CSA Unit 17 - Conversion Burners

Chapter 1
Guidelines for converting appliances

Not all appliances can be nor should be converted. Consult Code requirements, manufacturer's specifications, and local regulations while considering whether an appliance should be converted or whether an existing conversion burner was properly installed.

Created
MK **by Mike Kapin**

Purpose of Conversion Guidelines

Availability of Gas

Ensure a natural gas supply line is available for the area or that a propane supply system can be installed.

Design of the Combustion Chamber

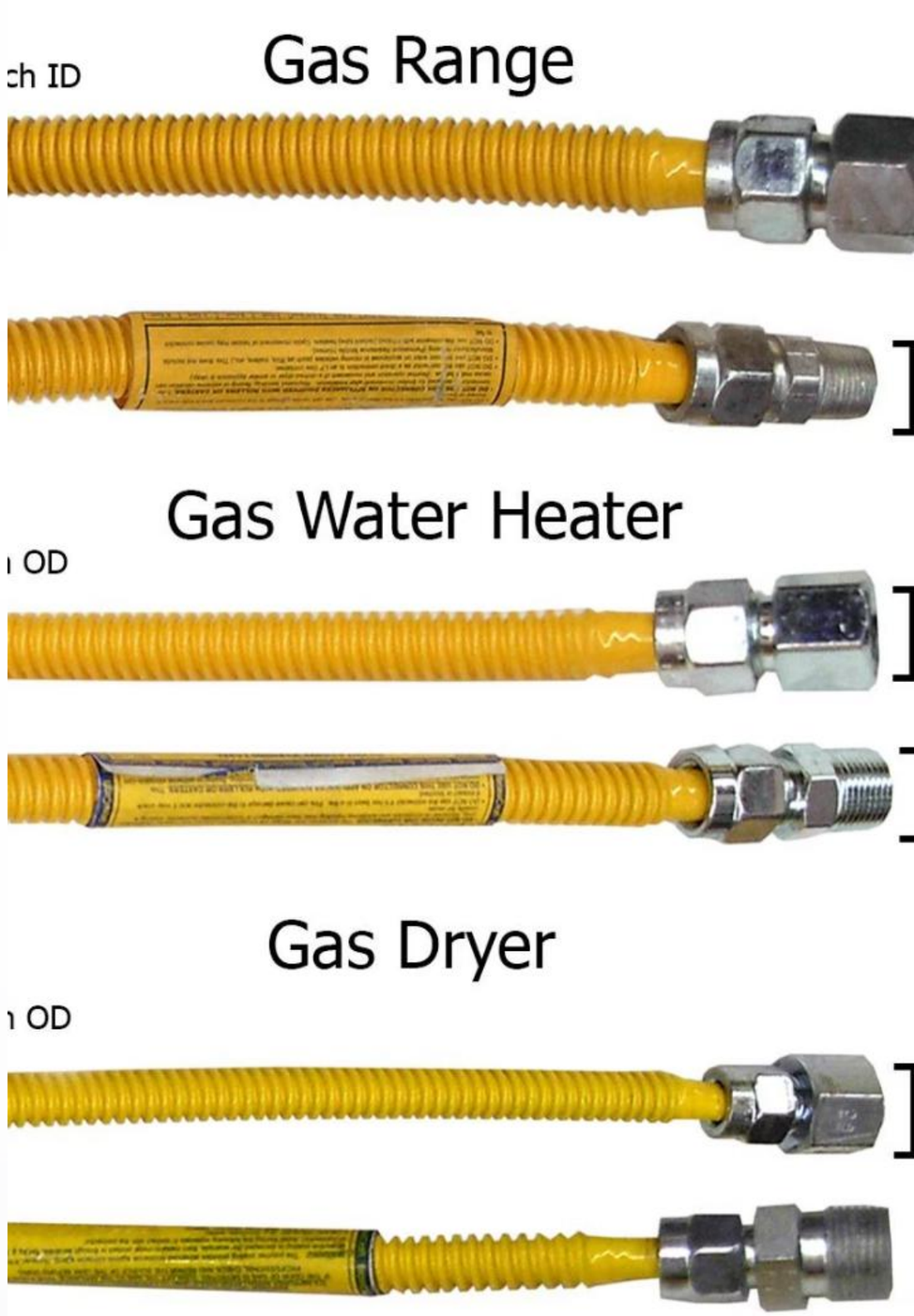
Consider the suitability of the combustion chamber design for conversion.

Appliance Venting

Assess the existing venting system and determine if a new one is required.

Appliance Approval

Verify that the appliance is approved for the specific purpose and conversion.



Responsibilities in New Installations

For new installations, the gas technician/fitter is responsible for determining the acceptability of an appliance, choosing the correct burner, and doing the installation.

Determining Acceptability

The technician must assess if the appliance is suitable for conversion.

Choosing the Correct Burner

Selecting the appropriate conversion burner for the appliance.

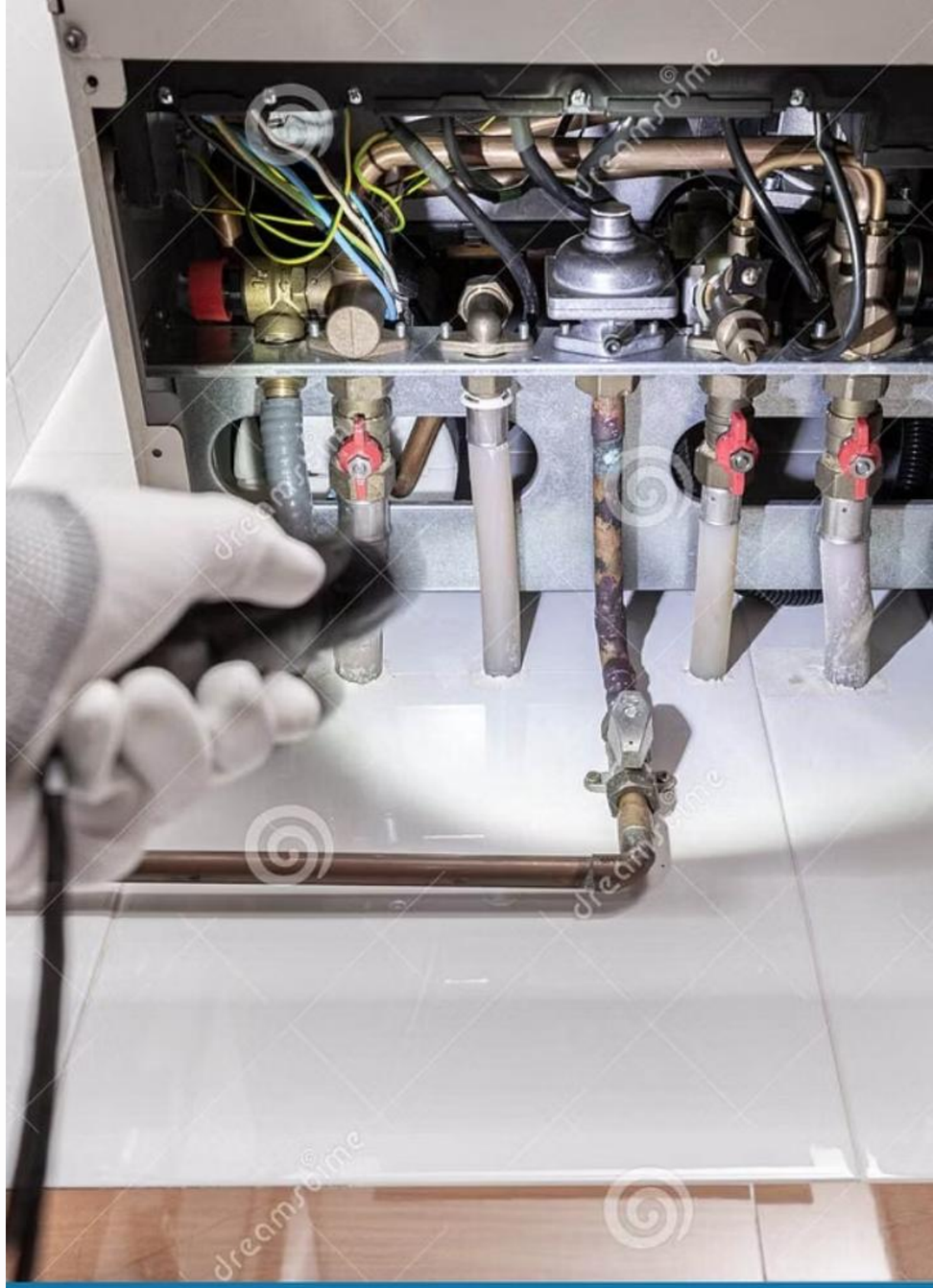
Performing the Installation

Ensuring the conversion is installed correctly and safely.

Responsibilities in Existing Installations

For existing installations, the gas technician/fitter servicing the converted appliance should assess whether the conversion complied with the legal requirements in effect at the conversion and whether it is still in compliance with current requirements and safety concerns. The technician's/fitter's responsibilities are included in the applicable Code.

- Assess compliance with past legal requirements.
- Verify compliance with current requirements and safety concerns.
- Understand issues related to conversion burners.



SAMPLE TECHNICAL TRAINING MANUAL

Chapter Objectives

At the end of this chapter, you will be able to:

1 **Determine Suitability of Appliance for Conversion**

Understand the factors that make an appliance suitable or unsuitable for conversion.

2 **Describe the Installer's Responsibilities**

Outline the duties and obligations of the installer during and after conversion.

3 **Outline Applicable Code Requirements**

Identify and apply the relevant CSA B149.1 Code requirements for conversions.

