSO_3$);
9. perform cavity test;
10. seal air paths to interior (e.g., at interior partitions, headers, etc.) with suitable caulking material;
11. install insulation material;
12. install appropriate sheathing material;
13. install layers of building sheathing papers;
14. replace cladding materials.

b) **Review of general steps involved in interior removal and restoration:**

1. remove interior walls;
2. remove UFFI from all cavities;
3. brush the cavities;
4. vacuum thoroughly;
5. spray wood members with sodium bisulphide solution ($Na HSO_3$);
6. perform cavity test;
7. seal air paths to interior (e.g., at interior partitions, headers, etc.) with suitable caulking material;
8. install insulation material;
9. install vapour barrier;
10. install wall finish.

SECTION D: CLEANUP AND DISPOSAL

8.14 INTRODUCTION

This section outlines the procedures for cleaning the home after the restoration procedures are complete. All cleaning steps should be followed to reduce the possibility of UFFI dust and gas remaining in the house.

8.15 STEP 5: CLEAN-UP

Subsequent to corrective work, a complete cleaning is necessary to remove any residual UFFI dust and gas from the living environment. Site clean-up after exterior removal includes cleaning both inside and out.

a) **Vacuum** the premises using an industrial vacuum. Locate the unit outdoors and use a long hose.

b) **Vacuum Furnace Air Ducts and Replace Furnace Filters.** Cold air return ducts are coated with a film of grease from cooking, etc. Other dust and pet hairs may be dropped on this film, which may also have adsorbed formaldehyde. Wash and remove dust and UFFI particles. When UFFI has been installed in ducts, dismantle and remove the UFFI, and steam-clean the ducts to remove the greasy film. In the case of joist and stud spaces used as ducts, remove the UFFI, wash, and treat with sodium bisulphite.

c) **Clean Carpets and Furniture.** Use a commercial hot water carpet cleaner. If this is not possible, a professional cleaner should clean the carpets and upholstered furniture. Beat foam cushions outdoors and vacuum.

d) **Wash or Dry-clean Clothes and Linens** to remove most of the UFFI gas which may have been absorbed from the UFFI. Since formaldehyde is water soluble, a mild laundry detergent is adequate.

e) **Wash all Interior Surfaces** using soap and water, and/or an ammonia based cleanser, and rinse with clean water (see caution on label of cleanser). This will remove most of the adsorbed UFFI gas and particles.

UFFI dust particles may have settled on various surfaces in the living environment. Wash all such surfaces thoroughly, paying particular attention to such areas as closets and cupboards.

CAUTION: Persons sensitized to certain chemicals found in some cleansers should not do the cleaning. Workers reacting to a cleanser should stop work immediately. A weak solution of the cleanser should be tried first to determine if there is a negative reaction.

8.16 STEP 6: DISPOSAL OF UFFI AND OTHER CONTAMINATED MATERIALS.

In cases of restoration after removal, it must be made clear to the homeowner the limits of the contractor's responsibilities in finishing and in final clean-up. However, disposal of UFFI and contaminated materials will normally remain the responsibility of the contractor. Safe and complete disposal is necessary for the safety of workers, occupants and neighbours, as well as for the environment. Proper procedures, therefore, must be followed during the actual removal, storage on site and transportation of these materials.

8.16.1 Storage on Site. All UFFI and contaminated materials, when dismantled, must be stored in industrial canisters at the site as they are removed, and the site must be tidy at the end of each working day. These canisters must be covered to prevent the wind from spreading the dust or the contaminated building materials around the job site or to neighbouring properties.

When the volume of debris is small, the UFFI and other loose materials can be placed in heavy-duty, tightly sealed garbage bags.

Before ordering a bin, ensure that the company you select does not dispose of debris by means of a crusher truck. Crushers will split the bags, releasing clouds of UFFI dust.

New materials for the restoration operation must be protected from contamination when stored on-site during the removal and cleaning operations.

8.16.2 Transporting the Material. Disposal canisters must be closed on site. Therefore, there should be no problem with transportation of materials. When a tarpaulin is used as a cover, ensure that it is well secured.

8.16.3 Disposal at Site. Provinces have different regulations regarding the dumping of UFFI. At this time, the most stringent rules require dumping and burial at an approved site where steps are taken to control drainage and to record the burial for future treatment. In general, debris should be taken to a controlled municipal dump where authorities should be informed that the load contains UFFI.

DO NOT ATTEMPT TO BURN UFFI OR UFFI-CONTAMINATED MATERIALS. Unless incineration is conducted under strictly controlled conditions, toxic gases are released.

Contractors and homeowners should check with local authorities to determine particular regulations regarding handling and disposal of materials. The following list specifies the appropriate authority by province.

Department of Environment
Elizabeth Towers
St. John's, Newfoundland

Tel: 709-737-2557

Direction des déchets dangereux
Environnement Québec
2360 Chemin St. Foy
Québec, Québec

Tel: 418-643-3794

Department of Community Affairs
3 Queen Street
P.O. Box 2000
Charlottetown, P.E.I.
C1A 7N8

Tel: 902-892-0221

Environmental Management Services
Room 333, Legislative Building
Winnipeg, Manitoba
R3C 0V8

Tel: 204-944-3719

Department of Environment
New Brunswick
Suite 1232
City Hall
15 North Market Square
St. John, New Brunswick
E2L 1E8

Tel: 506-658-2558

Saskatchewan Department of Health
T.C. Douglas Bldg.
3475 Albert Street
Regina, Saskatchewan
S4S 6X6

Tel: 306-565-6183

Department of Environment
P.O. Box 2107
Halifax, Nova Scotia
B3J 3B7

Tel: 902-424-5300

Alberta Environment
Standards and Approvals Branch
Oxbridge Place
9820 - 106 Street
Edmonton, Alberta

Tel: 403-427-5883
or Regional Landfill Authority

Ministry of Environment
Waste Management Branch
105 St. Clair Avenue West
Toronto, Ontario
M4V 1P5

Tel: 416-965-6191

Ministry of Environment
Waste Management Branch
810 Blanchard Street
Victoria, British Columbia

Tel: 604-387-4321

APPENDICES

A. INSULATING SHEATHING MATERIALS (ISMs)

B. THERMAL RESISTANCE VALUES OF COMMON BUILDING MATERIALS

C. RESISTANCE TO MOISTURE FLOW OF COMMON BUILDING MATERIALS

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APPENDIX A

INSULATING SHEATHING MATERIALS (ISMs)

Contents

A.1 INTRODUCTION

The use of insulating sheathing materials (ISMs), the proper attachment methods and the advantages and limitations of each type available at the time of printing are discussed in this section.

A.2 INSULATING SHEATHING MATERIALS (ISMs)

A.2.1 Combination Sheathing/Thermal Insulation Materials. The current trend in new construction is the use of combination sheathing/thermal insulation materials. While they cannot be used as structural substitutes for conventional sheathing, these insulating sheathing materials can:

a) replace existing sheathing, if framing is braced;
b) act as a backing for exterior cladding;
c) act as a sheathing material substitute for one of two sheathing paper layers.

Compared with conventional sheathing, insulating sheathings:

a) provide improved thermal resistance because of greater thickness and better thermal properties (the thermal resistance of sheathing materials is continuous over the framing);
b) are lightweight and easy to install;
c) generally, are moisture resistant;
d) can be used on conventional 38 x 89 mm studding to increase the amount of wall insulation.

A.2.2 Rigid and Semi-rigid Insulating Sheathing Materials:

- fibreglass;
- expanded polystyrene;
- extruded polystyrene;
- polyurethane/polyisocyanurate;
- wood fibre board;
- phenolic foam.

All these materials, except fibreglass and wood fibre board, can be categorized as lightweight cellular plastics **(LCPs).** They are accepted for use by CMHC for application to wood, steel and plank-frame walls. To be effective they must be installed only on flat surfaces.

A.2.3 Storage and Cutting:

a) **storage:** if ISMs are to be stored at the job site, they must be kept off the ground and covered with tarpaulins;

b) **cutting:** if cutting is necessary, straight and clean edges can be made using a utility knife, keyhole saw or electric saw.

A.3 INSTALLATION, ATTACHMENT AND PRE-FINISHING PROCEDURES

Despite the variety of insulating sheathing materials currently available, there are a number of common installation, attachment and pre-finishing procedures to consider.

A.3.1 Installation (Frame Walls)

a) ideally, sheathing should be applied so that it extends from the attic insulation to the foundation footing;

b) the sheathing should be butted tightly together;

c) all joints should be at the stud positions;

d) if the combined sheathing and batt insulation is to be totally effective, it is necessary to install a vapour barrier on the warm side of the batt insulation, and ensure that air leakage is reduced to a minimum;

e) in most cases, LCPs should be installed with at least two horizontal joints per storey. However, when insulation with a RMF value greater than 10 (less than 1 perm) over its total thickness is installed in direct contact with and on the outer surface of sheathing material, horizontal joints must be provided at least every 600 mm to allow for moisture diffusion (see Appendix C);

f) LCPs should not be used as a nailing base. Cladding and siding materials that require rigid backing materials must have 19 mm thick wood furring strips applied over the insulation sheathing and nailed directly to the studs. A useful practice is to chalk lines over the sheathing to illustrate where the studs run;

g) before applying the ISM, wood frame construction is often reinforced at each corner by recessing diagonal corner bracing flush with the face of the studs, using an approved metal strip or plywood corner bracing.

A.3.2 Attachment. Where there is an air space between LCPs and the cladding, ISMs should be applied to studs with large-headed galvanized nails or fasteners with washers 25 mm in diameter. The fastening nails should be long enough to penetrate the wood studs at least 25 mm. When finishing with brick, it is necessary to leave an air space between the brick and insulation (recommended 25 mm). Penetrations in the sheathing by corrosion resistant ties should be caulked.

A.3.3 **Finishing.** ISMs must be covered after installation to avoid damage. Before the application of cladding, apply a water-repellent breathing-type sheathing paper over the insulating sheathing (e.g., water-repellent asphalt paper).

A.4 ISMs: ADVANTAGES AND LIMITATIONS

Despite their advantages as insulating materials, ISMs have a number of limitations:

a) moisture problems could occur from the placement of a layer of relatively low permeability material on the cold side of the wall;
b) the cladding could be subject to slight distortion since ISMs are not as strong as conventional sheathing materials.

The previous sub-sections described the general procedures in applying ISMs to frame and cavity walls. Since these are general steps, certain ISMs may differ in application. The following sub-section discusses some of these materials in terms of their application, advantages and limitations.

A.4.1 **Fibreglass Sheathing** is a semi-rigid board with a factory applied facing. Composed of resin bonded fibres, it will neither settle nor slump. It can be used as a non-structural insulation for all wood and steel-frame walls. Fibreglass sheathing requires a water-repellent air-breathing paper on the exterior of the insulation.

a) **advantages:**
   - excellent dimensional stability;
   - excellent fire, water and fungus/vermin resistance;
   - high permeability.
b) **limitations:**
   - one of the lowest RSI values of ISMs (0.031/mm);
   - easily damaged;
   - phenol formaldehyde resin.

A.4.2 **Expanded Polystyrene Beadboard** is factory cured and cut according to board and shape specifications. It can be used as non-structural insulation for wood and steel frame walls and cavity walls.

a) **advantage:**
- low-cost/RSI value.

b) **limitations:**
- lowest RSI value/mm amongst ISMs (.027/mm);
- poor strength and durability;
- poor fire resistance;
- fire retardants may evaporate;
- easily damaged.

A.4.3 **Extruded Polystyrene Sheathing** is used as a base for wall and interior ceiling finishes, insulation for foundation walls and slabs on grade and for cavity masonry walls.

a) **advantages:**
- relatively high strength;
- high RSI value/mm (.035 mm);
- high resistance to moisture.

b) **limitations:**
- low moisture permeability;
- relatively high cost;
- easily damaged.

A.4.4 **Polyurethane/Polyisocyanurate** insulating materials are rigid foams sandwiched between aluminum foil skins (sometimes reinforced with glass fibre). They can be used as non-structural ISMs in both frame and cavity walls.

a) **advantages:**
- highest RSI value/mm (0.042/mm);
- fairly durable;
- foil reduces aging and gas emission.

b) **limitations:**

- high material cost;
- low permeability;
- damage easily.

A.4.5 Low-Density Wood Fibre Sheathing

a) **advantages:**

- used extensively;
- relatively cheap.

b) **limitation:**

- low RSI value.

APPENDIX B

THERMAL RESISTANCE VALUES OF COMMON BUILDING MATERIALS

Contents

B.1 THERMAL RESISTANCE VALUES OF COMMON BUILDING MATERIALS

Material	R/inch	RSI/mm
Insulation		
Fibreglass batt	3.17	.022
Rock wool batt	3.32	.023
Fibreglass loose (blown)	2.16	.015
Rock wool loose (blown)	2.74	.019
Cellulose (blown)	3.61	.025
Expanded polystyrene	3.89	.027
Extruded polystyrene	4.62	.032
Polyurethane (rigid)	6.06	.042
Fibreglass sheathing	4.47	.031
Cladding Materials		
Fibreboard siding	.45-.57 (3/8")	.10-.08 (9.5 mm)
Softwood lapped siding		
drop —	.80 (3/4")	.14 (18 mm)
bevel —	.80-1.0 (1/2"-3/4")	.14-.18 (12-19 mm)
Plywood	.57 (3/8")	.10 (9 mm)
Wood shingles	1.0	.17
Brick	.30-.42 (4")	.053-.074 (100 mm)
Stucco	.20 (1")	.001 (25 mm)
Metal clapboard with backing	1.40	.246
Sheathing Materials		
Softwood plywood	1.25	.0087
Mat-formed particleboard	1.25	.0087
Insulating fibreboard	2.45	.017
Sheathing paper	.06	.0004
Structural Materials		
Softwood lumber	1.25	.0087
Cedar logs and lumber	1.33	.009
Concrete		
high density	.06	.0004
low density	1.00	.006
Concrete block (3 oval core)		
sand and gravel aggregate	1.14 (8")	.20 (200 mm)
cinder aggregate	1.70 (8")	.30 (200 mm)
lightweight aggregate	1.99 (8")	.35 (200 mm)
Common brick		
clay or shale	.40 (4")	.07 (100 mm)

Material	R/inch	RSI/mm
Interior Finishing Materials		
Gypsum board	.45 (1/2")	.08 (13 mm)
Gypsum plaster (sand)	.10 (1/2")	.018 (13 mm)
(lightweight)	.32 (1/2")	.05 (13 mm)
Plywood	.40 (1/4")	.07 (7.5 mm)
Hardboard	.18 (1/4")	.032 (6 mm)
Fibreboard	2.39 (1")	.42 (25 mm)
Drywall	.45 (1/2")	.08 (13 mm)
Air Surfaces		
Horizontal surface (upward heat flow)	.61	.11
Horizontal surface (downward heat flow)	.92	.16
Vertical surface (Horizontal heat flow)	.68	.12
Moving air 7.5 - 15 mph	.17-.25	.03-.04

B.2 RESTORATION INSULATION MATERIALS - ADVANTAGES AND DISADVANTAGES

B.2.1 Batt/Mineral Fibre Insulation Materials. **Fibreglass** is a product consisting of long filaments (fibres) of spun glass, loosely bonded and cut into batts (1.2 m long). The fibres are coated with phenolic resins to provide bonding properties. The batts are usually unfaced, in which case they are called **"friction fit" batts.**

a) **advantages:**
- reasonable cost per RSI value;
- easy to install;
- relatively non-combustible (friction fit);
- resistant to water damage and non-settling;
- pre-manufactured with high quality.

b) **limitations:**
- cannot be installed in an enclosed cavity;
- awkward to use in tight or cramped spaces.