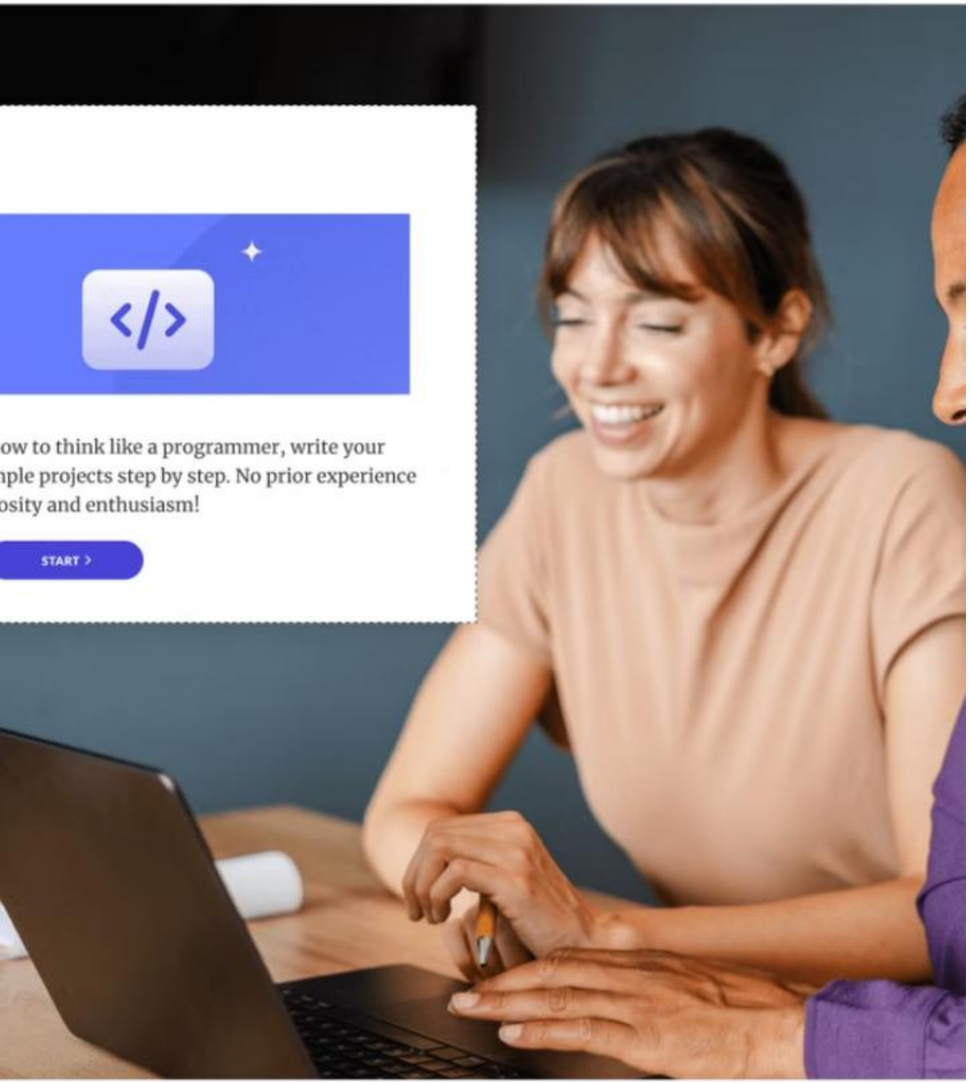
Terminology: Responsibility

> The state or fact of being responsible, answerable, or accountable for something within one's power, control, or management.

This definition is crucial for understanding the roles of gas technicians/fitters in appliance conversion.

Red Seal Alignment: CSA Gas Trade Units

12	D - Controls and Electrical Systems	Task 10	Selects and installs electronic components
13	D - Controls and Electrical Systems	Task 11	Selects and installs electrical components
14	D - Controls and Electrical Systems	Task 12	Installs automation and instrumentation control systems.
15	E - Installation of Systems and Equipment	Task 13	Installs gas-fired system piping and equipment
16	E - Installation of Systems and Equipment	Task 14	Installs gas-fired system components.
17	E - Installation of Systems and Equipment	Task 15	Installs propane storage and handling systems.
18	F - Testing Commissioning of Systems	Task 16	Tests gas-fired systems
19	F - Testing Commissioning of Systems	Task 17	Commissions gas-fired systems.
20	G - Servicing Gas-fired Systems	Task 18	Maintains gas-fired systems
21	G - Servicing Gas-fired Systems	Task 19	Repairs gas-fired systems.
22	G - Servicing Gas-fired Systems	Task 20	Decommissions gas-fired systems.

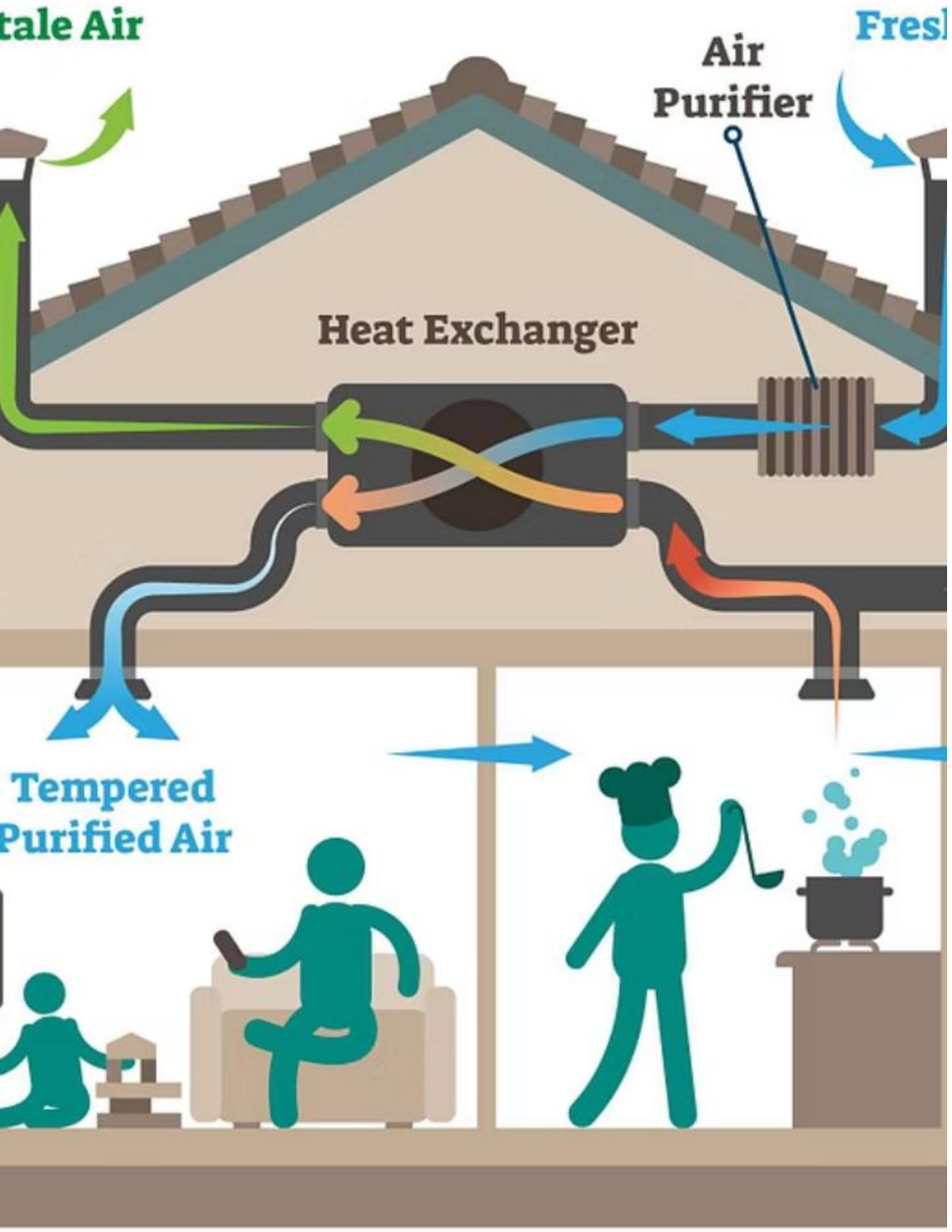


Red Seal Alignment: Occupational A - Common Skills

1	Occupational A - Common Skills	Task 1	Performs safety-related functions.
2	Occupational A - Common Skills	Task 2	Maintains and uses tools and equipment.
3	Occupational A - Common Skills	Task 3	Plans and prepares for installation, service and maintenance.

Red Seal Alignment: Preparation and B - Gas Piping Assembly

4	Preparation and B - Gas Piping Assembly	Task 4	Fits tube and tubing for gas piping systems.
5	Preparation and B - Gas Piping Assembly	Task 5	Fits plastic pipe for gas piping systems.
6	Preparation and B - Gas Piping Assembly	Task 6	Fits steel pipe for gas piping systems.



Red Seal Alignment: Venting Systems Supply and Air C

7	Venting Systems Supply and Air C	Task 7	Installs venting
8	Venting Systems Supply and Air C	Task 8	Installs air supply system.
9	Venting Systems Supply and Air C	Task 9	Installs draft control systems.

Red Seal Alignment: Domestic Appliances

10	Domestic Appliances	N/A	Domestic Appliances
11	Domestic Appliances	N/A	Domestic Gas-fired Refrigerators
12	Domestic Appliances	N/A	Conversion Burners
13	Domestic Appliances	N/A	Water Heaters and Combination Systems
14	Domestic Appliances	N/A	Forced Warm-air Heating Systems
15	Domestic Appliances	N/A	Hydronic Heating Systems
16	Domestic Appliances	N/A	Space Heaters and Decorative Appliances
17	Domestic Appliances	N/A	Venting Practices
18	Domestic Appliances	N/A	Forced-air Add-on Devices
19	Domestic Appliances	N/A	Air Handling

Factors to Consider Before Conversion

Before proceeding with the removal of parts from the existing appliance, complete a careful inspection of the condition of the appliance.

It is pointless to recommend the conversion of a unit when its general condition indicates that it is near the end of its useful life. Moreover, if the heating system is improperly sized or the unit cannot perform in extremely cold weather, the system itself requires improvements. A conversion to gas will not improve poorly designed systems.

The information below describes the five main factors to consider before conversion. Unless all factors are in place and workable, it is pointless to begin the conversion.

Factor 1: Appliance Approval

Code Requirements

Clause 4.2.1 of CSA B149.1, along with local regulations, requires that an appliance be of the type and rating approved for the specific purpose for which it is employed.