B.2.2 **Rock Wool** is a slag or rock product quite similar to fibreglass.

a) **advantages:**
- RSI factor per unit thickness approximately 10% greater than fibreglass.

b) **disadvantages:**
- damages easily during handling;
- produces considerable amounts of dust;
- are not readily available in most parts of Canada.

APPENDIX C

RESISTANCE TO MOISTURE FLOW OF COMMON BUILDING MATERIALS

Material	Average R.M.F. (1/Perm) 10^{-2} Pasm^2 ng
VAPOUR BARRIERS	
.15 mm (6 mil) polyethylene	30.0
.10 mm (4 mil) polyethylene	22.0
.05 mm (2 mil) polyethylene	11.0
PAINT AND WALLPAPER	
1 coat latex vapour barrier paint	2.9
vinyl wallpaper (normal thickness)	1.8
2 coats oil-based paint on plaster	0.9
ordinary wallpaper	0.1
INSULATIONS	
25 mm extruded polystyrene	2.8
25 mm polyurethane (rigid)	1.8
25 mm expanded polystyrene	0.4
100 mm rock wool	0.06
100 mm cellulose fibre	0.06
100 mm fibreglass wool	0.06
OTHER BUILDING MATERIALS	
100 mm glazed tile masonry	14.5
13 mm CDX plywood	3.4
5 mm asbestos-cement board	3.2
100 mm brick	1.8
200 mm concrete block	0.9
19 mm board (wood)	0.6
3 mm hardboard	0.2
6.8 kg tar paper	0.1
plaster	0.09
builders' sheathing paper	0.04
gypsum drywall	0.03
13 mm insulating board	0.03

NOTE: Under normal conditions any material with a Resistance to Moisture Flow (RMF) value of greater than 1.7 is sufficient to protect the structure from damage due to water vapour diffusion. To avoid creating excessive condensation from this flow of water vapour, it will be necessary to keep the outer surface of the wall or roof enclosure at least five times more permeable than the indoor surfaces. In the case of insulating exterior sheathings, it is essential to apply a continuous vapour barrier on the indoor surfaces with a RMF value of 22 (10^{-2}) (e.g., 15 mm polyethylene).

APPENDIX D
RESPIRATORS

Contents

D.1 TYPES OF RESPIRATORS

The use of respirators on the work site is mandatory at all times during the exposure of UFFI. The users of respirators must know their uses and limitations, including basic rules of fitting and testing, maintenance and repair, cleaning and storage.

There are two basic types of respirators:

D.1.1 Positive Pressure Respirators. There are two variations on this kind of device. One uses an air supply connected to the user's mask by a hose to supply the required air flow. The second uses a pressure cylinder much like a SCUBA tank carried by the user. Both types provide superior protection to workers in polluted environments because the breathing atmosphere is independent of atmospheric conditions. However, contractors have indicated some disadvantages to using this type of system. When sandblasting is used, an air supply must be provided to the blasting hood (Appendix F).

D.1.2 Air Purifying Respirators. Ordinary organic vapour respirators are ineffective for formaldehyde. UFFI workers should wear NIOSH-approved respirators, one for formaldehyde (HCHO) and another for acid gas (SO_2) (See 8.1.5). These cartridges filter out pollutants by trapping particles in the filter. Dust/mist pre-filters must also be used in conjunction with these masks. Filter-type masks do not supply air to the user and as they become clogged, the worker will experience increasing difficulty in breathing. Cartridges become saturated after a period of use, depending on the concentration and exposure, and must therefore be changed in accordance with the manufacturer's advice.

Only a limited number of manufacturers produce respirators for protection against formaldehyde while working with UFFI. An up-to-date list is available from distributors or upon request from the UFFI Centre.

D.2 SELECTION

It is necessary to select the type of respirator which is effective for the particular contaminant which is present in the work environment. In the demolition of UFFI houses, the major concern is formaldehyde gas, therefore a formaldehyde respirator must be worn by all workers on the site. It is important to have proper fit when the respirator is purchased (see D.3). Because of the possible presence of other forms of pollutants such as fungal spores and other UFFI particles, a dust/mist pre-filter must also be worn with the air purifying respirator.

D.3 FITTING

Test fitting consists of trying on respirators until a size and fit is achieved which is tight all around the seal, with no gaps in the continuity. Before proceeding to the work area, the worker must ensure that the respirator fits properly.

D.4 USE

a) use respirators strictly in accordance with procedures specified by the equipment manufacturer or CSA requirements;

b) change the pre-filters when breathing becomes difficult (indicating that the filters are becoming clogged);

c) change the cartridges or canisters after each use if they are used for demolition procedures. If used in normal working situations, change the cartridges or canisters when you smell or taste the contaminant, or notice irritation in your nose, mouth or throat;

d) if cartridges or filters are used in pairs, change both cartridges or filters at the same time. When cartridges and pre-filters are used in combination, you may need to change the pre-filters more often. However, when changing cartridges, it is good practice to change the pre-filters at the same time.

D.5 MAINTENANCE AND STORAGE

a) **Inspection.** Respirators should be checked regularly to ensure that all parts are in good order. Any required repairs, replacements or adjustments must be ensured by the foreman and verified by the wearer;

b) **Cleaning.** CSA standards require users to clean and disinfect respirators regularly. Instructions for cleaning the respirator will come in the packaging, or may be obtained from the supplier;

c) **Storage.** After inspection and cleaning, respirators should be stored in sealed plastic, in a cool and dry atmosphere, ensuring that they are not distorted.

D.6 RESPONSIBILITY

The employer is responsible for ensuring that respirators are properly maintained and that employees wear them as required during corrective measures. Workers must be trained in the proper use, care, maintenance, cleaning, repair, storage and limitations of the respirator being used.

D.7 USE OF RESPIRATORS

The users of respirators must know their uses and limitations, including basic rules for fitting, testing, maintenance and repair, cleaning and storage.

The following basic rules apply:

a) use respirators strictly in accordance with the procedure specified by the equipment manufacturer;

b) train workers in the proper use, care, maintenance, cleaning, repair, storage and limitations of the respirator being used;

c) wear the respirators properly with straps well positioned and secured;

d) ensure that compressed air respirators, with a portable cylinder and positive pressure mask, meet CSA standards;

e) ensure that compressed air from a portable cylinder or compressor or both, meets the CSA Standard Z94.4-M1982 for Compressed Breathing Air;

f) disinfect, inspect and clean respirators used by each worker at least once every day. Clean and disinfect respirators used by more than one worker after each use;

g) replace deteriorated parts of respirators immediately or discontinue use until the unit is repaired;

h) thoroughly test respirators before each use, at least once per month, and service after each use;

i) store the respirators and replacement parts carefully in a convenient, clean and sanitary location. Protect inhalation and exhalation valves and other key parts which restrict the intake of airborne contaminants.

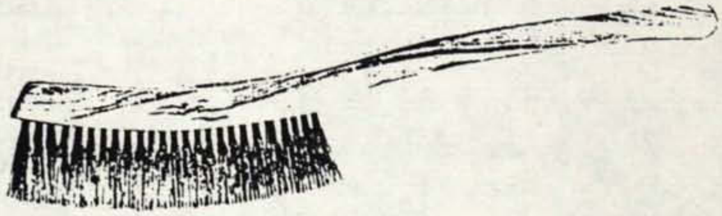
Close supervision is necessary to ensure that workers comply with these basic rules because they tend to be concerned more about the discomfort and inconvenience of the equipment than about safety.

APPENDIX E

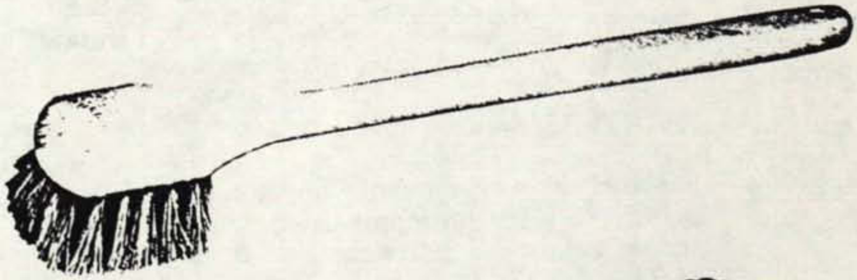
RECOMMENDED EQUIPMENT

BRUSHES

A long, narrow brush with stiff bristles is especially good for extremely narrow areas

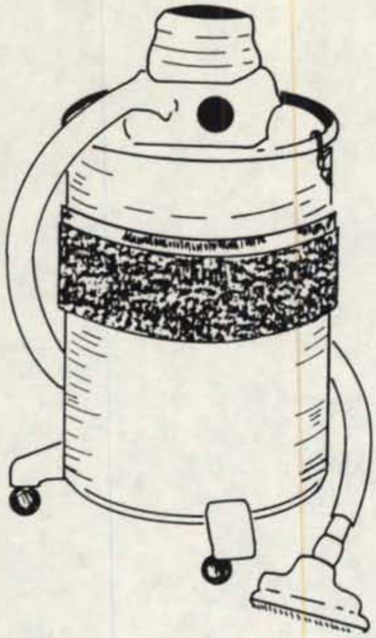


A long-handled brush is particularly useful in hard to reach cavities



A knob type scrub brush is the best choice for general all purpose brushing. Longer handles permit cleaning of areas difficult to reach with other brushes.

A scrub brush, which is designed for added working strength, has a hardwood block handle and hard working cleansing fibres with glazed ends for corner scrubbing, can be used during a follow up second brushing of surfaces which were in contact with UFFI.

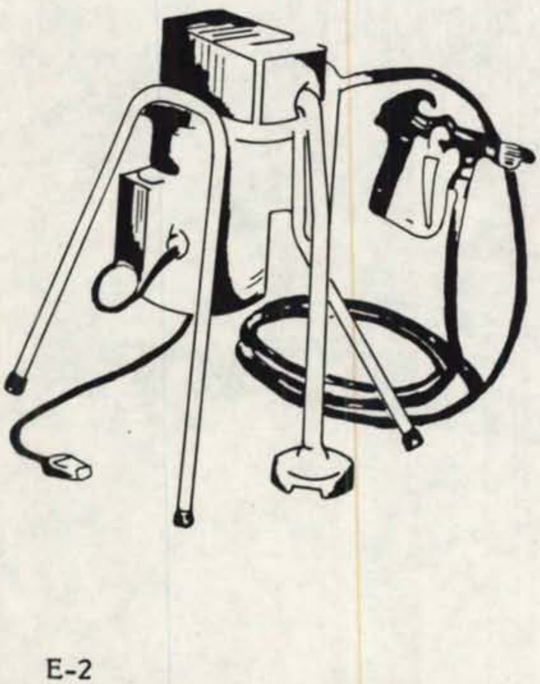


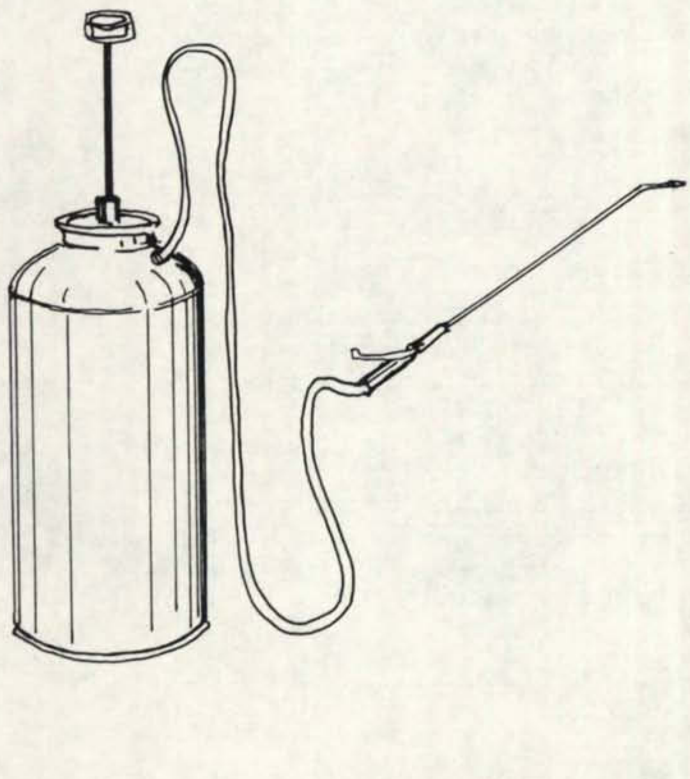
INDUSTRIAL VACUUMS

A variety of Canadian manufacturing firms produce industrial vacuum cleaners which would be suitable for use by a contractor during removal and cleaning procedures. The contractor should choose a machine with an extremely long hose of large diameter for removing large chunks of material. The attachments for the machine should include a long head capable of reaching into narrow cavities. Its capacity can vary from five to twenty gallons. A dry vacuum should be adequate. The vacuum should be located outside with sufficient suction hose to reach indoors. If located indoors, use an exhaust hose long enough to exhaust outdoors. The exhaust air may be bubbled through a large bucket of water to trap UFFI particles and formaldehyde.

SPRAYERS

For the sake of convenience, electric airless spraying equipment has been chosen by contractors for the application of the 3% sodium bisulphite solution. The equipment should either be lightweight or have a hose of sufficient length to spray difficult to reach cavities. In some cases, hand pump sprayers have proven adequate.





APPENDIX F
SANDBLASTING

Contents

F.1 INTRODUCTION

Sandblasting has been used successfully as an alternative to brushing and vacuuming. The operation cleans wood components quickly but the extra costs for set-up and tear-down time, special equipment and clothing can be prohibitive. Advice should be sought from experienced users and suppliers.