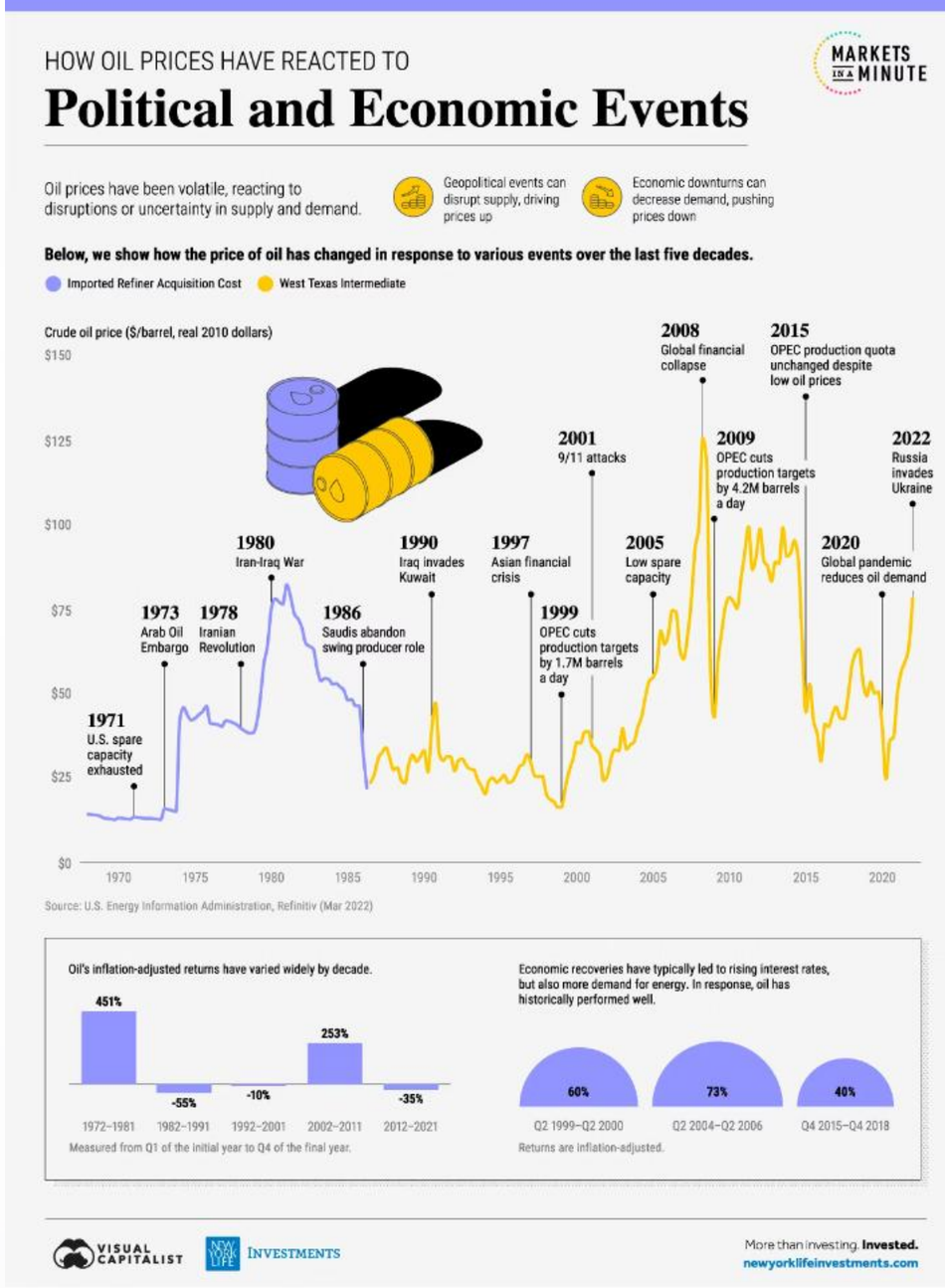
Re-approval Considerations

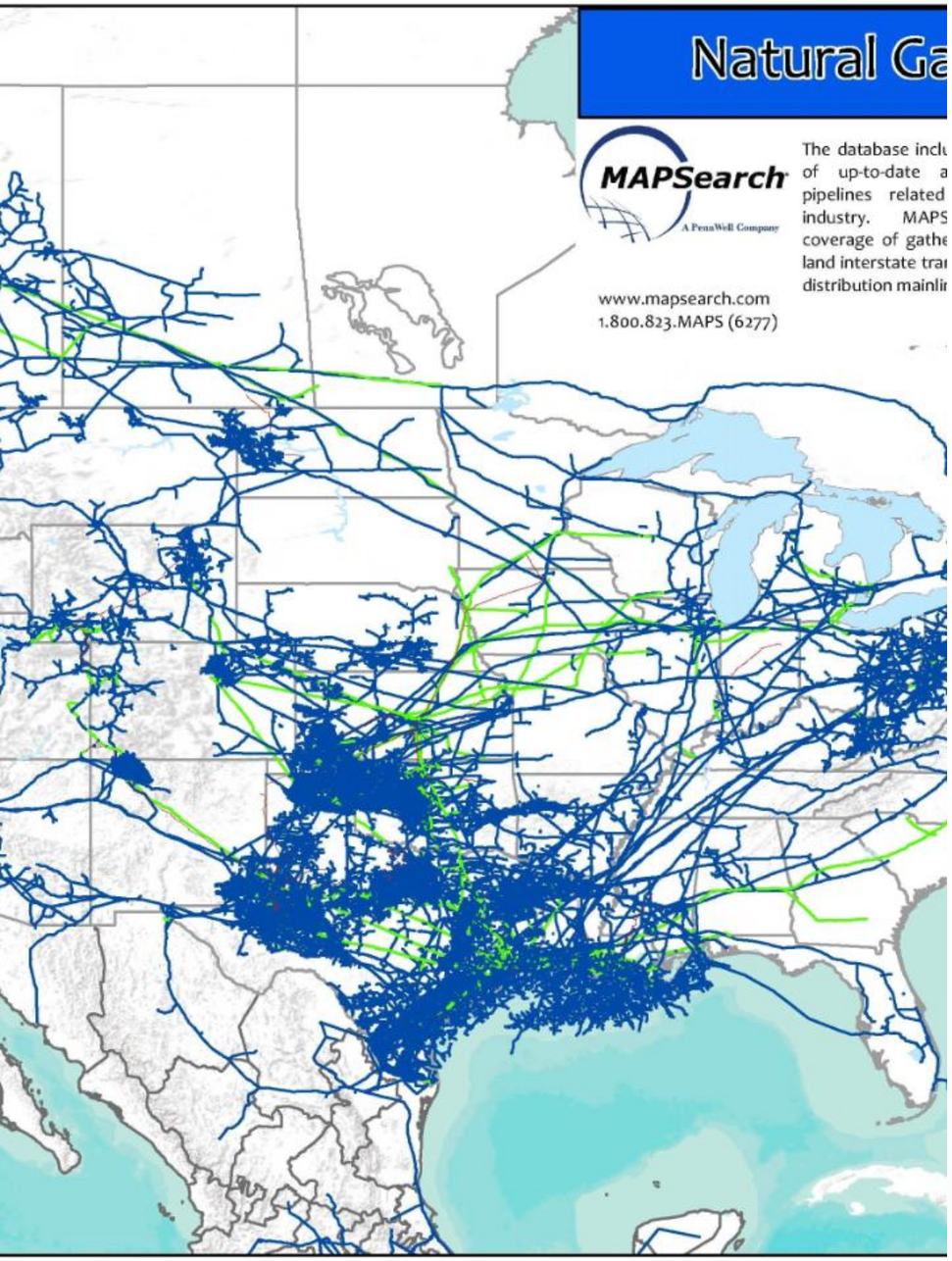
Unless the appliance was originally approved for use with a specific make and model of gas conversion burner, the conversion may require re-approval of the appliance by the authority having jurisdiction. If this is the case, consider the cost of a field approval when making a decision regarding the feasibility of a new conversion or a decision to leave an existing installation in operation.

Historical Context of Appliance Approval

Although the legal and liability issues related to appliance approval are often the most important factor in determining whether a new conversion should be conducted, these issues were not usually considered before 1980, when most conversion burners were installed.

Following the "oil crisis" of 1973, when oil prices skyrocketed, many local authorities gave tacit approval for oil-to-gas conversions based on the use of approved gas conversion burners installed in accordance with burner manufacturer's instructions and Code requirements established at that time.





Factor 2: Availability of Natural Gas/Propane

Check with the local gas company to ensure that a natural gas supply line is available for the area or that a propane supply system can be installed.

Natural Gas Supply

Verify the presence of a natural gas supply line in the conversion area.

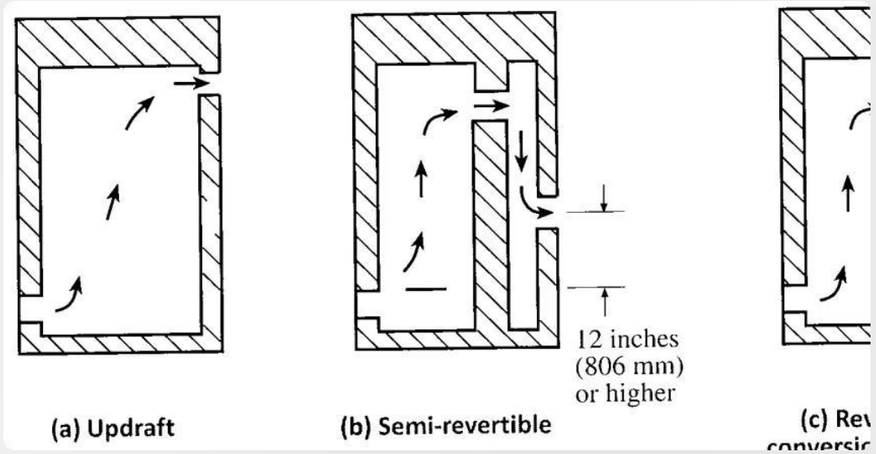
Propane System Installation

Confirm the feasibility of installing a propane supply system if natural gas is unavailable.

Factor 3: Design of Combustion Chamber - Updraft Type

The most suitable combustion chamber design for conversion is the updraft type shown in Figure 1-1(a).

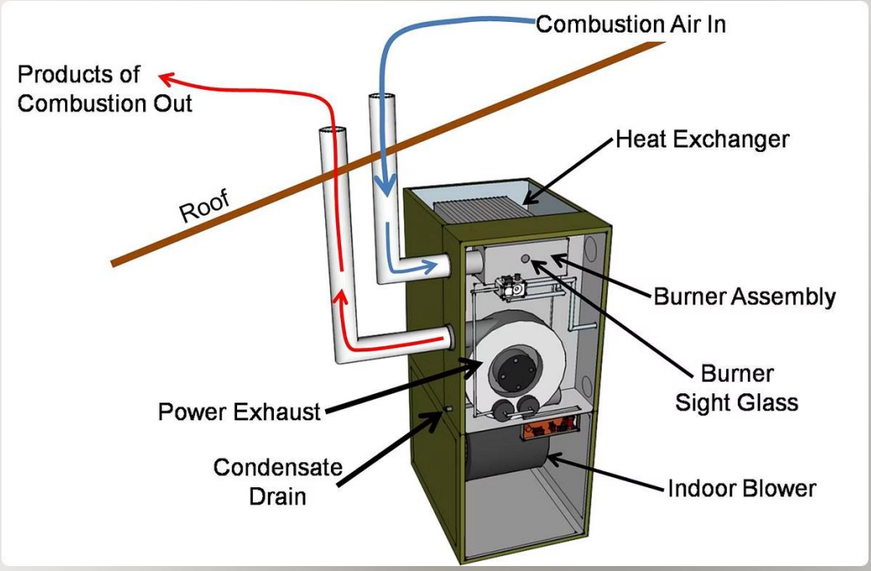
Appliances having a semi-revertible flue [Figure 1-1(b)] are more difficult to convert satisfactorily and burner selection is somewhat limited. Some heat exchanger designs are not suitable for conversion.