F.2 PROCEDURES

F.2.1 Exterior Removal:

a) identify wall cavities where UFFI exists;

b) erect scaffolding around walls;

c) tape polyethylene on the exterior of all openings such as, windows, fans, dryer exhaust ports, and chimneys;

d) stretch 6 mil polyethylene sheets over scaffolding to cover walls to create a work "tent";

e) create a positive internal pressure with a 1000 cfm fan connected to the house by a ten metre long, 600 mm diameter polyethylene sleeve, on the side furthest away from the removal site. The sleeve can be taped to a sheet of plywood fitted in the doorway, or taped through a rear window. Only clean air must be blown into the house. Installation of a pre-fan air filter and periodic cleaning of the filter is recommended;

f) check the existance of a positive pressure in the house by observing **slight ballooning** of the polyethylene taped-over window;

g) open cavities and remove the bulk of the foam;

h) connect high pressure hose from compressor to the sand blaster tank;

i) fit the nozzle to the high pressure air hose from the sand-blaster. Experiment to choose the nozzle most appropriate to achieve the best scatter pattern: with 30/30 silica sand and 5.6 kg/cm^2 pressure, a 6 mm orifice, venturi type nozzle is probably best. Make sure that the air used is dry, otherwise wet sand will clog the valves. Shortening of the nozzle might be required to reduce the temperature of air leaving the nozzle;

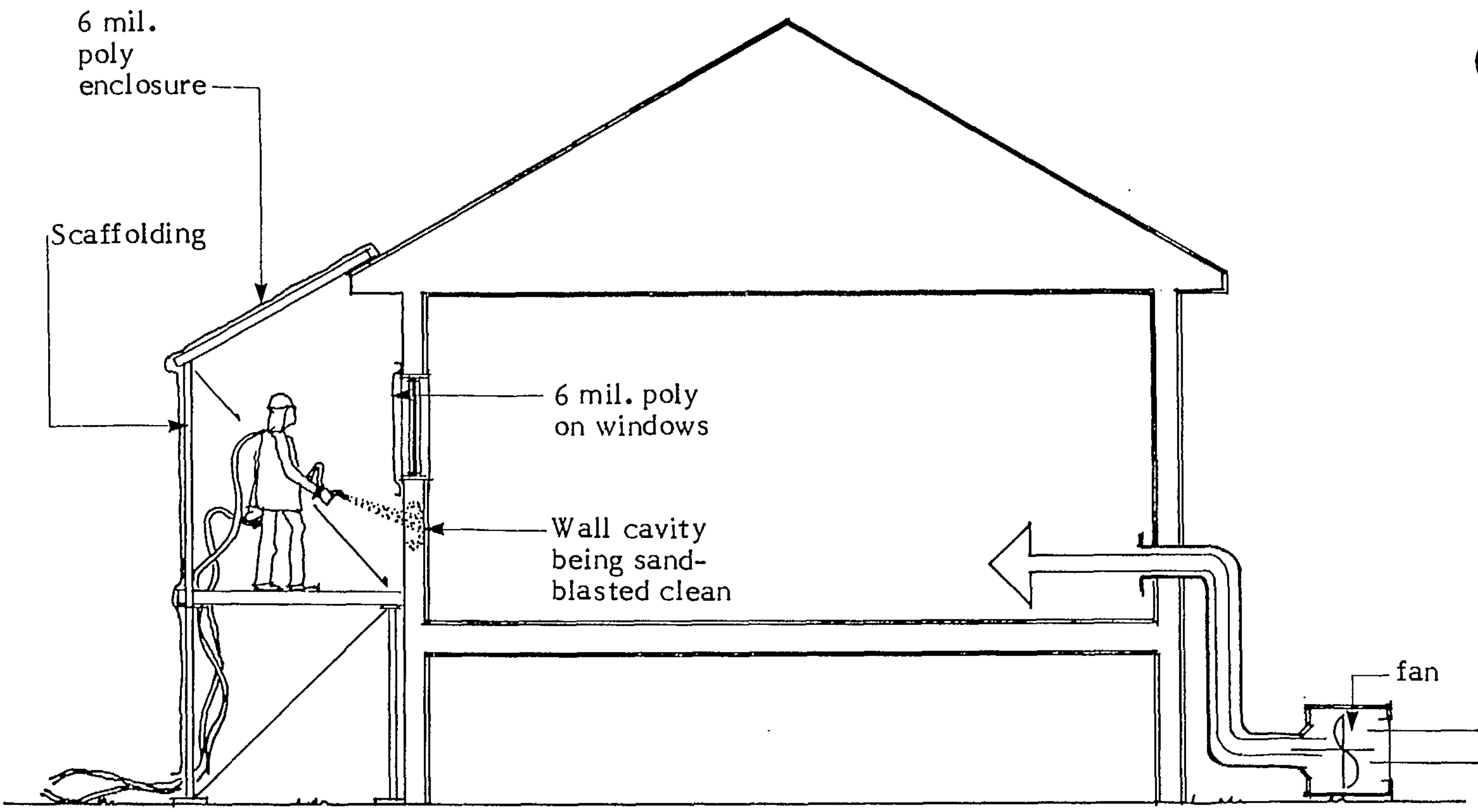
j) connect the hood air supply line via an inline air filter and pressure regulator. Make sure that the air supplied is breathable and free of oil mist, dust, carbon monoxide or other toxic gases.

NOTE: The use of a high-pressure quick-connect is recommended.

k) using the controls on the sandblaster tank, adjust the air pressure and sand flow for various cavity surfaces;

l) clean and neutralize the cavities before collapsing the "tent".

NOTE: For safety considerations, use compressors with safety covers and garbage containers with high sides.
Check with the supplier as to the possible presence of toxic gases in compressed air.



F.2.2 **Interior Removal.** Same as exterior -- except polyethylene sheets are erected from ceiling to floor about 2 m from the wall.

Wires and fixtures should be protected against damage.

A vacuum cleaner should be operating to ensure air movement to the exterior. Exhausted dusty air should preferably be purged through a water container.

F.3 AIRLINE FILTERS

Air Filters remove most of the oil, condensed water, particulates, odours and organic vapours (but not carbon monoxide), while providing a cleaner air supply for one to four users.

a) heavy duty compressors should have an extremely rugged inside and outside to resist corrosion;

b) high capacity filtering can be achieved by using a large disposable filter cartridge allowing longer periods of filtration, or by arranging two or more filters in parallel for even greater capacity;

c) lightweight models weigh about 10 kg and are easily portable with carrying handle;

d) efficient air flow should remain high with a minimum pressure drop during use;

e) maintenance should be minimum; that is, the unit should be simple to install, self-contained, and ready to operate on site;

f) the unit should supply dry, clean air to tools and pneumatic systems to reduce down-time repair costs.

WARNING: Air filters do not remove carbon monoxide and other toxic gases.

F.4 AIR-SUPPLIED BLASTING HOOD

F.4.1 Requirements. The air-supplied blasting hood should meet MESA/NIOSH requirements and should offer the operator:

a) controlled safety;

b) air conditioning (optional);

c) good visibility;

d) low noise level.

F.4.2 Features. Some air supplied hoods are molded in one piece with a rugged outer cape which will stand up under the toughest blasting conditions. Self-adjusting head band, inner cape and uniform air distribution assure a comfortable and clean condition at all times. The hood should meet impact, penetration and insulation requirements. The hood should conform to NIOSH Approval No. TC 19C--84, type C&CE (schedule 19C). Other features should include adjustable belt, air control valve, breathing tube assembly of 8 m of non-kink air hose and a large plastic window that is easily replaced through the hinged window frame. The use of an air purifier is required with all air supplied hoods.

F.5 SANDBLASTING NOZZLES

Sandblasting nozzles come in many different lengths and shapes. Each one is designed for a particular purpose. Metric conversions for dimensions, air flow rates, power ratings and weights related to nozzles and the air requirement chart were not readily available at time of publication.

F.5.1 Long Straight Orifice Nozzles.

a) the (nominal) 3" long nozzle is considered a general all-purpose nozzle. It has been called the "shot gun" because it is designed for close-up blasting (less than 30 cm from surface being cleaned);

b) the (nominal) 6" long nozzle is often referred to as the "rifle". The barrel concentrates the blasting pattern and is able to maintain a distance of between 30-60 cm from the surface. Both style nozzles are manufactured with long wearing liner.

F.5.2 Ceramic 3" Long Straight Orifice Nozzles. Although ceramic nozzles are more durable than steel or iron types, they are recommended only where blasting is done on an occasional basis. These nozzles are suitable for use with sand or aluminum oxide, and can be used in cabinet or outdoor operations.

F.5.3 **Angle Tungsten Carbide Nozzles** were developed specifically for cleaning the inside surfaces of pipes, tubes, cylinders and other applications where an angle in the blasting stream is desired. Many industrial users have successfully increased production by replacing straight barrel nozzles with angle types when cleaning hard-to-reach areas.

F.5.4 **Boron Carbide-Venturi Nozzles** (3"- and 6"-long straight orifice) are guaranteed for a minimum of 750 blasting hours with sand and 1500 hours with metal grit or shot. When blasting with aluminum oxide or silicon carbide, boron carbide nozzles only are recommended.

NOTE: Manufacturers should be consulted as to requirements regarding weight and density of sand, air pressure and horsepower.

APPENDIX G
TYPES OF HEAT RECOVERY VENTILATORS

Contents

G.1 Types of HRVs. Plate-type units are most commonly used for residential application. Heat pipe units, capillary blowers and rotary type models are also available. There are a number of other types (thermosyphon, coil and pump loop), but they are not readily available for residential application in Canada.

a) **Plate-type heat exchanger** is the most commonly available type for residential use. Basically, a sandwich of thin plates is used to separate the air streams, with exhaust and fresh air passing through alternate separations (i.e., fresh air flows through every second space, and exhaust air flows through the spaces between). The plates are arranged to maximize the surface area over which the air streams pass. A temperature difference between the two air streams causes heat to flow from one to the other through the plates.

Plates are constructed of various materials, such as aluminum, glass, polypropylene, polyethylene, treated paper, ABS, styrene.

A drawing of a plate-type heat exchanger is shown in Figure 7.4. It is simple in construction, with no moving parts except the fan and is generally reliable. Cross leakage (crossing of the two streams) is low if the seals at the edges of the plates are properly designed and installed. The thermal effectiveness for this type is in the range of 40% to 80% for most design flow rates.

Provision for automatic defrost is normally required.

b) **Heat pipe heat exchanger** resembles a plain straight pipe which is sealed at both ends. It can conduct heat effectively. The pipe is charged with a working fluid (e.g., a refrigerant) which acts as a heat transfer medium. Heat is transferred into one end of the tube and absorbed by the fluid (see Figure 7.5a). The fluid vaporizes and is propelled by locally increased vapour pressure toward the colder end of the pipe. Here the vapour condenses, releasing its latent heat through the heat pipe wall.

A wick structure returns the fluid to the evaporation section while ensuring an even distribution of fluid on the inner wall of the heat pipe.

A drawing of a heat pipe HRV is shown in Figure 7.5b. The exhaust air stream passes through the condensor side of the heat pipes while the incoming fresh air stream passes the evaporator side. The air streams are separated by a plate through which the heat pipes pass.

Residential heat pipes are normally made of aluminum or copper and contain a non-toxic working fluid such as Freon. Heat transfer may be enhanced by the addition of metal fins.

The unit has no moving parts except the fan. Cross leakage is usually very low. Thermal effectiveness for this type is in the range of 60% to 80% for most design flow rates.

Defrost is normally required.

c) **Rotary heat exchanger**'s heat transfer core is often referred to as a "heat wheel". As it rotates in the casing, any given point on the core passes alternately through the supply and exhaust air streams. Energy is transferred from the warm air stream to the heat transfer medium (the core) which then transfers the energy to the cooler air stream. A drawing of a rotary heat exchanger is shown in Figure 7.6.

Heat transfer media can be made of metallic and non-metallic materials. Examples are woven aluminum, corrugated aluminum foil and permeable synthetic foam.

Rotary heat exchangers require two fans, one for each air stream, usually built into the unit. In addition, there is a power requirement for the rotating core. Some cross leakage and moisture transfer occurs. Defrost is not normally required. Thermal effectiveness can range from 60% to 80%.

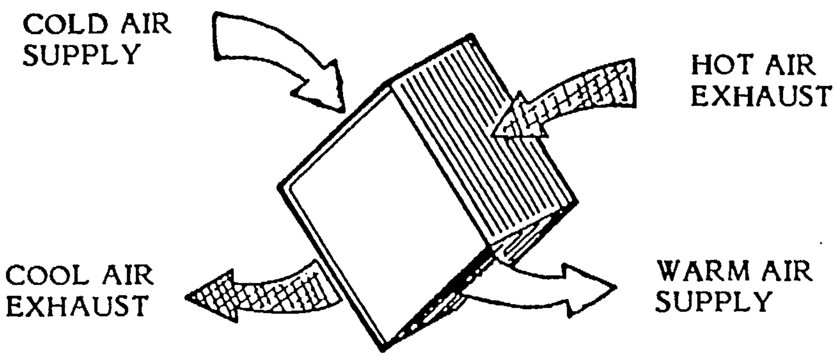
d) **Capillary blowers** eliminate the need for a separate fan by combining into one element the core and the means of moving the air. The design is simple and compact.

The blower is comprised of a permeable material which, when rotated, generates air flow by centrifugal action. Supply and exhaust streams are separated by a baffle inside the permeable ring and by ducts outside. As with the heat wheel, heat exchange takes place as elements of the permeable ring pass alternately between the cold and warm air streams. A drawing of a capillary blower is shown in Figure 7.7.

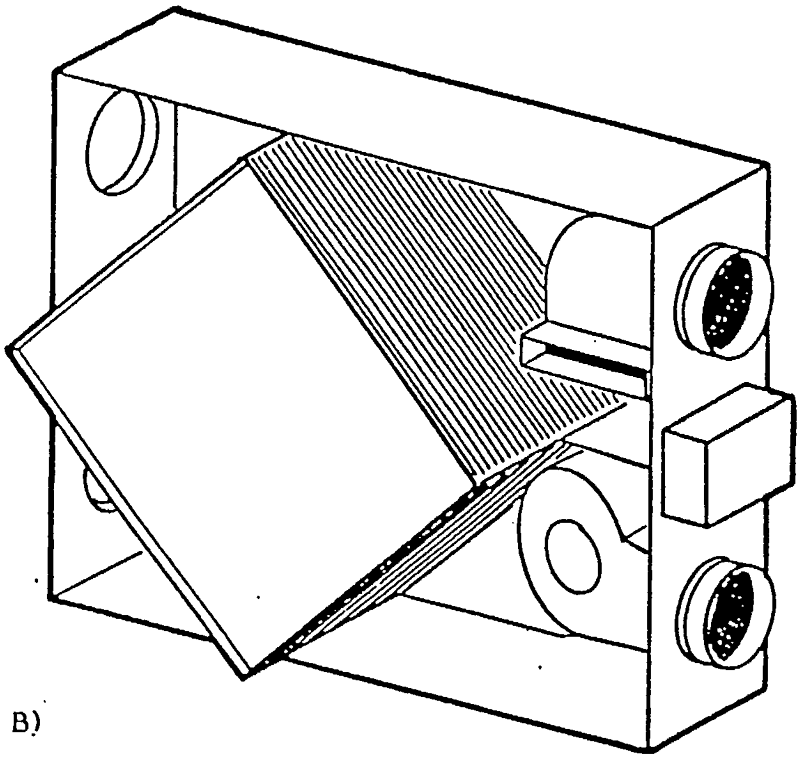
Cross leakage and moisture transfer can occur. Defrost is not normally required. Thermal effectiveness generally ranges from 40% to 50%.

e) **Coil energy recovery loop.** Fluid is circulated by means of valves and a pump through finned tube coils located in both air streams. There is a high flexibility for installation of this system; however, the installation costs and maintenance requirements are restrictive.

G.2 ILLUSTRATIONS

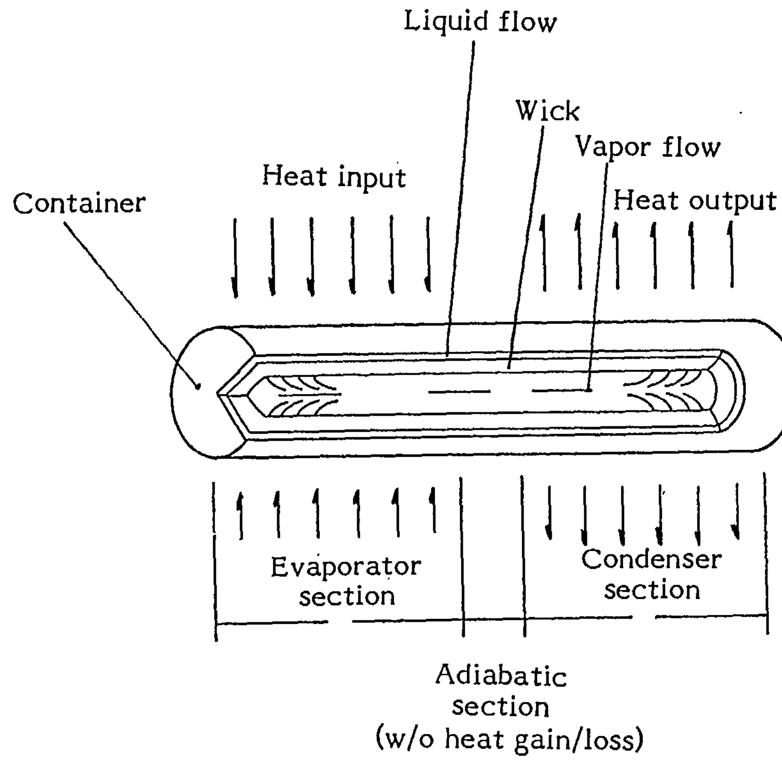


A)

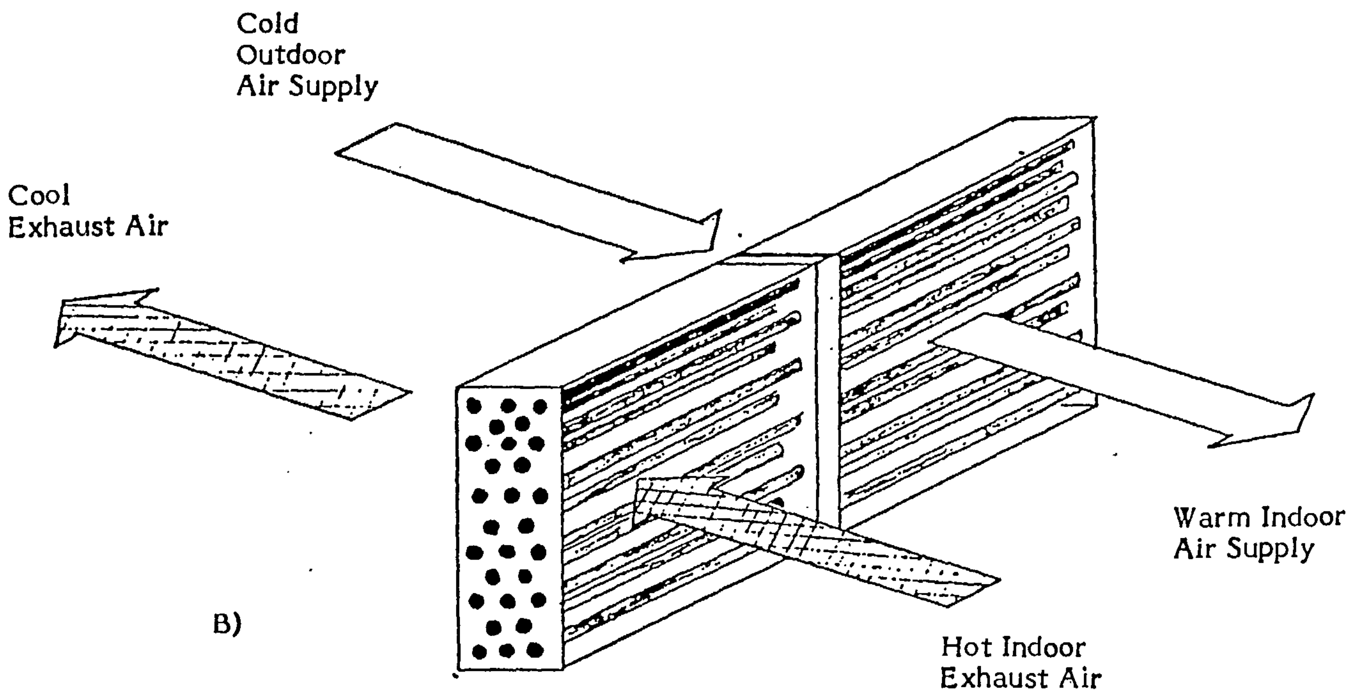


B)

FIGURE G.1 A) PLATE-TYPE HEAT EXCHANGER CORE
B) CUT-AWAY VIEW OF A PLATE-TYPE HRV



A)



B)

FIGURE G.2 A) HEAT PIPE
B) HEAT PIPE HRV

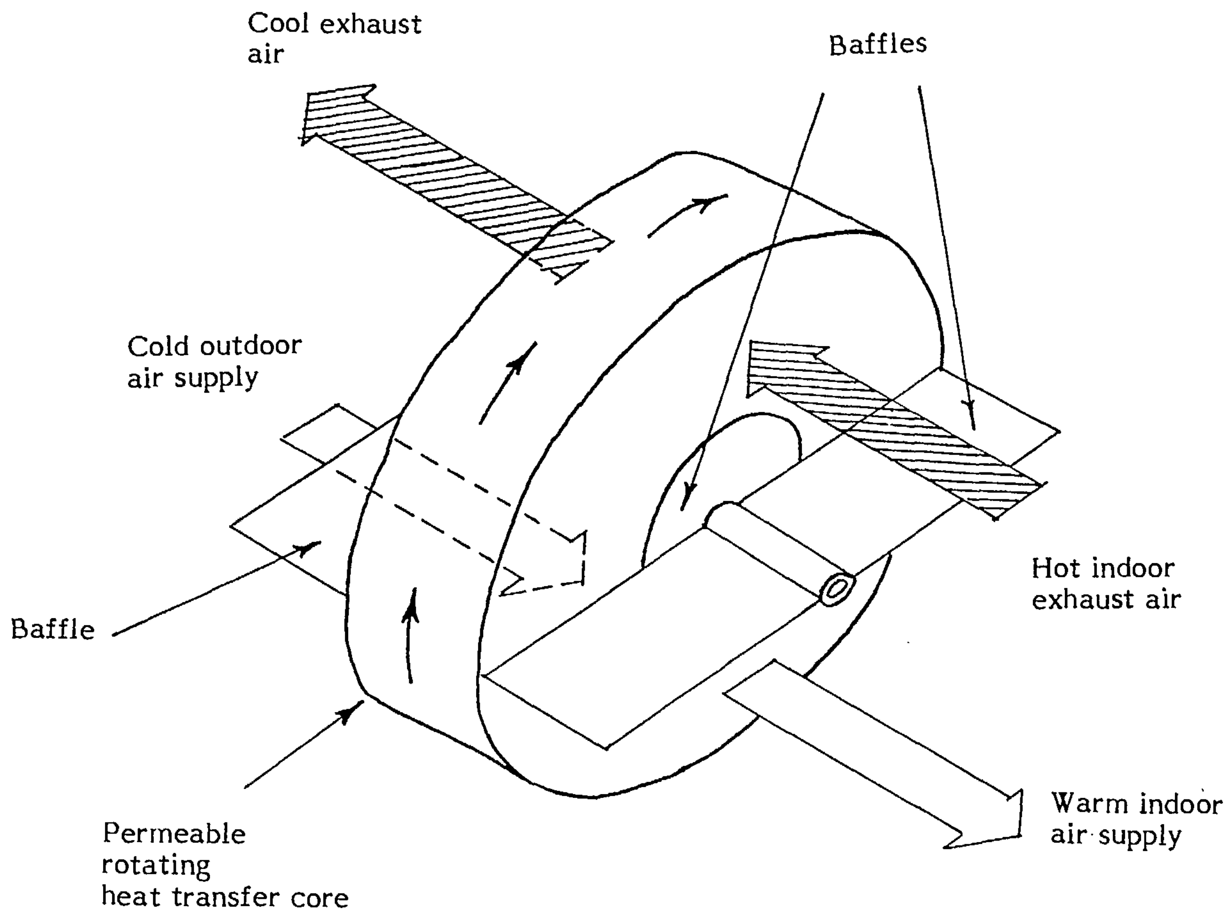


FIGURE G.3 ROTARY HRV

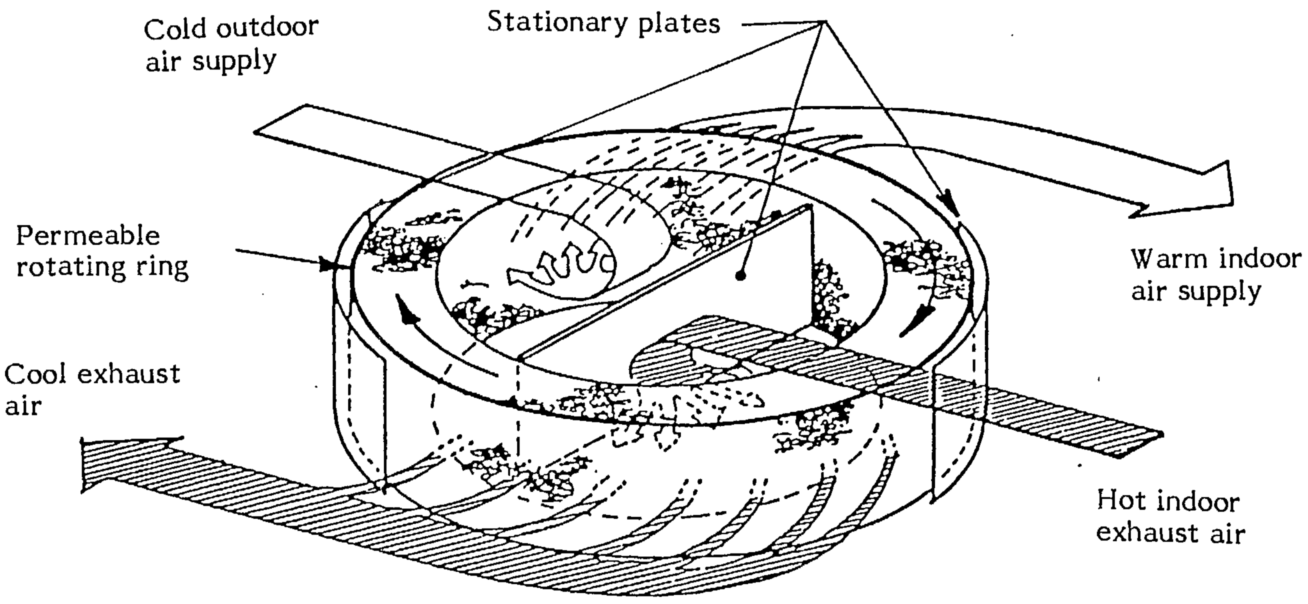


FIGURE G.4 CAPILLARY BLOWER HRV

APPENDIX H

INSTALLATION GUIDELINES FOR HEAT RECOVERY VENTILATORS (HRVs)

Contents

APPENDIX H

INSTALLATION GUIDELINES FOR HEAT RECOVERY VENTILATORS (HRVs)

The following objectives and guidelines pertain only to HEAT RECOVERY VENTILATOR (HRV) ventilation measures for UFFI homes based on current state of the art knowledge, and are subject to future changes arising from research and development in the field of residential ventilation.

H.1 OBJECTIVES FOR THE USE OF HRVs IN THE UFFI PROGRAM

a) that the unit will provide sufficient ventilation to reduce the concentration of formaldehyde in UFFI homes. The size and installed air delivery capacity will depend upon the requirements of the house in question;

b) that these units will not contribute substantially to negative or positive pressure in the house. Balancing, defrost and fail-safe features must be incorporated in the system;

c) that ductwork be installed in such a way as to minimize the resistance to air flow in order that the unit will be able to perform at its optimum capacity;

d) that installation of HRVs and the associated ductwork and accessories shall be done only by contractors who have been trained by the manufacturers and in accordance with UFFI Centre guidelines.

H.2 GUIDELINES FOR THE INSTALLATION AND OPERATION OF HRVs USED IN THE UFFI PROGRAM

The following guidelines are based on the third draft of the Canadian Standards Association Guidelines C-444 for the installation of Heat Recovery Ventilators and have been modified to suit the purpose of the UFFI Program.

NOTE: The numbering system follows that of the CSA standard rather than that of this Manual.

H.2.1 Scope

1.1 this standard covers the installation guidelines for self-contained heat recovery ventilators that comprise factory-assembled elements in which heat is transferred between two isolated air streams. The heat recovery ventilator will have a maximum rated capacity of not less than 25 l/s and not more than 200 l/s;

1.2 this standard covers heat recovery ventilators for installation in existing homes with urea formaldehyde foam insulation;

1.3 this standard includes equipment selection, minimum installation guidelines and information to be provided to the homeowner;

1.4 where reference is made to other publications, such reference shall be considered to refer to the latest edition and any revisions thereto approved by the organization issuing that publication.

H.2.2 Definitions

The following definitions apply in this standard:

a) **balanced system:** a ventilation system in which the flow rates of the exhaust air leaving the building is equal to the supply air entering the building as measured at the heat recovery ventilator;

b) **qualified:** acceptable to the UFFI Centre;

c) **heat recovery ventilator:** a factory-assembled unit in which heat is transferred between two isolated air streams (previously referred to as air-to-air heat exchanger);

d) **hoods:** exterior wall terminals for the supply air inlet and the exhaust air outlet;

e) **net ventilation:** the amount of outdoor air entering the building through the heat recovery ventilator.

H.2.3 General Guidelines

3.1 Equipment

3.1.1 The heat recovery ventilator shall be accompanied by up-to-date, clear, correct and comprehensive instructions and pertinent tables or graphs for:

a) determining performance at other than rating conditions;
b) properly installing the equipment, including an air distribution system for providing delivered air in accordance with Chapter 32 of the ASHRAE Handbook of Fundamentals, 1981;
c) trouble-shooting malfunctions;
d) informing the homeowner about operation, minor trouble-shooting, and routine maintenance. This shall be provided to the homeowner as a separate manual;
e) label(s) intended to be affixed to any component of the system which require "caution, cleaning and/or maintenance" and the installer's service label;
f) the range of outdoor temperatures at which the equipment is designed to operate.