Factor 3: Design of Combustion Chamber - Revertible Type Restrictions

For example, when an oil furnace is a fully revertible type [Figure 1-1(c)], having the centreline of its flue outlet within 12 inches (300 mm) of the burner port, Clause 7.8.1 of the CSA B149.1 prohibits the installation of a conversion burner unless a bypass is installed to allow gas that may build up in the heat exchanger during failed trials-for-ignition to escape the vent.

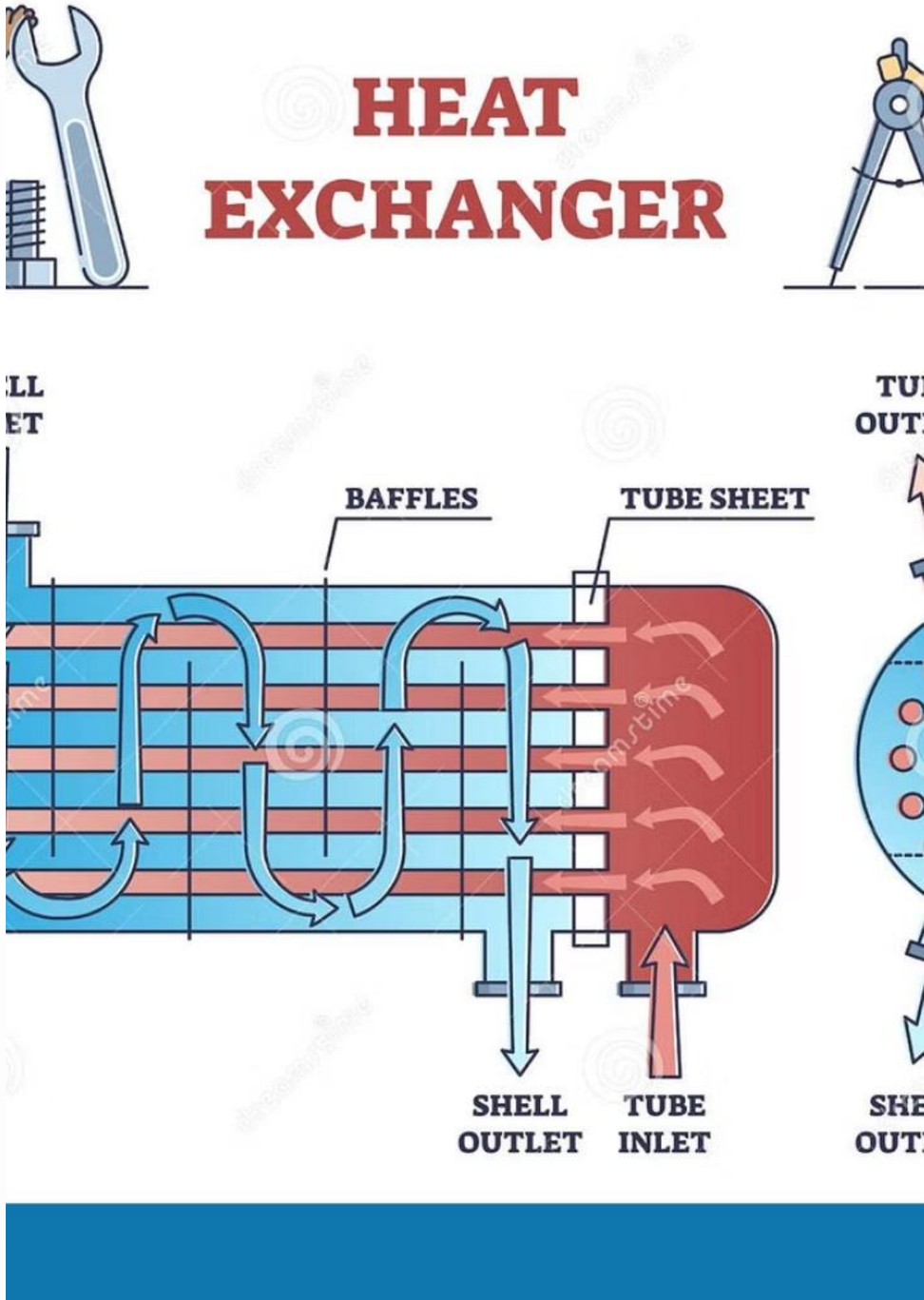
- Centreline of flue outlet within 12 inches (300 mm) of burner port.
- Requires a bypass for gas escape during failed ignition trials.
- Prohibited without bypass installation.



Factor 4: Efficiency of Current Appliance

Oil and solid-fuel appliances operate with larger, more radiant flames than gas burners and, thus, produce a larger amount of radiant heat transfer. To get the maximum heat transfer from a conversion, it is desirable to have a maximum scrubbing of the flue gas against the heat exchanger areas.

Units without secondary heat exchangers, shelves on top of the unit, or a pot-belly design do not usually result in efficient conversions.

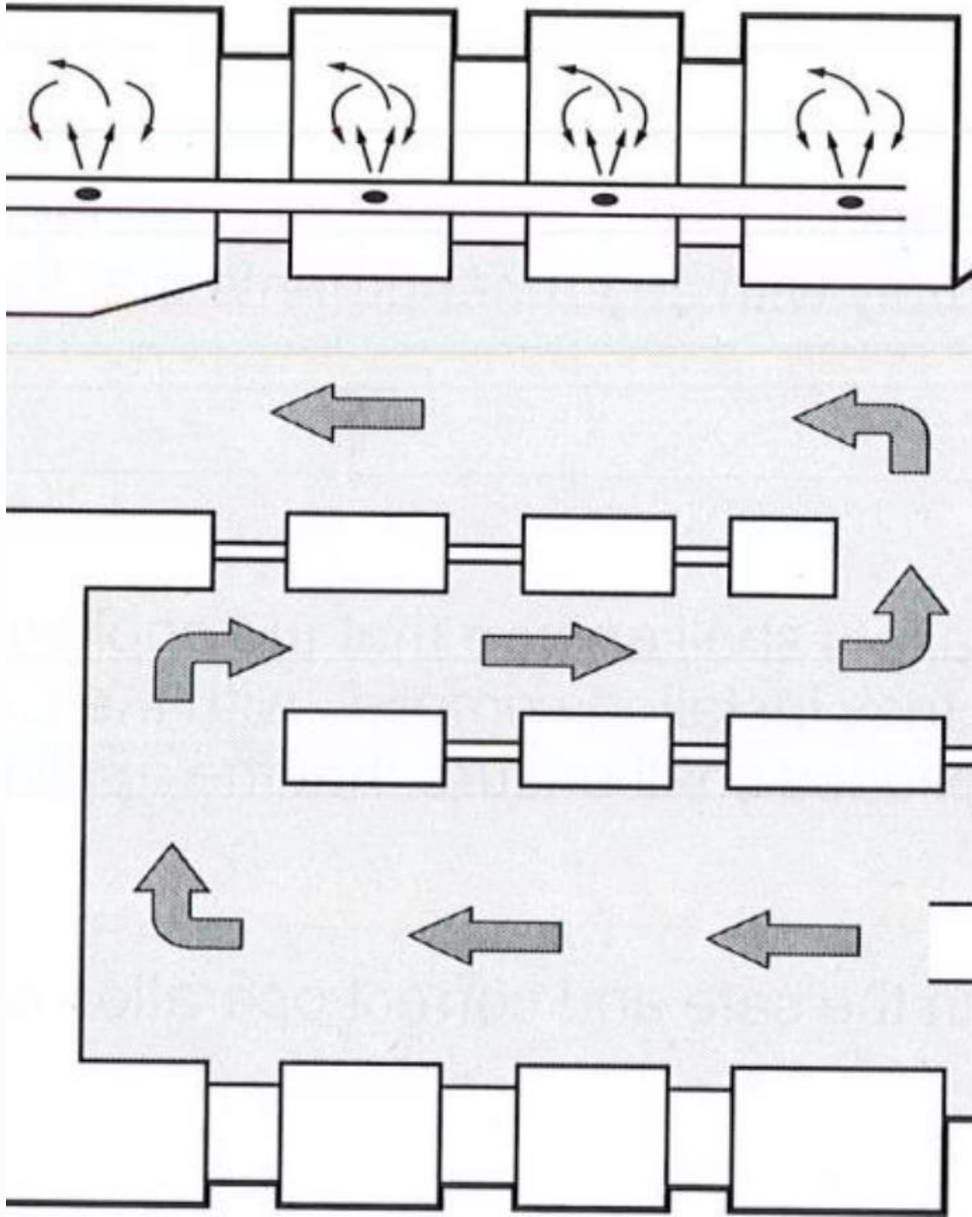


Updraft Boiler Efficiency

To increase efficiency, updraft boilers will have multiple passes, such as the three-pass boiler shown in Figure 1-2.

This design maximizes heat transfer by increasing the contact time between flue gases and heat exchanger surfaces.