3.1.2 The heat recovery ventilator shall be equipped with means of automatic self-defrost if the equipment design is such that blockage may occur.

3.1.3 The heat recovery ventilator shall be shipped with a written warranty understandable to the purchaser.

3.1.4 An installation kit including vibration isolators, for both the equipment and duct connections, shall be available if not provided as an integral part of the equipment.

3.1.5 The heat recovery ventilator shall not be designed in such a way as to cause a net outflow of air from the building. If the supply fan is switched off to cause defrost, the exhaust flow shall be bypassed back into the building. Other means of defrost are acceptable, providing they do not contribute to house negative pressure.

3.1.6 The heat recovery ventilator shall be designed so as to shut off the exhaust air fan should an obstruction cause a decrease in the incoming air flow (fail-safe mechanism). Other methods are acceptable providing they do not contribute to house negative pressure.

3.2 Installation — General

3.2.1 The installing contractor shall ensure that the general guidelines of clauses 3.2.2 to 3.2.4 are carried out.

3.2.2 The installing contractor shall adhere to all applicable bylaws, codes and regulations, as well as specifications detailed by the manufacturer, wholesaler or distributor, and CSA Standard C22.1 - Canadian Electrical Code Part 1.

3.2.3 The CCA Heat Recovery Ventilator-Installation Data Form (CCA 2522), shall be completed by the registered installer and distributed as per the numbered code at the bottom of the form.

3.2.4 The individual who is directly in charge of the installation crew must be a qualified technician who has received manufacturer training, must be on site at all times while the work is being performed, and must be responsible for a competent job being done.

H.2.4 System Application

4.1 The system shall be applied with the assurance that the application meets the requirements of clauses 4.2 to 4.17.

4.2 The system application shall meet the requirements of all applicable bylaws, codes, regulations and standards.

4.3 The duct system shall be designed in accordance with the manufacturer's recommendations. Air duct size shall not be less than 125 mm in diameter (130 cm^2). Supply and return diffusers to have a minimum free area of 130 cm^2.

4.4 Fresh air for the ventilation of rooms and spaces for urea formaldehyde foam insulated homes shall be provided at a rate of one half (1/2) air change per hour by a combination of natural and mechanical ventilation. The mechanical rate of ventilation shall not be less than 1/4 air change per hour.

4.5 The system shall be applied to provide distribution of fresh air within the building, as specified in clause 4.4.

4.6 Equipment shall be located to optimize operating efficiency, due consideration being given to:

a) keeping duct runs from the heat recovery ventilator to the outside as short as possible and minimize bends and restrictions;

b) locating the equipment so as to minimize sound and vibration problems, i.e., avoid locating under or near rooms such as bedrooms, etc.;

c) locating the equipment so as to ensure good access for servicing;

d) location of supply and exhaust hoods in accordance with the heat recovery ventilator manufacturer's instructions, taking into consideration snow levels, automotive exhaust, other contaminants, and ensuring that hoods are not installed in restricted areas such as a garage or shed.

4.7 The heat recovery ventilator shall not be directly connected to any combustion appliance, clothes dryer, range hood exhaust or heating system.

4.8 Flexible non-metallic duct connections at the equipment shall be installed to minimize vibration transmission to the duct system, and noise transmission to the building.

4.9 The workmanship for the duct system shall meet industry acceptable standards and all joints shall be taped where possible.

4.10 All flexible ducts shall meet the requirement of ULC Class 1 Air Duct Connectors Standard No. 181.

4.11 Two or more units shall not be connected in parallel air flow, to a common air duct system, unless specifically approved by a regulatory authority.

4.12 Continuous fan operation shall be recommended with control of higher speed where applicable by one or more of the following:

a) dehumidistat/with manual over-ride;

b) interval timer/with manual over-ride;

c) manually operated switch.

4.13 The installation of insulation with vapour barrier shall be required for any ducts leading to and from the equipment to the outside, and must be sufficient to avoid the accumulation of moisture on the outside surface of the duct and the ventilator.

4.14 Where required, a minimum 15 mm nominal pipe size condensate drain, pitched in the direction of flow and complete with a trap shall be installed; free condensate flow to a building drain may be required.

4.15 All control wiring and supervision of the power wiring connections to all the heat recovery ventilator components shall be the responsibility of the contractor installing the heat recovery ventilator as referred to in clause 3.2.2.

4.16 The heat recovery ventilator and all condensate lines must be installed in a space where the temperature is maintained above the freezing point.

4.17 Warm air ducts shall be insulated against heat loss if located in an unheated area.

4.18 When an HRV is installed in an air-conditioned home, the homeowner must be advised that the HRV should be operated at the same time as the air conditioner.

4.19 Supply and exhaust hoods shall be equipped with bird screen which shall have a mesh size not less than 6 mm.

4.20 Rigid ducting must be used in the straightest possible runs and with minimum use of flexible ducts for connectors. The length of duct runs must be kept to an absolute minimum.

H.2.5 System Installation

5.1 The installing contractor shall ensure that the system installation meets the requirements of clauses 5.2 to 5.26.

5.2 All procedures recommended by the manufacturer of the equipment for start-up, including air balancing and air flow measurement shall be followed. To certify that all start-up steps including air balancing and air flow measurements have been done, the start-up mechanic shall complete and sign the UFFI Centre form (CCA 2522) - "Heat Recovery Ventilator Installation Data".

5.3 The equipment shall be installed to minimize any noise problems, and shall use the components from the installation kit referred to in clause 3.1.4. The equipment shall not come in direct contact with structural elements such as joists, sub-floors, walls, etc.

5.4 Filter(s) should be installed in accordance with the manufacturer's instructions. Clean air filter(s) shall be installed at start-up.

5.5 Access shall be provided for cleaning and servicing without moving the unit or requiring the use of special tools.

5.6 The outside supply and exhaust hoods shall be separated a minimum of 2 m and be installed such that the bottom of the hoods are a minimum of 450 mm above the finished grade. The hoods shall be installed to minimize cross-contamination and contaminants from other sources. Intake hoods shall not be located in the driveway unless no other location is possible, and if so necessary, shall be a minimum of 1.5 m above finished grade.

5.7 Supply and exhaust duct and hoods between the heat recovery ventilator and the outside wall shall be properly and correctly caulked and shall be properly sealed with an air vapour barrier. The hoods shall be sized to accommodate the ducts to which they are connected and must be identified as to which duct and hood is supply and which is exhaust.

5.8 The ductwork shall be installed by qualified personnel.

5.9 A means of balancing air flow in branch ducts shall be provided where necessary.

5.10 Any power wiring shall be installed by qualified personnel (see 3.2.2.

5.11 All of the control wiring and power wiring connections shall be thoroughly checked out at start-up.

5.12 All workmanship shall be of good calibre and in accordance with accepted industry practices and standards.

5.13 All ductwork and wiring shall be properly supported or clipped to prevent sagging, excessive movement or an unsightly installation.

5.14 Auxiliary condensate drains shall be installed wherever recommended by the manufacturer.

5.15 The system shall be adjusted for balanced air flows. Incoming and outgoing air flows through the system shall be balanced by means of manual adjustments on the heat recovery ventilator so as not to contribute to negative or positive pressure buildup in the home (see 5.2).

5.16 The results shall be recorded on the HRV Installation Data form as described in clauses 3.2.3 and 5.2.

5.17 All components and accessories of the system shall be a combination approved by the manufacturer.

5.18 The purchaser shall be given the manufacturer's operation maintenance information, and all information on special controls.

5.19 A sticker shall be affixed to all elements of the unit which require "caution, cleaning and/or maintenance" (see also clause 3.1.1(e)).

5.20 The heat recovery ventilator shall not be installed in such a way as to cause a net outflow of air from the building. If the supply fan is switched off to cause defrost, the exhaust flow shall be bypassed back into the building (see also 3.1.5).

5.21 The purchaser shall be advised of the need to verify that an adequate supply of combustion air is available for all combustion equipment or fireplaces. It is also recommended that a qualified organization and mechanic perform this verification.

5.22 Indoor grills and registers shall be located so that supply air is introduced into the building to minimize discomfort.

5.23 The installer shall review the system operation with the purchaser (see clause 3.1.1(d) and 5.18).

5.24 Indirect connections to the return air duct of the warm air heating system shall be positioned approximately 300 mm from said opening, and shall be sized in accordance with the manufacturer's instructions. In no case shall such an opening be installed into or within 2 m (6 1/2 ft) of the return air plenum.

5.25 Wall cavities shall not be used as ductwork. Ductwork is not to be run in wall cavities, except where proper joints and special wall ducting can be accommodated.

5.26 An installer's service sticker shall be affixed to the unit so that the label is easily seen.

APPENDIX I
COMBUSTION AIR SUPPLY

Contents

I.7 SELECTED EXCERPTS FROM CSA B365-M-1982 INSTALLATION CODE FOR SOLID-FUEL BURNING APPLIANCES AND EQUIPMENT

I.1 INTRODUCTION

This appendix provides background information on the problem of supplying combustion air for combustion appliances, according to present standards and codes, particularly in UFFI homes sealed and ventilated according to Chapter 7. Provision must also be made for dilution and make-up air.

The background information includes excerpts from recent publications and codes as they apply to combustion air supply. The appendix includes:

a) general definitions;
b) fundamentals of air sealing;
c) excerpts concerning air supply from the applicable CSA code and the CGA code;
d) some current combustion air supply devices.

NOTE: These excerpts do not excuse the contractor from meeting all sections of each applicable code.

I.2 DEFINITIONS

I.2.1 **Appliance** is a device that uses a hydrocarbon and includes all valves, fittings, controls and components attached or to be attached thereto.

I.2.2 **Combustion Air** is that air which is required by combustion appliances in the home for the efficient combustion of fuel in the appliance.

I.2.3 **Dilution Air** is that air which is required for appliances with flues or chimneys to ensure adequate draft to carry combustion products out of the home.

I.2.4 **Make-Up Air** is that air which is required to be induced into the home to offset the air exhausted from the home.

I.3 AMENDED EXCERPT FROM "AIR SEALING HOMES FOR ENERGY CONSERVATION", SECOND DRAFT, EMR (BETT PROGRAM), 1984, CHAPTER 4

I.3.1 Fundamentals

a) **combustion appliances** include the following:
   - combustion furnaces (oil, natural gas, propane, wood or coal-fired);
   - combustion domestic hot water heaters (oil, natural gas or wood-fired);
   - fireplaces;
   - wood stoves;
   - space heaters (oil or natural gas-fired);
   - combustion cooking ranges (natural gas or propane);
   - combustion clothes dryers and refrigerators (natural gas or propane);
   - free-standing heaters (such as the kerosene heaters which have recently penetrated the market).

   Most of these appliances have flues but several, such as ranges, refrigerators and free-standing heaters, do not;

b) **combustion air requirements.** In houses with any of the above combustion appliances, air is required for burning the fuel and for ensuring that there is an adequate draft to carry combustion products out of the home (dilution air).

   The air required for burning and dilution is generally drawn from within the house and replaced by air infiltration or ventilation. Thus, the issue of combustion air supply is one of the quantity of air available , rather than the quality. For this reason, combustion air supply and air quality issues are treated separately in this Manual. Corrective measures for problems in each area also tend to be different, although there is some overlap and interaction.

An adequate combustion air supply is not a concern under two principal circumstances:

- when the appliances are provided with their own supply of air ducted directly from outside;
- when all of the heat-generating appliances in the home are electric and therefore do not burn fuel.

Air enters an appliance through the combustion chamber. The fuel, oxygen and in some cases, other components of the air, combine to produce combustion products (such as CO_2, CO, NO_x, SO_2, and other particulates, depending on the type of fuel and efficiency of the appliance). Along with excess air and dilution air, they are then exhausted outside through the flue.

Combustion air is only required when the burner is on. The amount required will depend on the rate at which fuel is burned. Pilot lights on gas appliances also require small amounts of air.

The air requirements for various combustion appliances are shown in Table I.1.

TABLE I.1

AIR REQUIREMENTS FOR COMBUSTION APPLICANCES (L/s - LITRES PER SECOND)

Appliance	Air Requirements		
	Combustion	Dilution	Total
Oil furnace (29.3 kW input)	13 L/s	55 L/s	68 L/s
Gas furnace (29.3 kW input)	11 L/s	31 L/s	42 L/s
Domestic hot water heater			9 L/s
Fireplace (2 kg of hardwood per hour)			188 L/s
Woodstove (6 to 9 kW)			5 L/s

Most houses contain a range of other exhaust vent systems, including:

- kitchen vents;
- bathroom vents;
- dryer vents;
- vents for built-in house vacuum systems.

The selection, design and location of these other systems will vary considerably from one house to another. Some may have fans and dampers while others (such as some ceiling vent ducts in bathrooms) may have none. Regardless, it is important to note that all these systems are designed to **exhaust** air from the house. Open windows can also be used as a ventilation system but differ from the above in that they allow two-way ventilation and are usually used only in warm weather.

When the exhaust vent systems are operating, they exhaust air from the house and reduce the pressure inside the house.

c) **consequences of inadequate combustion air supply.** If, for any number of reasons, there is insufficient combustion air available to an appliance, backdrafting, pulsations or sooting can occur. If the householder or contractor identifies any of these occurrences, a registered heating contractor should be called in immediately. (These occurrences can also result from a blockage in the chimney due to debris, ice build-up or some other cause see I.3.4.)

The most serious consequences occur when there is a backdraft of combustion equipment. This introduces a range of pollutants into the house. Nitrogen oxides, sulphur dioxide and carbon dioxide all cause respiratory problems; carbon monoxide is the most dangerous. It binds to red blood cells, displacing oxygen. At low levels, exposure can cause symptoms such as headaches, dizziness, weakness, nausea, vomiting and loss of muscle control. Exposure to high concentrations, for even short periods, can lead to unconsciousness, brain damage, and death.

I.3.2 Effects of Air Sealing depend on the level of airtightness that is achieved. If the sealing is aimed at achieving a moderate level of airtightness, then the air leakage processes of the house will generally continue to provide enough air for the combustion processes. For example, if the foundation is sealed, then the combustion appliances will tend to draw their air through other parts of the house envelope.

If the sealing achieves a high level of airtightness, then the rate of air leakage may not be enough to sustain the combustion processes. If this happens, the combustion appliances will compete with each other and with the ventilation systems in the house. This, in turn, can create various short-term hazards or longer-term air quality problems. For example, the interaction of a furnace and a fireplace could cause smoke, harmful flue gases or combustion products to be drawn back into the house. Similarly, when a bathroom vent, range vent, or dryer exhaust vent are operating, combustion appliances may backdraft.