Figure 1-2
Three-pass boiler



Factor 5: Appliance Venting - Chimney Condition

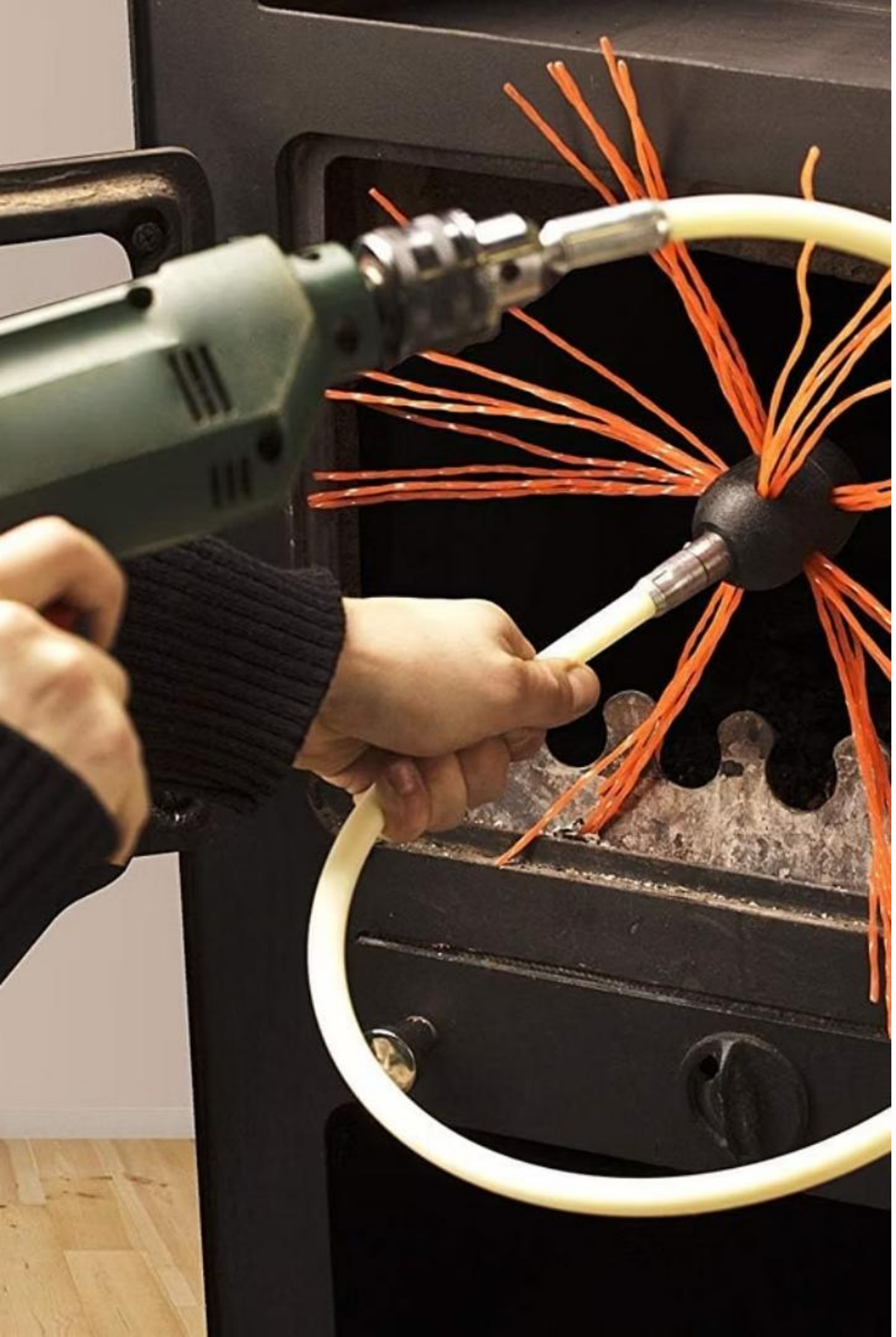
Most oil and solid-fuel appliances vent to a masonry chimney. Due to the lower flue gas temperatures of gas firing, condensation can develop in an oversized and unlined chimney. If the chimney is in poor condition, or if it is not possible to install a liner, a new vent system must be installed as part of the conversion.

Condensation Risk

Lower flue gas temperatures from gas firing can lead to condensation in oversized/unlined chimneys.

Chimney Condition

Poor chimney condition or inability to install a liner necessitates a new vent system.



Factor 5: Appliance Venting - Soot Accumulation

Additionally, if soot has accumulated inside a chimney flue, further arrangements will have to be made to have the chimney thoroughly cleaned out. Unless this is done, there is danger that the soot will dry out and fall down in large quantities, blocking the vent connector.

- Thorough chimney cleaning is essential.
- Soot can dry out and block the vent connector.
- Blocked vent connectors pose a safety hazard.

Other Factors to Consider: Overall Heating System

Questioning the owner on the efficiency of the appliance may point to weak spots in the system that will not necessarily be improved with a conversion. Some rooms may be poorly heated because of:

Insufficient Duct or Register Capacity

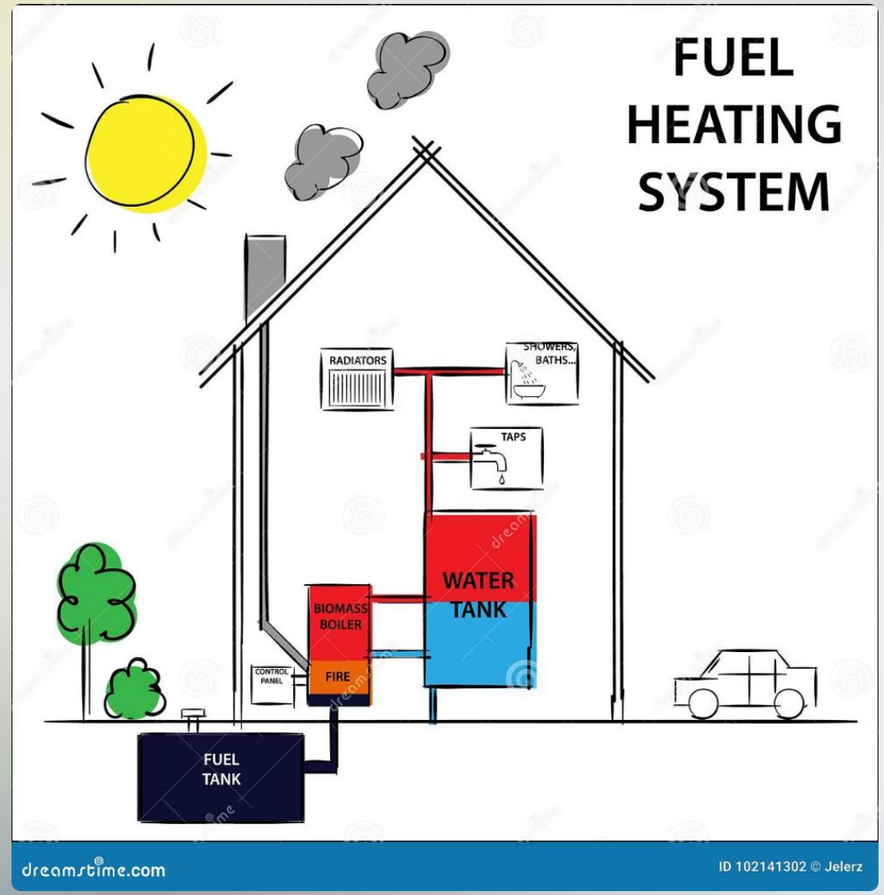
Inadequate airflow due to undersized or blocked ducts/registers.

Small Radiators

Radiators that are too small to adequately heat the room.

Incorrectly Located Thermostat

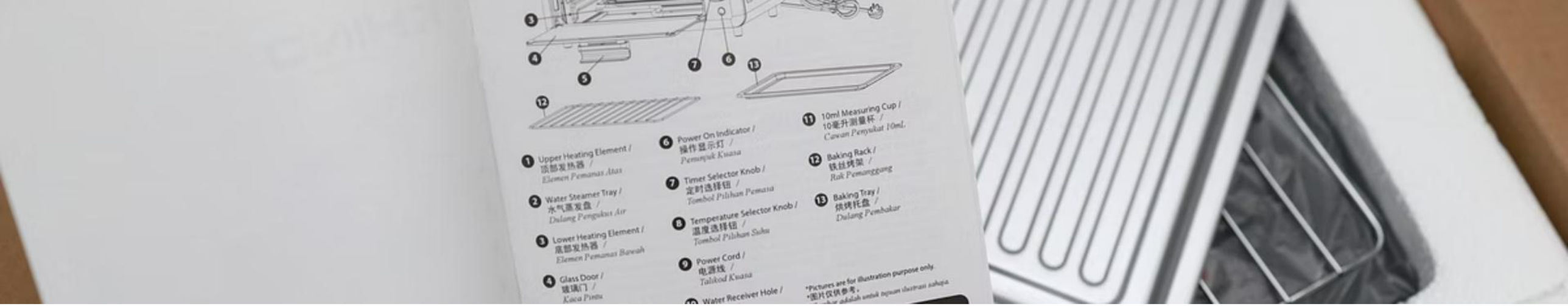
Thermostat placement that does not accurately reflect the room's temperature needs.



Other Factors to Consider: Age of Appliance

Oil-fired appliances that are more than 10 years old should not be converted.

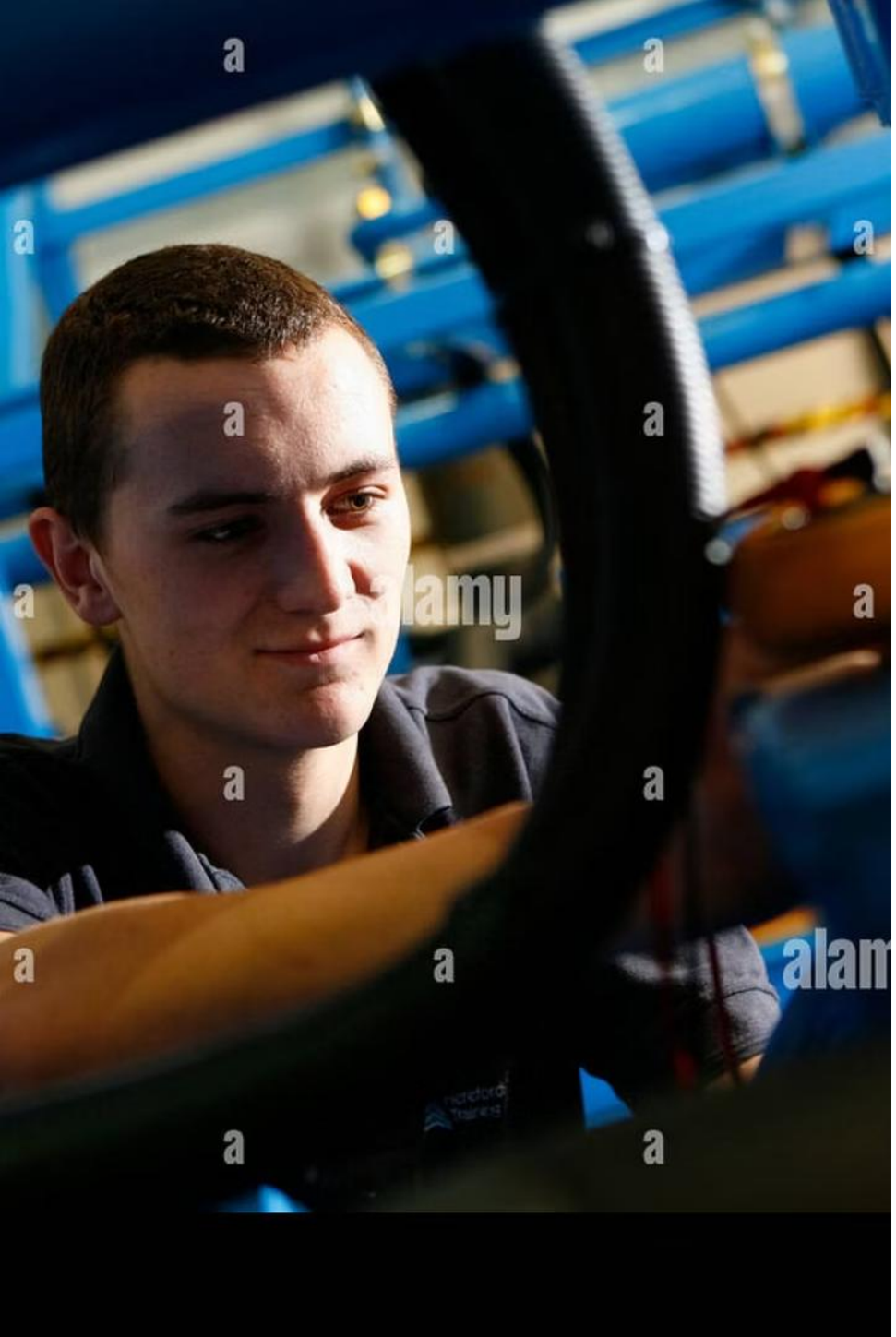
This is due to potential wear and tear, reduced efficiency, and safety concerns associated with older units.