There are many more undesirable interactions of this sort. **It is obvious that, where a house is sealed to a high level of airtightness, it may be essential to provide the house with an improved air supply system (dilution or make-up air) that provides enough air to avoid backdrafting and other related problems.**

It is most stongly recommended that, where a house is to be sealed to a high level of airtightness, the contractor should first educate the householder about the problems that might arise, and about the necessary improvements to the air supply system (with their associated costs).

I.3.3 Remedial Measures.

a) **introduction.** Where extensive air sealing measures result in such a high degree of airtightness that insufficient combustion air is available to the furnace or other combustion appliances in the home, **remedial measures must be taken.** Note that, in marginal circumstances, the combustion air supply may be sufficient until several such appliances operate simultaneously or an exhaust fan or open upper storey window creates negative pressure. This situation may be alleviated with the provision of a separate make-up air vent. Even marginal situations are dangerous, and must be identified and remedied. The house should be able to withstand the worst combination of conditions without creating any risk to the occupants. It is the air sealing contractor's responsibility to see that the house conforms to this requirement.

b) **problem indicators.** To determine the existence of a problem, there are three possible indicators:

i) the backdraft test identifies potential problems by simulating the conditions most likely to create backdrafting. Details of this test are not included.

ii) a fan depressurization test of airtightness is probably less sensitive to real-life situations. Using a door fan, the test can be performed to determine the rate of air infiltration after air sealing. If the rate is less than the combined requirements of the combustion appliances and exhaust systems (as determined by rated capacities and requirements), then there is a problem. It is difficult, however, to quantify the air supply requirements of a fireplace or intake through an open upper-storey window.

iii) if the occupants report combustion odours, sooting, pulsations of combustion appliances, backdrafting, or health problems, this is a strong indicator of a serious combustion air supply deficiency.

c) **correcting air supply problems** may be done in two ways:

i) precautionary measures to avoid occasional competition for air;
ii) remedial measures to solve ongoing problems of insufficient air for major combustion appliances.

d) **precautionary measures.**

i) fireplace air supply. A fireplace should have its own air supply and fireplace doors should be installed to minimize the possibility of inside air being drawn into the fireplace for combustion purposes. A 150 mm insulated duct can be run from outside to just in front of the fireplace. There should be an adequate damper that is closed when the fireplace is not in use. Alternatively, a window should be open in the same room as the fireplace when it is in use;

ii) open upper-storey windows should be avoided. Some homeowners leave them open because the upper floors are uncomfortably hot. The open window acts as an exhaust vent due to the stack effect. In these circumstances, the heat distribution system should be balanced by a heating contractor to prevent the upper floors from overheating, thus eliminating the need for the open window;

iii) exhaust fans, including kitchen and bathroom vents and automatic dryer exhaust vents, should always be used with discretion. Prolonged use wastes heat and could compete with the chimney. Power attic vents should not be run during winter or when the furnace is on, particularly if the attic has not been air-sealed. The power vent can pull air from the house into the attic.

e) remedial measures for insufficient combustion air involve several variations for bringing outside air to the combustion appliance:

NOTE: It is both dangerous and against the code to supply outside air via a duct connected directly to the burner or dilution air intake, unless the furnace is specifically designed for this arrangement.

i) **supplying combustion air to an enclosed furnace room.** If the furnace or other combustion appliance is in an enclosed room, outside air can be supplied through ducts running from outdoors into the furnace room. (Air ducts from outdoors can also be used where the combustion device is not situated in an enclosed room.)

Both gas and oil furnaces require two ducts. For details, contractors should refer to:

- "Installation Code for Natural Gas Burning Appliances and Equipment" (Canadian Gas Association CAN1-5149.1-M80), or
- "Installation Code for Oil Burning Equipment" (Canadian Standards Association Standard B139-1976). In the case of coal- and wood-burning appliances, refer to the appropriate codes.

If cold outside air is drawn directly into an enclosed furnace room, the room should be moderately well sealed from the rest of the house, using the sealing techniques presented in Chapter 6. The door should be weatherstripped and plenum and duct joints sealed with duct tape. Cloth-backed or high-temperature duct tape should be used on the warm air plenum joints.

Heat loss from the furnace body and warm air plenum counters the cooling effect of the incoming outside air. As a result, ambient temperatures in the area of the furnace should be between 10° and 20°C.

The temperature in the furnace room **should not be allowed to drop below about 10°C.** If it does, excessive condensation or even freezing may occur in the flue(s) and the operation of the furnace itself might be impeded. Some experts have suggested that one way to guard against this, is to install a small exhaust fan in the furnace room wall to bring warm air from the house into the room during furnace operation.

NOTE: Caution should be exercised in employing closed furnace rooms that isolate the furnace from the house, as there has been only limited experience with this approach to date.

ii) **new furnace.** If the homeowner is buying a new heating system, furnaces with low or no indoor air requirements should be considered. High efficiency gas condensing furnaces and induced fan furnaces require a minimal amount of dilution air. High efficiency gas pulse furnaces are provided with combustion/dilution air directly from outside. These types of furnaces do not require a chimney.

NOTE: The following are not adequate remedies for combustion air supply problems:

- heat recovery ventilators;
- outside air duct to cold air plenum (i.e., without an additional hole in the warm air plenum).

These systems are designed to deal only with humidity and air quality problems. If the house has been energy sealed or has both air quality and combustion air supply problems, remedial measures for both are necessary.

NOTE: The foregoing discussion of remedial measures for combustion air supply problems is intended for their general information only and not as a prescription for dealing with specific cases. This is a new and evolving area. When faced with such problems, the air sealing contractor should seek advice from knowledgeable experts in the field.

I.3.4 A Related Problem: Chimney Condensation. Condensation of water vapour in the chimney of a furnace is a problem that can exist in a house before air sealing. It causes poor draft and situations similar to insufficient combustion air supply. It is also a problem that can be triggered in some cases by air sealing and by conversion from oil to gas furnaces. The problem occurs when the exhaust gases cool to the point where moisture condenses on the sides of a chimney flue.

This can cause mortar and brick to deteriorate and fall down, sometimes blocking or constricting the flue. In extreme cases, ice can actually form (usually at the top) and block off the flue.

Chimneys should be inspected from the clean-out doors as part of regular furnace servicing and as part of a pre-air sealing inspection by contractors. The signs of condensation in chimneys are:

a) debris at the base of the chimney or at the base of a domestic hot water tank flue;
b) efflorescence (white powder) on the exterior surface of the chimney. Water vapour passes through the brick, picks up salts and deposits them on the outside surface of the brick;
c) water seepage or black stains from the clean-out doors;
d) deteriorating brick work (masonry turns to powder).

Chimneys susceptible to condensation damage include the following cases:

a) no chimney liner;
b) improper flue size;
c) decorative chimney cap;
d) frequent cycling of furnace, or long "off" periods;
e) oil to gas conversion.

If such problems exist, the remedial measures include:

a) installation of an approved metal chimney liner. Such a liner will heat up more rapidly than a masonry flue and will isolate any condensation that might occur from the brick;
b) downsizing an oil furnace (generally after air sealing and insulation) by reducing nozzle size. This lengthens the burn time and reduces frequent on and off cycles which contribute to condensation;
c) installation of an automatic flue damper which prevents warm moist air escaping up the flue when the furnace is off. (This is

not permissible in some provinces, such as Ontario, except where the damper is part of the original equipment or specifically approved.)

I.4 INTRODUCTION TO EXCERPTS

The codes (from which the portions below were selected) are written for the installation of new appliances. However, the contractor must verify the combustion air requirements as though a new installation of each appliance was being effected. It may be required that knowledgeable experts in each field verify individual systems and the full mechanical system in the home.

I.5 SELECTED EXCERPTS FROM: CSA CODE B139 (1976) "INSTALLATION CODE FOR OIL BURNING EQUIPMENT"

NOTE: The numbering system corresponds to that in the CSA code and not to the system in this manual.

I.5.1 Venting and Air Supply

4.1 General

4.1.1 When an oil burning appliance is located within a building, provision shall be made to vent the products of combustion safely to outside the building and such venting shall not pass through or be installed in return air, hot air, ventilating or combustion air ducts and shafts.

4.1.2 When an oil burning appliance is located within a building sufficient air for combustion of the oil and ventilation of the appliance shall be supplied to the space wherein the appliance is located.

NOTE: See CSA Code, Appendix A for information on supply of air for combustion and ventilation.

4.2 Venting Products of Combustion

4.2.1 General. The venting facilities shall be adequate to assure no hazard from the products of combustion.

4.3 Air for Combustion and Ventilation

4.3.1 General

4.3.1.1 Oil burning appliances shall be installed only where:

a) an adequate supply of combustion air is available to assure proper combustion;
b) ambient air temperatures are maintained within safe operating limits;
c) provision is made to compensate for the air drawn from the area by other appliances such as exhaust fans, clothes dryers or fireplaces.

4.3.1.4 Each duct used to convey air from the outdoors shall have:

a) a cross-sectional area throughout its length at least equal to the free area of the inlet and outlet openings which it connects;
b) a minimum dimension of 3 inches at any cross section.

NOTE: When considering ducting or ventilating openings reference should be made to applicable building regulations.

4.3.1.5 When an adjustable damper is provided in any opening intended to admit combustion air into the room within which the appliance is installed, the damper shall be interlocked to prevent any burner from starting before the damper is fully open.

I.6 SELECTED EXCERPTS FROM: CANADIAN GAS ASSOCIATION CAN1-B149.1-M80 "INSTALLATION CODE FOR NATURAL GAS BURNING APPLIANCES AND EQUIPMENT"

I.6.1 Section 6. Air for Combustion, Venting and Ventilation

6.1 General

6.1.1 An appliance shall be installed in a location where there is a sufficient air supply for combustion air, venting and ventilation air.

6.1.2 An appliance when installed shall not interfere with the proper circulation of the air supply. When a building is so tightly sealed that infiltration does not meet the air supply requirements, outside air supply shall be provided.

6.1.3 A duct used to convey air supply to or from the outdoors shall be of metal or other noncombustible material and shall be of the same cross-sectional area as the free area of the opening to which they connect. The smaller dimension of a rectangular duct shall not be less than 3 inches (75 mm).

6.1.4 When an air supply is required from the outdoors, as in Clause 6.1.2, Subsection 6.2 or Clause 9.1.2 and the air supply is for a natural draft or a fan assisted burner, the bottom of the air supply opening or the termination of the air supply duct shall be not more than 18 inches (450 mm) nor less than 6 inches (150 mm) above the floor level.

6.1.5 When the input of an appliance or when the combined input of a number of appliances installed in a single enclosure is

a) 400 000 Btuh (120 kW) or less, the air supply requirements shall be calculated in accordance with Subsection 6.2 or 6.3 except as provided in Subsection 6.6 or,

b) more than 400 000 Btuh (120 kW), the air supply requirements shall be calculated in accordance with Subsection 9.1.

6.1.6 Responsibility for the proper and adequate venting of all types of appliances shall rest with the installer.

6.1.7 No opening shall be located in a furnace return air system within the same room or space as a furnace unless combustion and ventilation air is provided to the room or space, and in no case shall such an opening be installed in or within 6 feet (2 m) of the return air plenum.

6.2 Appliances Located in Unconfined Spaces

6.2.1 When an appliance is located in an unconfined space within a building having insufficient infiltration, the air supply shall be otained from outdoors by means of a permanent opening, or openings, having a total free area of not less than 1 $inch^2$ per 5000 Btuh (450 mm^2 per kW) of the total input rating of all appliances. The opening or openings may be connected to the cold air return of a heating system.

6.3 Appliances Located in Confined Spaces

6.3.1 When an appliance is located in a confined space and all the air supply is from inside the building, the space shall be provided with two permanent openings freely communicating with interior areas having, in turn, adequate infiltration from outside. The openings shall conform to the following:

a) the lower opening shall not be more than 18 inches (450 mm) nor less than 6 inches (150 mm) above floor level and shall have a free opening of not less than 1 $inch^2$ per 1000 Btuh (2225 mm^2 per kW) of the total input rating of all appliances in the space;

b) the upper opening shall be located as near the ceiling as is practicable, but not lower than any relief opening of a draft hood or draft regulator and shall have a free area not less than the total area of all vents or chimneys from the appliances contained therein, except for closet type installations, where the area shall be not less than that ot the lower opening.

6.3.2 When an appliance is located in a confined space and the air supply is from the outdoors, the space shall be provided with two permanent openings that communicate directly to the outdoors by means of openings or ducts. The openings shall conform to the following:

a) the lower opening shall be not more than 18 inches (450 mm) nor less than 6 inches (150 mm) above the floor levels and shall have a free opening of not less than:

i) 1 $inch^2$ per 2000 Btuh (1100 mm^2 per kW) of the total input rating of all appliances in the space when communication with outdoors is by means of a horizontal duct or,

ii) 1 $inch^2$ per 4000 Btuh (500 mm^2 per kW) of the total input rating of all appliances in the space when communications with outdoors is directly by an opening or by means of a vertical duct;

b) the upper opening shall be located as near the ceiling as is practicable, but not lower than any relief opening of a draft hood or draft regulator and shall have a free area not less than the total area of all vents and chimneys from the appliances contained therein, except for a closet type installation where the area shall be not less than that of the lower opening.

6.3.3 When an appliance is located in a confined space and the ventilation air is from inside the building and the combustion and draft hood dilution air supply is from outdoors.

a) the space shall be provided with an opening for ventilation sized and located in accordance with Clause 6.3.1(b);

b) one permanent air supply opening shall be provided for combustion and draft hood dilution air that communicates directly with outdoors. This opening shall have a free area of not less than 1 $inch^2$ per 5000 Btuh, (450 mm^2 per kW) of the total input rating of all appliances in the confined space and may be connected to the cold air return of a heating system.

6.4 Dampers, Louvres and Grilles

6.4.1 The free area for an air supply opening area in Subsections 6.2 and 6.3 shall be calculated by subtracting the blockage area of all fixed louvres, grilles or screens from the gross area of the opening.

6.4.2 Apertures in a fixed louvre, a grille or screen shall have no dimension smaller than 0.25 inch (6 mm).

6.4.3 A manually operated damper or manually adjustable louvres shall not be used.

6.4.4 An automatically operated damper or automatically adjustable louvre shall be interlocked so that the main burner cannot operate unless the damper or louvre is in the fully open position.

6.5 Conditions Created by Exhaust Fans or Fireplaces

6.5.1 When operation of an exhaust fan, a clothes dryer, a kitchen exhaust system or a fireplace may create a condition causing unsatisfactory combustion or venting of an appliance, provisions shall be made to overcome such conditions and shall be subject to the approval of the enforcing authority.

6.6 Engineered Installations

6.6.1 The requirements of air supply specified in Subsections 6.2 and 6.3 may be changed in an engineered installation subject to the approval of the enforcing authority.

6.7 Exceptions

6.7.1 When the air supply is provided by mechanical means, an air flow sensing device shall be installed. It shall be wired into the safety limit circuit of the primary safety control to shut off the gas in the event of air supply failure. When an appliance is not equipped with a combustion safety control, the restoration of the gas supply shall be by a manual reset device.