Other Factors to Consider: Manufacturer's Recommendations

Check with the manufacturer before conversion since some units may specifically not be recommended for conversion.

Adhering to manufacturer guidelines ensures compatibility and safe operation of the converted appliance.



Installer's Responsibilities: Quality and Safety

The success and continued safe operation of a conversion burner installation depends a great deal on the quality of workmanship and the care taken during the initial burner installation.

The responsibility for a safe and satisfactory installation rests with the person who:

Determines Acceptability

Assesses if an appliance is suitable for conversion.

Specifies the Best Burner

Chooses the most appropriate burner for the job.

Handles the Installation

Ensures the conversion is performed correctly.

Installer's Responsibilities: Installing Contractor

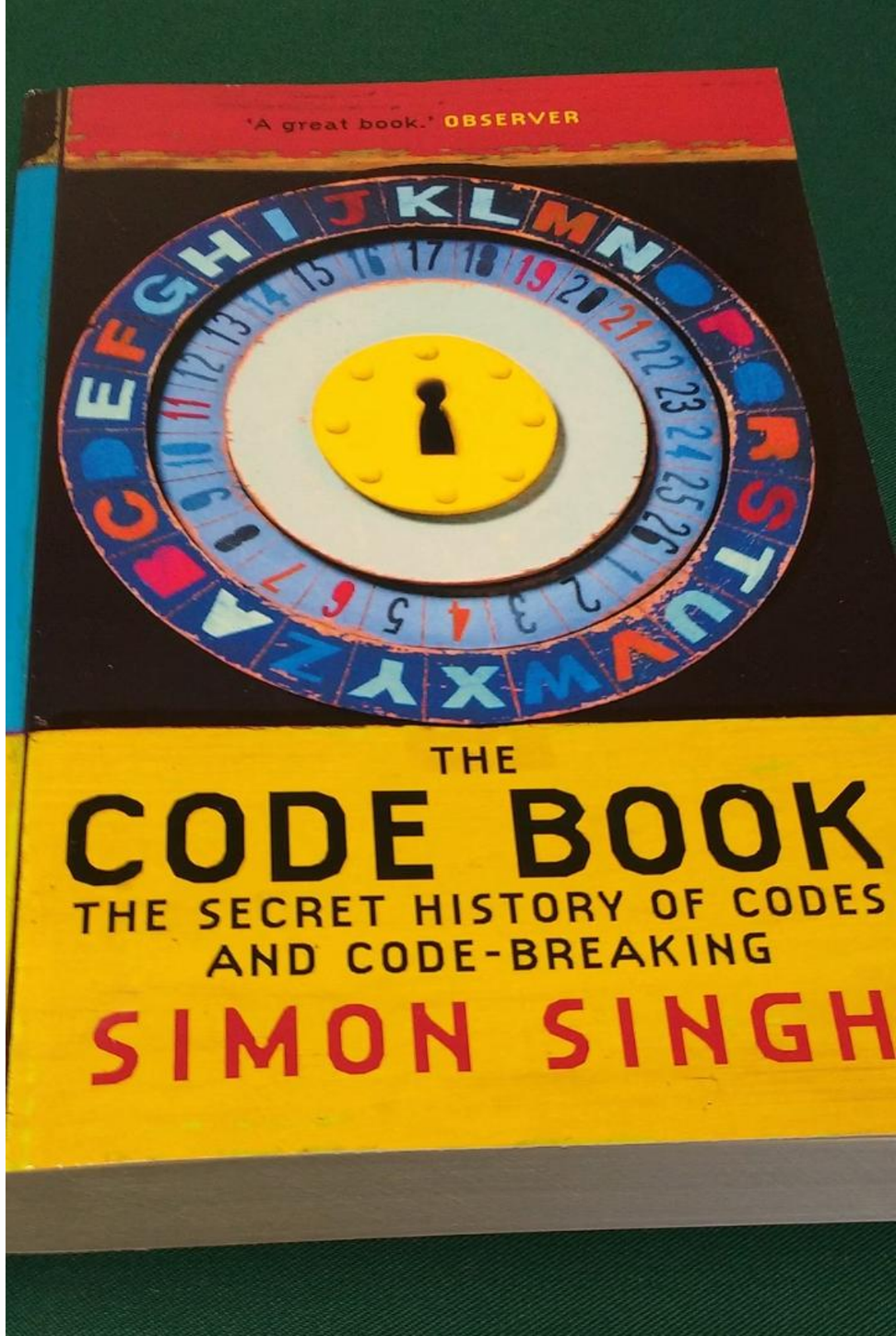
In many cases, one person or organization, the installing contractor, assumes these responsibilities.

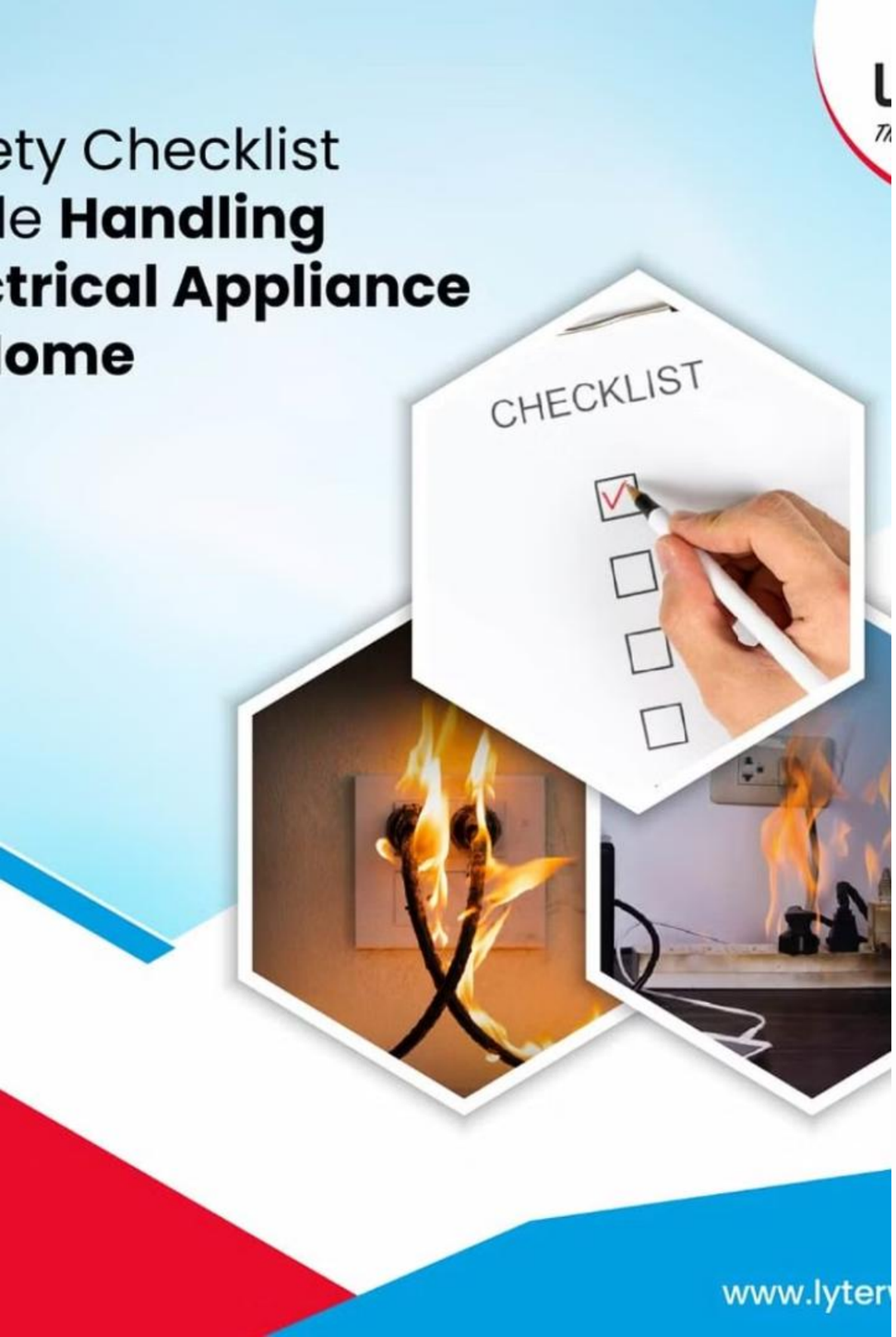
This consolidates accountability and ensures a streamlined process for appliance conversion.

Code Requirements: CSA B149.1 Clause 4.3

Clause 4.3 of CSA B149.1 clearly specifies the installer's responsibilities during and after a conversion. He/she must also comply with any amendments that the local authority having jurisdiction makes to the Code.

This ensures that all installations meet the highest safety and operational standards.





Installer's Responsibilities: Clause 4.3.1

Before leaving installations, installers shall ensure that the appliance, accessory, component, equipment, or piping and tubing they installed complies with the Code requirements, and the equipment, or piping and tubing may and ensure that the appliance is in safe working order.

This clause emphasizes the importance of thorough checks before completing an installation.

Installer's Responsibilities: Clause 4.3.2

Installers shall instruct the user in the safe and correct operation of all appliances or equipment that they install.

Proper user instruction is vital for safe and efficient appliance operation.

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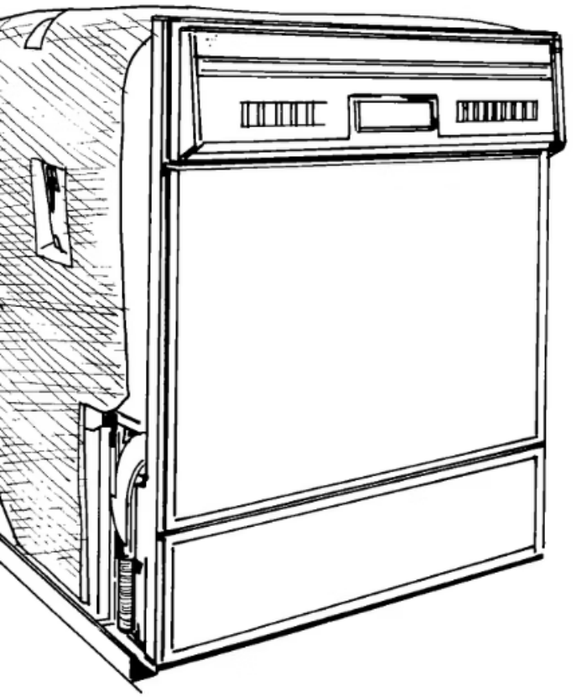
stallation Instruction

Undercounter Dishwash



IMPORTANT:
Installer: Leave Installation Instructions with the homeowne
Homeowner: Keep Installation Instructions for future reference
Save Installation Instructions fo local electrical inspector's use.

Part No. 4171206

Before you start.

Proper installation is your responsibility. Make sure you have everything necessary for correct installation. It is the personal responsibility and obligation of the customer to contact a qualified installer to a that electrical and plumbing installation meet national and lo codes and ordinances.

Check location where dishwast will be installed. The location sl provide:

- Easy access to water, electri and drainage.
- Convenient loading — the be position is left or right of kitch sink.
- Opening that is square for pr dishwasher operation and appearance.
- Cabinet front that is perpendi to floor.
- Protection against freezing to prevent the water inlet valve, water lines to dishwasher, wa lines in dishwasher, and drair rupturing. (Ruptures from fre are not covered by the warrar
- 1/4" minimum clearance betw motor and flooring to prevent motor overheating.

Installer's Responsibilities: Clause 4.3.3

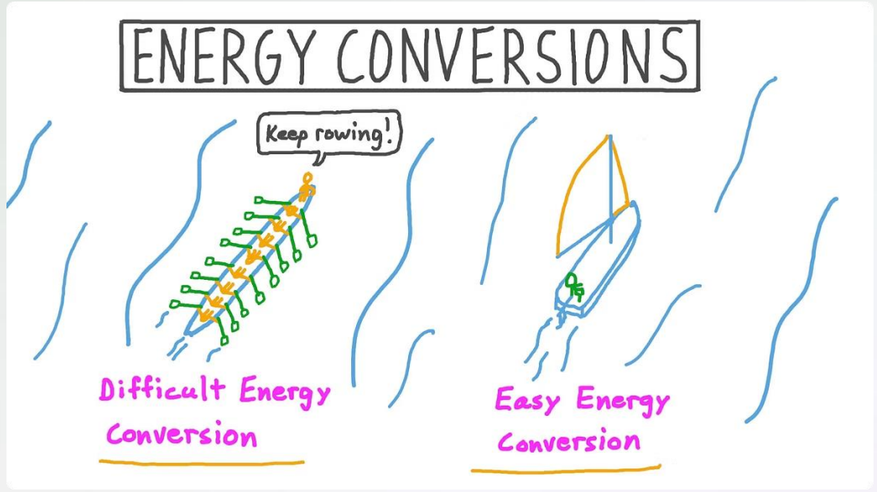
The installer shall ensure that the manufacturer's instructions supplied with the appliance are left with the user.

Providing manufacturer's instructions empowers users with essential information for maintenance and troubleshooting.

Installer's Responsibilities: Clause 4.3.4

Before installing any replacement part of an appliance, the installer shall ensure that the replacement part characteristics at least equivalent to those of the original part.

This ensures that replacement parts maintain the appliance's original performance and safety standards.



Installer's Responsibilities: Clause 4.3.5 - Energy Conversion Advice

When the installation or conversion of an appliance constitutes a conversion from another form of energy, the installer shall advise the user of the appliance, at the time of installation or conversion, to have the former form of energy either removed or left safe and secure from accidental activation.

This advice is critical for preventing hazards associated with residual energy sources.

Installer's Responsibilities: Clause 4.3.5 a) - Fuel Oil Supply Tank

For example, the user shall be advised:

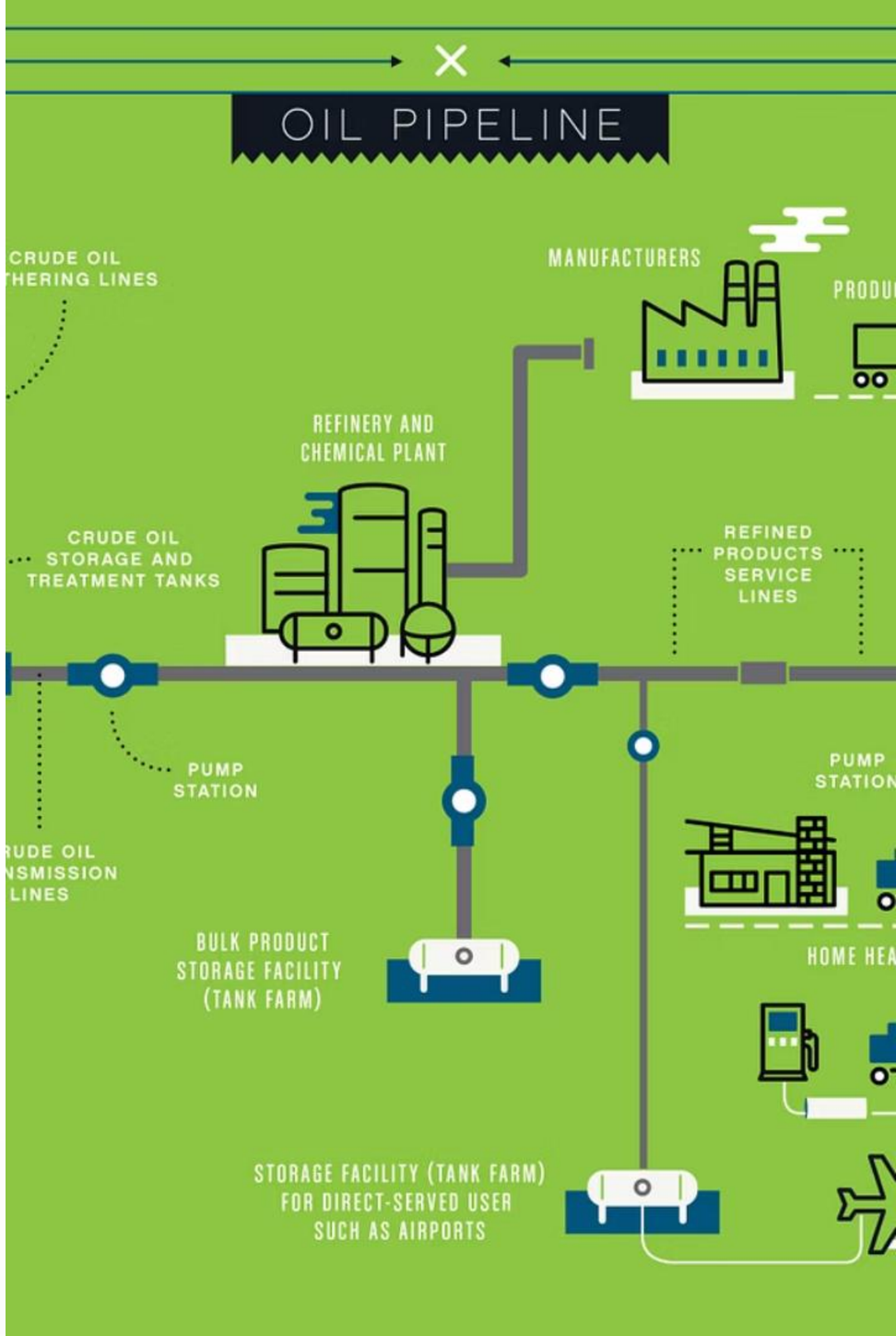
a) in the case of a fuel oil supply tank

- i) to remove the fill pipe, and cap or plug the exposed fill pipe opening to an inside tank;
- ii) to shut off the tank outlet valve, remove the filter, and plug or cap the valve outlet; and
- iii) where the tank is located outdoors, to disconnect all exposed piping or tubing, and cap or plug the piping or tubing as close as practicable to the tank;

Installer's Responsibilities: Clause 4.3.5 b) - Fuel Oil Central Distributing System

b) in the case of a fuel oil central distributing system

- i) to shut off the fuel oil supply line valve located within the building; and
- ii) to disconnect the fuel oil supply line immediately downstream of the meter, and cap or plug the outlet of the meter;



Installer's Responsibilities: Clause 4.3.5 c) - Propane System

c) in the case of a propane system

- i) to shut off the cylinder or tank valve; and
- ii) to disconnect and cap or plug the propane supply piping or tubing outdoors;

Installer's Responsibilities: Clause 4.3.5 d) - Electrical Appliance

d) in the case of an electrical appliance

- i) to ensure that the overcurrent protection, fuse, or circuit breaker has been removed or put in the off position.

Installer's Responsibilities: Clause 4.3.6 - Written Advice

The installer installing the installation or conversion, as specified in Clause 4.3.5, shall advise the user of the appliance in writing of the procedures to be followed in discontinuing the supply of the former form of energy.

Written advice ensures clear communication and a record of safety instructions.

Installer's Responsibilities: Clause 4.3.7 - Pressure Tests

It shall be the responsibility of the installer of a piping or tubing system to perform pressure tests in accordance with Clause 6.22.2 and to ensure that the piping or tubing system is gastight at the completion of the tests.

Pressure tests are crucial for verifying the integrity and safety of the gas piping system.

Installer's Responsibilities: Clause 4.3.8 - Appliance Tests

It shall be the responsibility of the installer of an appliance to perform tests in accordance with Clause 6.22.3 and to ensure that the system is gas-tight at the completion of the tests.