6.7.2 When all the air supply is provided by a make-up air heater and the appliance is interlocked with the heater, the requirements of Subsections 6.1 to 6.6 inclusive need not apply.

6.13.7 A vent shall not terminate:

a) in a location where flue gases may enter a combustion air inlet of an adjacent appliance or a building air inlet, and shall be at least 6 ft (1.8 m) from any such inlet or,

b) less than 3 ft (900 mm) from any other building opening.

6.20 Dampers and Attachments

The requirements of this Subsection shall apply only to natural draft venting.

6.20.1 A device or attachment which might in any way impair the combustion or safe venting of the combustion products is prohibited.

6.23 Draft Regulators

6.23.1 A draft regulator when used, shall be located so that the relief opening is not obstructed by any part of the appliance or adjacent construction. When used with an incinerator, a draft regulator shall be of the single-acting type. In all other installations, it shall be of the double-acting type.

I.7 SELECTED EXCERPTS FROM CSA B365-M1982 "INSTALLATION CODE FOR SOLID-FUEL BURNING APPLIANCES AND EQUIPMENT"

3.9 Electrical Features. Electrical wiring and equipment shall be installed in accordance with provincial regulations or in the absence of such regulations, in accordance with CSA Standard C22.1, Canadian Electrical Code, Part I.

3.10 Gas, Oil, or Electric Heating Features

3.10.1 When gas, oil, or electric heating equipment is used with a solid-fuel burning appliance and equipment, the gas, oil, or electric heating shall be installed in accordance with provincial regulations or in the absence of such regulations, in accordance with CGA Standards CAN1-B149.1, Installation Code for Natural Gas Burning Appliances and Equipment, and CAN1-B149.2, Installation Code for Propane Burning Appliances and Equipment; and CSA Standards B139, Installation Code for Oil Burning Equipment, and C22.1, Canadian Electrical Code, Part I, respectively.

4. Air for Combustion and Ventilation

4.1 A solid-fuel burning appliance shall be located in such a manner as not to interfere with proper circulation of air for combustion or ventilation within the space.

4.2 When the building construction is such that normal infiltration does not meet the requirements for combustion air and ventilating air, outside air shall be introduced to the space in which the solid-fuel burning appliance is located.

NOTES:

1 The minimum size of openings for this purpose may be determined by trial and error to accommodate the flue characteristics, the firing rate, the building characteristics, etc., i.e., as a guide, the combustion air opening may be 0.5 times the flue collar area.

2 A solid-fuel burning appliance should be installed only where:

a) ambient air temperatures are maintained within acceptable operating limits;

b) provision is made to compensate for the air drawn from the area by other appliances such as exhaust fans, clothes dryers, or fireplaces.

APPENDIX J
NEUTRALIZATION PROCESS

APPENDIX J
NEUTRALIZATION PROCESS

Neutralization is the process by which an active chemical is made inactive by another chemical.

Formaldehyde is neutralized by sodium bisulphite. The combination of these two chemicals produces a stable chemical (which does not react), once the water in the solution evaporates (dries).

Neutralization will occur in the thin film of water on the wood surface only as long as both formaldehyde and sodium bisulphite are in water. It will not take place in the air, or if the water turns to ice.

UFFI is made of tiny "blocks" (called polymethylolureas). These "blocks" were adsorbed by the building materials which were in contact with the UFFI.

The first step in neutralizing is to flush the "blocks" from the wood, and to lessen their potential to emit formaldehyde.

Formaldehyde emission will increase with a rise in temperature and moisture. However, it is a slow-release process. Warm water washing accelerates the release of formaldehyde. Because it takes a long time for formaldehyde to travel from within the wood to its surface, it is necessary to wait at least 24 hours before applying the sodium bisulphite solution. The formaldehyde which has reached the surface can then be neutralized.

NOTES

1. If the sodium bisulphite is applied too soon after the warm water wash, the formaldehyde may not have reached the surface of the wood. By the time it has, the water will have evaporated from the soidum bisulphite solution, meaning that the formaldehyde will not be neutralized.

2. Under freezing conditions, very little formaldehyde will be released from the wood, and no reaction will take place in ice.

3. If the wall cavity is closed up with the solution frozen onto the surface of the wood, neutralization will not be effective. Not enough of the solution will be left on the surface by the time the formaldehyde is released. Furthermore, because of higher moisture content in a closed cavity, the structure could be more vulnerable to rot and fungal growth.

The second application of sodium bisulphite solution neutralizes any formaldehyde that has been slow to reach the surface and further reduces formaldehyde emissions.

NOTES:

1. Saturation must be complete during each application (droplets running down the wood surface).

2. Allow at least 24 hours drying time between each step, and make sure that the cavity is dry before proceeding with the next step.

3. When the moisture content and the temperature increase, so will formaldehyde emission.

4. A minimum temperature of 5°C must be maintained during the entire neutralization and testing procedure.

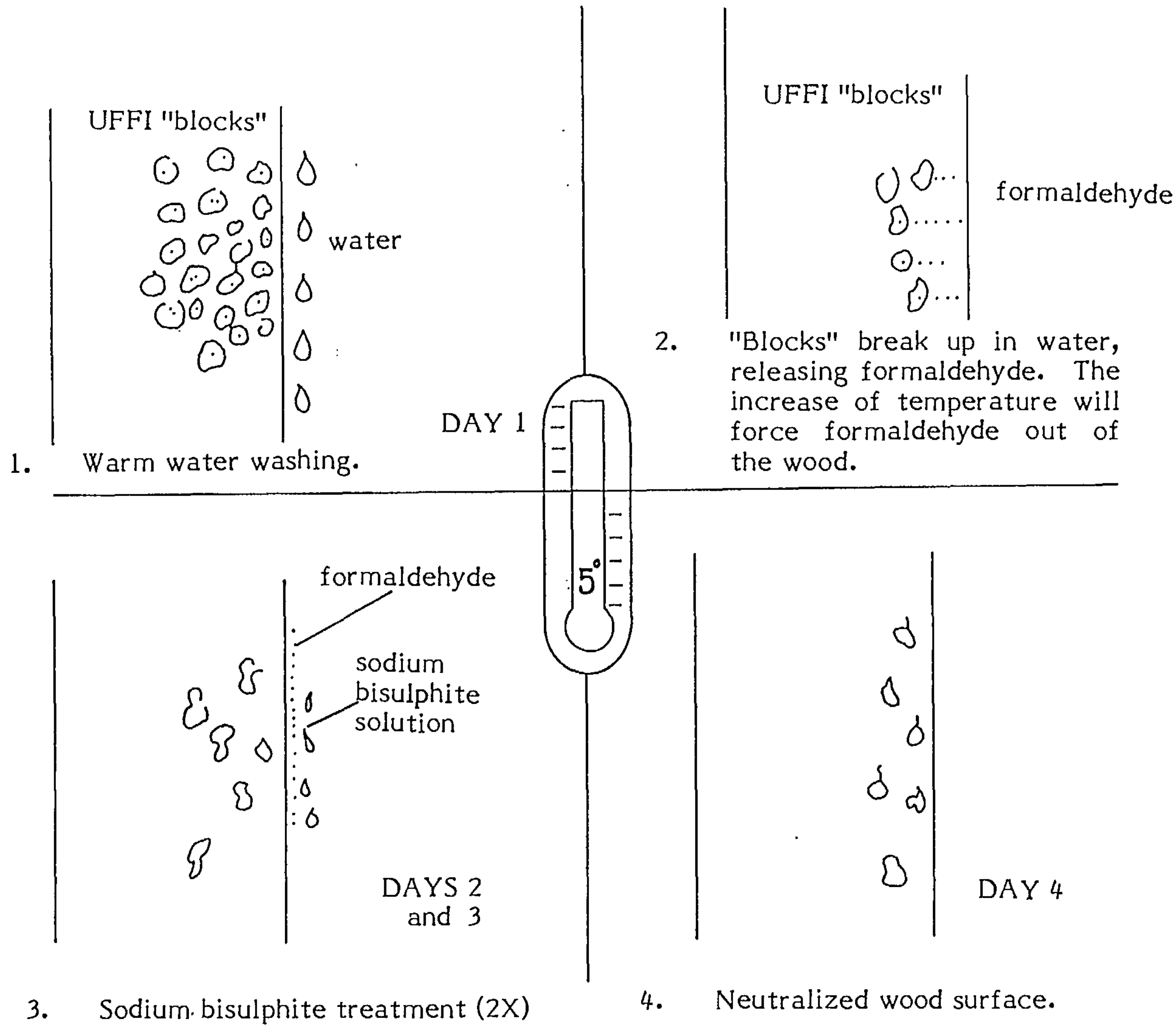


FIGURE J.1 THE NEUTRALIZATION PROCESS

APPENDIX K
STANDARD SPECIFICATION FOR UFFI CORRECTIVE MEASURES

This appendix is intended to provide a detailed description of the work included in each of the UFFI Corrective Measures. Registered Contractors must follow this standard specification when preparing an estimate and contract, and when carrying out corrective measures, unless specific exclusions are required by the homeowner. Such exclusions must be detailed in the contract.

K.1 SEALING

K.1.1 **Basic Sealing.** On the interior surface of all walls and flat or cathedral roofs containing UFFI, undertake the pre-sealing and sealing operations as detailed in (a) and (b) below.

a) **Perform the following pre-sealing actions:**

i) thoroughly clean joints to be caulked:

- remove loose materials using a paint scraper and wire brush;
- wash the joints with detergent, rinse, and permit them to dry;

ii) pack any joints wider than 10 mm with oakum, plastic foam rope filler, or pieces of compressed insulation batts before sealing with caulking;

iii) repair areas to be caulked:

- replace badly deteriorated wood;
- secure loose boards;
- carry out other necessary repair work;

iv) repair major openings in walls: i.e., inspect openings, insulate the area behind the opening, install a vapour barrier and repair the interior with a suitable finish such as gypsum;

v) repair minor cracks in the wall finish with appropriate material;

vi) remove UFFI overflow from the roof and other accessible places.

b) **Seal the following:**

i) all cracks or gaps between the interior finish and trim;

ii) all electrical outlets, cover plates and switch plates;

iii) openings where pipes, vents or wires enter the wall containing UFFI. If the rough opening is considerably larger than the pipe, patch with the same material as the wall. Patch around all pipes, patch all wires, cables, exhaust vents, fans and other penetrations, where necessary, and then caulk;

iv) cracks in the interior finish. When necessary, first pack cracks in the interior finish with appropriate materials, as detailed in above;

v) baseboards. If they are not to be removed, caulk along the edges next to the wall and the floor. Cracks and gaps wider than 10 mm must be packed before being caulked. Take care to caulk the vertical joint at the corners. Use a transparent or paintable caulking. Where the baseboard is loose or has sprung from the wall at the top, inject caulking well into the gap and then secure and tighten the baseboard against the wall by nailing or screwing it to the framing. If the bottom of the baseboard is against flooring (tile, sheet linoleum, plastic, hardwood or parquet) seal the junction of the baseboard tightly with the flooring material. If a shoe mould is in place, remove it and caulk generously between the baseboard and floor. Reinstall the shoe mould firmly into the caulking material. If the floor is carpeted, remove any shoe mould holding the carpet in place. If the carpet is cemented down, protect the edge with wide masking tape. Push its edge down into the gap between the carpet and the baseboard. Lay caulking in the gap between the tape and the baseboard and press down well against the underlay and the baseboard. When the caulking dries, cut and remove that part of the tape covering the rug. Reinstall the shoe mould. If the carpet is held with a tack strip, free the carpet and turn it back from the baseboard to expose the junctions between the baseboard and the tack strip, and between the tack strip and the floor underlay. Lay caulking in both junctions and let it dry. Reinstall the carpet and the shoe mould. If the carpet is held only with a shoe mould or a one-piece baseboard, remove it and turn back the carpet to expose the junction of the baseboard and the floor underlay. If the gap is wide, pack it with oakum or flexible insulation before sealing it with caulking. When dried, reinstall the carpet and the shoe mould;

vi) window trim, door trim, cornices, dadoes;

vii) under the exterior wall at the top of the foundation, if there is no basement ceiling. If there is direct access between the wall cavities and the basement (for example, in balloon framing), seal and block this gap;

viii) remove, or seal off, from the living space any UFFI inside the building envelope in such locations as around bathtubs, kitchen cupboards, etc.

K.1.2 **Final Entry Point Sealing.** In addition to Basic Sealing (Section K.1.1):

a) seal both faces of all interior partitions in the manner described in Section K.1.1;

b) seal all gaps, cracks and openings in stairwells, including the landing and ceiling, in the manner described in Section K.1.1.

K.1.3 Structural Sealing. In addition to basic sealing, there are two options:

a) **Open-Access Sealing.** At all locations where an interior partition or an enclosed floor/ceiling intersects with an exterior wall, flat or cathedral roof containing UFFI:

i) cut away strips of interior finish, to gain direct access to hidden zones. For partitions, the cut-away strip will normally be the full width of a stud cavity. For ceilings, the width of cut will depend on the framing pattern but will be at least 300 mm;

ii) block large gaps in the framing with appropriate materials;

iii) plug smaller gaps (e.g., strapping spaces) by stuffing with mineral wool insulation;

iv) drill and plug shrinkage gaps in subfloor joints with caulking over the width of the wall above. If the subfloor boards are tongue-and-groove, drill each gap to allow the joint to be plugged through to the indoor edge of the baseboard or to the finish flooring above;

v) remove any UFFI found in partitions and floor systems;

vi) cut and install rigid insulation as necessary in the header joist area and seal;

vii) seal with spray sealant all cracks, packing and blocking;

viii) replace cut-away finished materials with compatible new materials and make good to a stage that is ready for repainting.

b) **Drill-and-Spray Sealing.** At all locations where an interior partition or an enclosed floor/ceiling intersects with an exterior wall containing UFFI:

i) drill holes (35 mm diameter) through the interior finish to gain access to hidden zones (minimum two per ceiling/floor joist space and four per partition/wall stud cavity junction, unless spraying through the bottom of the partition from the basement);

ii) seal the leaks by spraying them with a sealant capable of building a thick, impermeable and elastic film which will adhere to the building materials and bridge the cracks;

iii) check sealed cavities with an optical probe and respray if necessary;

iv) repair the holes to a stage that is ready for repainting.

K.1.4 **Energy Sealing.** In addition to Basic Sealing, either Final Entry Point Sealing (Section K.1.2) or Structural Sealing (Section K.1.3) must be done:

a) caulk basement sills, floor headers and windows;

b) seal electrical outlets and leaks in the upper ceilings;

c) tape and/or caulk all partition tops;

d) tightly pack and seal plumbing stacks and chimneys where they pass through into the attic or roof space;

e) apply weather stripping to all opening parts in the exterior envelope: doors, windows, roof access hatch, etc.;

f) provide separate combustion air intake ducts as required to all fuel-burning appliances.

K.2 VENTILATION

K.2.1 Ventilation with a Heat Recovery Ventilator (HRV)

a) with the assistance of a heating, ventilation, air conditioning (HVAC) consultant, design the capacity of the HRV, the air distribution duct system and other details of the installation in accordance with Chapter 7;

b) undertake complete energy sealing (see Section K.1.4);

c) install the HRV and duct system in a neat and workmanlike manner and according to CSA installation guidelines. Use an HRV which meets the requirements of the UFFI Centre (see Chapter 7 and Appendix H);

d) start-up and adjust the system.

K.3 REMOVAL

K.3.1 Removal from the Interior

a) **Site preparation**

i) remove from the work area all household furniture, furnishings, and food;

ii) isolate the work area from adjacent living areas and spaces;

iii) assure that adequate ventilation of the work area is provided;

iv) assure that the electrical circuits serving the work area have been disconnected;

v) assure that all exhaust fan grills, and heating supply and return registers have been effectively covered and sealed;

vi) set up an on-site covered container or provide heavy-duty garbage bags for storage until disposal of UFFI and UFFI-contaminated materials can be accomplished;

vii) protect on-site materials.

b) **Exposure and removal**

i) ensure that workers are wearing the prescribed protective clothing and respirators;

ii) locate fans to blow any UFFI dust away from the workers;

iii) maintain good construction site housekeeping practices throughout the duration of the contract;

iv) carefully remove all trim and wall cladding materials as necessary to expose the UFFI and to provide access for its removal (such materials can be re-installed if they are not contaminated or if they have been given the prescribed treatment). All UFFI must be removed;

v) take necessary precautions to protect workers and to prevent damage during removal of UFFI to any electrical wire, plumbing pipes, or ductwork;

vi) remove all UFFI and any other materials such as batt insulation from the cavities. Place this waste in industrial disposal canisters, or package it in polyethylene sheets or bags, as it is stripped from the cavities, and put it into the on-site container;

vii) check window and door shim spaces, lintels and adjacent framing details for UFFI in hidden cavities;

viii) avoid weakening or damaging the structure during removal operations;

ix) brush and vacuum all surfaces of the cavities to assure removal of all residual UFFI particles; control dust by vacuuming narrow cavities. Vent the vacuum to the exterior and/or bubble the exhaust through water in a container;

x) brush residues from electrical wires so as not to damage the insulation, if wiring is not to be replaced;

xi) report to the owner any significant defect in, damage to, and/or deterioration of, the exposed framing or any mechanical or electrical equipment in the cavity;

xii) if exposed electrical wiring, receptacle boxes, connectors or other components show damage or corrosion, leave open until the damage has been reported to the appropriate authority;

xiii) check areas where UFFI may have penetrated. All UFFI must be removed.

c) **Chemical treatment following UFFI removal**

i) when the surfaces in contact with UFFI have been brushed or sandblasted and then vacuumed, wash the wooden or masonry surfaces which have been in contact with UFFI with warm water, then allow to dry;

ii) apply one coat of 3 per cent solution by weight of sodium bisulphite (NA HSO_3) onto wood surfaces only with a new or very clean fog or airless sprayer, sponge, or mop and let the wood dry thoroughly (24 hours minimum). Apply a second coat and let dry thoroughly (24 hours minimum).

Spray onto the wood until a slight running of the liquid occurs. Avoid spraying into electrical outlets;

iii) arrange for CMHC to test the neutralized areas. If the formaldehyde level is below 0.5 ppm, proceed with the restoration of the structure, if higher, undertake a comprehensive investigation to locate UFFI which may have been overlooked (or other sources of formaldehyde) and remove it. Apply another coating of sodium bisulphite solution, and permit the cavities to dry thoroughly (24 hours minimum).

Proceed with the restoration of the structure.

d) **Insulation and restoration.** All requirements of the applicable building regulations must be met when doing insulation and restoration work. The following steps are to be taken in restoring the structure after UFFI removal:

i) advise the homeowner if any wooden structural members have been damaged and require replacement;
ii) install blocking where necessary between storeys or between wall and joist spaces;
iii) plug and seal openings passing through wall plates;
iv) advise the homeowner if there is any deterioration in electrical components;
v) seal:

- between rough openings and the frames of windows and exterior doors with the appropriate materials;
- around pipe entry points and wires passing through the exterior wall, with the appropriate materials;

vi) insulate:

- the interior of exposed header areas with roll batts of mineral fibre, or extruded polystyrene;
- the open cavities in wood frame houses with friction fit batt insulation. Ensure that the batts fit snugly;
- between furring strips with appropriate materials;

vii) cut and place the insulation:

- to fit in odd-shaped cavities formed by structures such as bracing and fire stops;
- to fit in the space between studs or furring;
- to fit around the exterior of water pipes, electrical boxes for plug outlets and switches, and plumbing pipes and vents. When batts are used, cut, split, or trim the batts if necessary to avoid excessive compression.

viii) install a vapour barrier:

- wrap all electrical boxes on exterior walls in polyethylene. Ensure that sufficient thermal insulation is placed behind the box to avoid a thermal bridge;
- using an acoustical sealant, seal the perimeter of each sheet of 0.15 mm (6 mil) poly installed along the interior of exterior walls; overlap the poly at joints between sheets at least 100 mm and seal each joint with acoustical sealant, the joint to be made over a framing member.;
- after the main vapour barrier has been installed, unfold and tape the edges of the poly from inside electrical boxes to the main vapour barrier covering the wall, or if polypans were used, staple the poly around the caulked edges of polypans;
- seal header areas between floors which have been opened;
- when the stud space of a partition wall next to an exterior wall has been opened, continue the air/vapour barrier across the partition;
- caulk the main vapour barrier around the perimeters of each window and door frame;
- install gaskets behind electrical wall outlets and switch plates, and place "child-proofing" plugs in unused outlets. Caulk or use two-sided sticky tape to seal the gasket.

ix) install an acceptable interior finish; normally gypsum board (drywall). Ensure that the vapour barrier is not punctured during the installation of the interior finish. Avoid breaking the air seal at electrical outlets and switches, baseboards, window and door frames, and junctions of partitioned walls and ceilings.

e) **Cleanup and disposal**

i) subsequent to corrective work, a complete cleaning must be undertaken to remove any residual UFFI dust and gas from the living environment:

- vacuum the premises using an industrial vacuum; locate the unit outdoors and use a long hose;
- visually verify the air distribution system by using a mirror or by breaking return air joints on horizontal runs;
- vacuum furnace air ducts and replace furnace filters;
- clean carpets, drapes, etc;

ii) all UFFI and contaminated materials, when dismantled, must be stored in industrial canisters at the site as they are removed. These canisters must be covered to prevent the wind from spreading the dust or contaminated building materials around the job site or to neighboring properties;

- when the volume of debris is small, UFFI and other loose materials can be placed in heavy-duty garbage bags, which must be tightly sealed;
- new materials for the restoration operation must be protected from contamination when stored on-site during the removal and cleaning operations;
- disposal canisters must be kept closed. When a tarpaulin is used as a cover, care must be taken to ensure that it is well secured, so as to prevent particles of dust from entering the environment;

- check with local authorities to determine regulations regarding handling and disposal of these materials and comply with those regulations.

K.3.2 Removal from Exterior

a) **Site preparation**

i) provide a tarpaulin-type drop sheet to protect the exposed framing assembly and to contain UFFI dust. Leave the protection in place until replacement of sheathing materials is complete;

ii) take measures to protect workers from electrical or other external hazards;

iii) provide covered disposal containers in a safe, accessible location for deposit of UFFI and contaminated material;

iv) protect any roof which is used as a working deck or which supports scaffolding;

v) seal the inside surface of the walls containing UFFI as detailed in Section K.1.1;

vi) pressurize the living space slightly to minimize dust infiltration.

b) **Exposure and removal**

i) ensure that workers are wearing prescribed protective clothing and respirators;

ii) locate fans to blow any UFFI dust away from the workers;

iii) maintain good construction site housekeeping practices throughout the duration of the contract;

iv) carefully remove all cladding, trim and sheathing materials as necessary to expose the UFFI and to provide access for its removal (such materials can be re-installed if they are not contaminated or if they have been properly neutralized). All UFFI must be removed.

In the case of brick veneer houses:

- dismantle veneer starting from the top;
- remove all UFFI from the space behind the veneer;
- remove building paper and sheathing;
- remove UFFI from the wall stud cavities.

v) take necessary precautions to protect workers and to prevent damage during removal of UFFI to electrical wire, plumbing pipes, or ductwork;

vi) remove all UFFI and any other materials such as batt insulation from the cavities. Place this waste in industrial disposal canisters, or package it in polyethylene sheets or bags, as it is stripped from the cavities, and put it into the on-site container;

vii) check window and door shim spaces, lintels and adjacent framing details for UFFI in cavities;

viii) avoid weakening or damaging the structure during removal operations;

ix) brush and vacuum all surfaces of the cavities to assure removal of all residual UFFI particles; control dust by vacuuming narrow cavities; vent the vacuum to the exterior and/or bubble the exhaust through water in a container;

x) brush residues from electrical wires so as not to damage the insulation, if wiring is not to be replaced;

xi) report to the owner any significant defect in, damage to, and/or deterioration of, the exposed framing or any mechanical or electrical equipment in the cavity;

xii) if exposed electrical wiring, receptacle boxes, connectors or other components show damage or corrosion, leave open until the damage has been reported to the appropriate authority;

xiii) check areas where UFFI may have penetrated. All UFFI must be removed.

c) **Chemical treatment following UFFI removal**

i) when the surfaces in contact with UFFI residues have been brushed or sandblasted and then vacuumed, wash the wooden and masonry surfaces which have been in contact with the UFFI with warm water, then allow to dry;

ii) apply one coat of 3% solution by weight of sodium bisulphite (NA HSO_3) onto wood surfaces only with a new or very clean fog or airless sprayer, sponge, or mop and let the wood dry thoroughly (24 hours minimum). Apply a second coat and let dry thoroughly (24 hours minimum); spray onto the wood until a slight running of the liquid occurs. Avoid spraying into electrical outlets, or onto plaster;

iii) arrange for CMHC to test the neutralized areas. If the level is below 0.5 ppm, proceed with the restoration of the structure, if higher, undertake a comprehensive investigation to locate UFFI which may have been overlooked (or other sources of formaldehyde) and remove it. Apply another coating of sodium bisulphite solution, and permit the cavities to dry thoroughly (a minimum of 24 hours).

Proceed with the restoration of the structure.

d) **Insulation and restoration.** All the requirements of the applicable building regulations must be met when doing insulation and resotration work. The following steps are to be taken in restoring the structure after UFFI removal:

i) advise the homeowner of any wooden structural members that have been damaged and require replacement;

ii) install blocking where necessary between storeys or between wall and joist spaces;

iii) plug and seal openings passing through wall plates;

iv) advise the homeowner if there is any deterioration in electrical components;

v) seal:

- between rough openings and the frames of windows and exterior doors with the appropriate materials;
- around pipe entry points and wires passing through the exterior wall, with the appropriate materials;

vi) insulate:

- the interior of exposed header areas with roll batts of mineral fibre, or extruded polystyrene;
- the open cavities in wood frame houses with friction fit batt insulation. Ensure that the batts fit snugly;
- between furring strips with appropriate materials.

vii) cut and place the insulation:

- to fit in odd-shaped cavities formed by structures such as bracing and fire stops;
- to fit in the space between studs or furring;
- to fit around the exterior of water pipes, electrical boxes for plug outlets and switches, and plumbing pipes and vents. When batts are used, cut, split, or trim the batts if necessary to avoid excessive compression.

viii) install sheathing, building paper, cladding or brick veneer as appropriate; materials, construction details and workmanship must be in accordance with the applicable building regulations.

c) **Cleanup and disposal**

i) subsequent to corrective work, a complete cleaning must be undertaken to remove any residual UFFI dust and gas from the living environment:

- vacuum the premises using an industrial vacuum; locate the unit outdoors and use a long hose;

- visually verify the air distribution system by using a mirror or by breaking return air joints on horizontal runs;
- vacuum furnace air ducts and replace furnace filters;
- clean carpets, drapes, etc.

ii) all UFFI and contaminated materials, when dismantled, must be stored in industrial canisters at the site as they are removed. These canisters must be covered to prevent the wind from spreading the dust or contaminated building materials around the job site or to neighbouring properties.

- when the volume of debris is small, UFFI and other loose materials can be placed in heavy-duty garbage bags, which must be tighly sealed;
- new materials for the restoration operation must be protected from contamination when stored on-site during the removal and cleaning operations;
- disposal canisters must be kept closed. When a tarpaulin is used as a cover, care must be taken to ensure that it is well secured, so as to prevent particles of dust from entering the environment;
- check with local authorities to determine the regulations regarding handling and disposal of these materials and comply with those regulations.

APPENDIX L
METRIC EQUIVALENTS

IMPERIAL TO METRIC (SI) CONVERSION

(Multiply the imperial unit by the factor given in the equation to get the metric (SI) conversion.)

Length	1 ft = 0.3048 m 1 in = 25.4 mm
Area	1 ft^2 = 0.0929 m^2
Volume	1 litre = 0.001 m^3 1 gallon = 4.55 litre 1 ft^3 = 0.0283 m^3
Mass	1 lb = 0.454 kg
Density	1 lb/ft^3 = 16.03 kg/m^3
Energy	1 Btu = 1.05 x 10^3 J 1 Btu = 1.05 KJ
Power	1 J/s = 1 W 1 Btu/h = 0.293 W
U-Value	1 Btu/h ft^2 °F = 5.678 W/m^2 °C
R-Value	1 h ft^2 °F/Btu = 0.1761 m^2 °C/W
R/unit thickness	1 R/in = 0.00693 RSI/mm
Permeance (water vapour)	1 grain/h ft^2 = 57.5 ng/Pas m^2
Resistance to Moisture Flow	1 h ft^2/grain = 0.0174 Pas m^2/ng

METRIC (SI) TO IMPERIAL CONVERSIONS

(Multiply the metric (SI) unit by the factor given in the equation to get the imperial conversion.)

Length	1 m = 3.281 ft
	1 mm = 0.0394 in
Area	1 m^2 = 10.76 ft^2
Volume	1 m^3 = 1000 litre
	= 35.31 ft^3
	1 litre = 0.220 gallon
Mass	1 kg = 2.205 lb
Density	1 kg/m^3 = 0.0624 lb/ft^3
Energy	1 J = 9.48 x 10^{-4} Btu
	1 KJ = 0.948 Btu
Power	1 W = 1 J/s
	= 3.412 Btu/h
U-Value	1 W/m^2 °C = 0.1761 Btu/h ft^2 °F
R-Value	1 m^2 °C/W = 5.678 h ft^2 °F/Btu
R/unit thickness	1 RSI/mm = 144.2 R/in
Permeance (water vapour)	1 ng/Pasm^2 = 0.0174 grain/h ft^2
Resistance to Moisture Flow	1 Pasm^2/ng = 57.5 h ft^2/grain

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