These tests confirm the gas-tightness of the entire system, preventing leaks and ensuring safe operation.

Ontario Amendment: Clause 4.3.5 a) - Fuel Oil Tank

Note: For Ontario, Clause 4.3.5 a) is revoked and the following substituted for it:

a) In the case of a fuel oil tank,

- i) Remove the fill pipe and cap or plug the exposed fill pipe opening to an inside tank; however, do not remove the tank vent pipe;
- ii) Shut off the tank outlet valve, remove the filter, and plug or cap the valve outlet;
- iii) where the tank is located outdoors, disconnect all exposed piping or tubing as close as practicable to the tank; cap or plug the exposed fill pipe opening to the tank; however, do not remove the tank vent pipe; and
- iv) advise the owner/operator of the tank in writing that the tank may be required to be removed in accordance with the Fuel Oil Regulation and the oil shall be removed by a certificate holder trained for the purpose.

National Fuel Gas Code

HANDBOOK

Code Requirements for Conversions: Overview

CSA B149.1 specifies clearly the requirements for conversions. The intent of these sections is to ensure safe operation of the appliance, compatibility of the burner, and proper venting.

These requirements are foundational for all appliance conversions.

Code Requirements: Approval - Clause 4.2.1

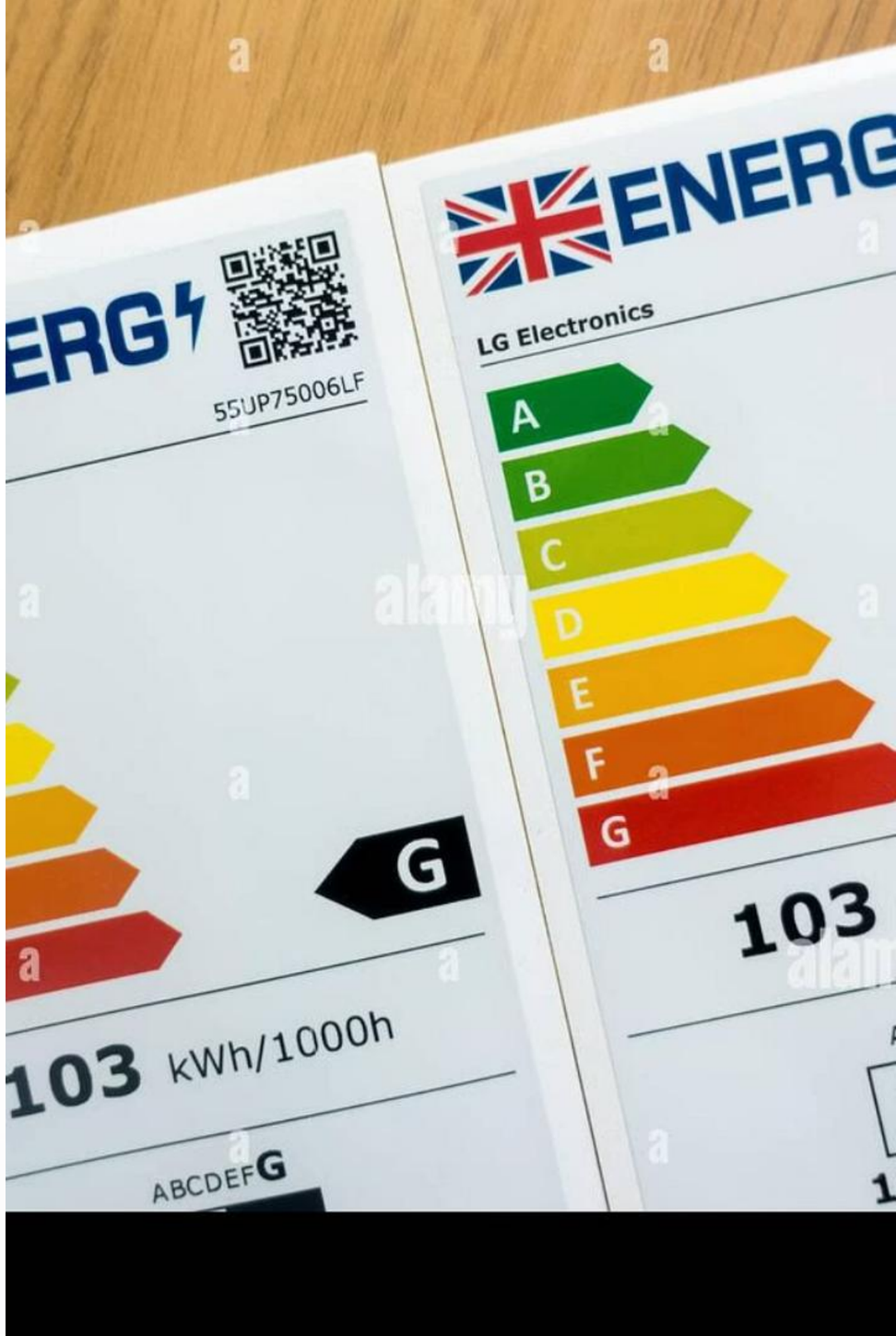
An appliance, accessory, component, equipment, or material used in an installation shall be of a type and rating approved for the specific purpose for which it is employed.

This clause ensures that all parts of the installation meet safety and performance standards.

Code Requirements: Suitability of Use - Clause 4.5.3

When an appliance is converted from the gas or fuel specified on the rating plate, the which an appliance is corrected is with the manufacturer's certified instructions. If there are no manufacturer's instructions for conversion of the appliance, the converted appliance shall be approved.

This emphasizes the importance of manufacturer guidelines or re-approval for converted appliances.



Code Requirements: Conversions - Clause 7.6.1 - Clearances

The minimum clearances from combustible material for a furnace converted to gas shall be

For a boiler

as specified in Clause 7.1.3;

For a forced-air furnace

- i) from top (casing, bonnet, or plenum) 1 in (25 mm);
- ii) the jacket sides and rear 6 in (150 mm); and
- iii) front 24 in (610 mm); and

For a gravity furnace

- i) vertical 6 in (150 mm);
- ii) sides and rear 6 in (150 mm); and
- iii) front 24 in (610 mm), except as specified in Clause 4.13.2.

Code Requirements: Conversions - Clause 7.6.2 - Cleaning and Examination

An appliance to be converted shall be thoroughly cleaned, leak tested, and examined for serviceability. Any unserviceable parts shall be repaired or replaced.

This ensures the appliance is in optimal condition before conversion.

Code Requirements: Conversions - Clause 7.6.3 - Chimney Requirements

When an existing vented appliance is to be converted from a solid or liquid fuel, the chimney shall be examined and shall meet the requirements of Clauses 8.12.2 to 8.12.11.

Proper chimney condition is vital for safe and efficient venting of converted appliances.

Code Requirements: Conversion Burners – Clause 7.7.1 – Burner Compatibility

A conversion burner designed by the manufacturer of the appliance to be converted, or a burner compatible with the appliance to be converted, shall be used.

Using compatible burners ensures proper function and safety.

Code Requirements: Conversion Burners - Clause 7.7.2 - Mobile Home Furnaces

When an oil-fired furnace in a mobile home is converted to gas, the conversion shall be by means of

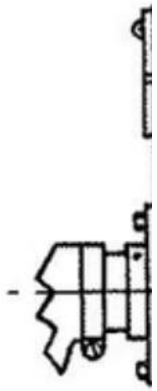
- a) the furnace manufacturer's certified burner conversion package; or
- b) a certified conversion burner, provided that
- i) the basic design of the furnace is not altered; and
- ii) when adjusted, the burner firing rate does not exceed the furnace manufacturer's specified firing rate.

Note: Combustion and ventilation air requirements for mobile homes are detailed in CSA Z240 MH Series. Designing and sizing the venting and clearances should align with the manufacturer's recommendations.

2. RECOMMENDED MINIMUM INSIDE DIMENS
OF REFRACTORY-TYPE COMBUSTION CHAM

4 Dimension (C)	5 Suggested Height (H)	6 Minimum Dia. Vertical Cyl.
3	8	7
3.5	9	7.5
3.5	9	8
3.5	9	8.5
4	10	9
4	10	9.5
4	10	10
4	10	11
4.5	11	12
4.5	11	13
4.5	11	14
4.5	11	15
5	12	16
5	12	17
5	12	18

Fig. 5



shown in column (2). Often,
e well with chambers shorter
2).

dimensions can be exceeded

cylinders should be at least

Code Requirements: Conversion of Warm-Air Furnaces - Clause 7.7.3 - Burner Positioning

A conversion burner shall be correctly positioned and firmly secured to eliminate direct flame impingement on any surface other than a flame spreader.

Correct positioning prevents damage and ensures efficient combustion.

Code Requirements: Conversion of Warm-Air Furnaces - Clause 7.8.1 - Revertible Flue Furnace Restrictions

A revertible flue furnace shall not be converted by the installation of

- a) a natural-draft burner, unless
- i) the centreline of the flue collar is at least 12 in (300 mm) above the burner port;
- ii) the flue outlet is extended to permit installation of the draft regulator so that the relief opening is at least 12 in (300 mm) above the highest flue pass; and
- iii) a bypass at least 1 in (25 mm) in diameter is connected to the top of the highest flue pass and extends through the outer casing, terminating in the vent connector. A direct draft damper may be used as an alternative to the bypass; or
- b) a fan-assisted burner, unless
- i) there is compliance with the requirements of Items a) i) to iii); or
- ii) there is compliance with the requirements of Items a) i) and the burner incorporates spark ignition, a pre-purge, and an automatic valve with an integral dual safety shut-off feature.

Code Requirements: Conversion of Warm-Air Furnaces - Clause 7.8.2 - Bypass Construction

The bypass referred to in Item a) iii) of Clause 7.8.1 shall be gas-tight and shall be constructed of metal at least equivalent in strength and corrosion resistance to the metal from which it is extended.

This ensures the bypass is durable and prevents gas leaks.

Code Requirements: Conversion of Warm-Air Furnaces - Clause 7.8.3 - Secondary Heating Surface

A forced-air furnace with a secondary heating surface located on the suction side of the circulating air blower shall not be converted to gas except where such a heating surface consists of a single cylindrical flue pipe passing directly from the primary heat exchanger to the flue collar and having a single continuously gas-tight welded joint.

This restriction prevents potential hazards related to gas leaks in the air stream.

Code Requirements: Conversion of Warm-Air Furnaces - Clause 7.8.4 - Caution Sign

An easily readable caution sign or label of durable material having black letters on a yellow background shall be either on or attached to each side of the circulating air blower compartment access door of a fuel converted forced-air furnace and shall be worded as follows:

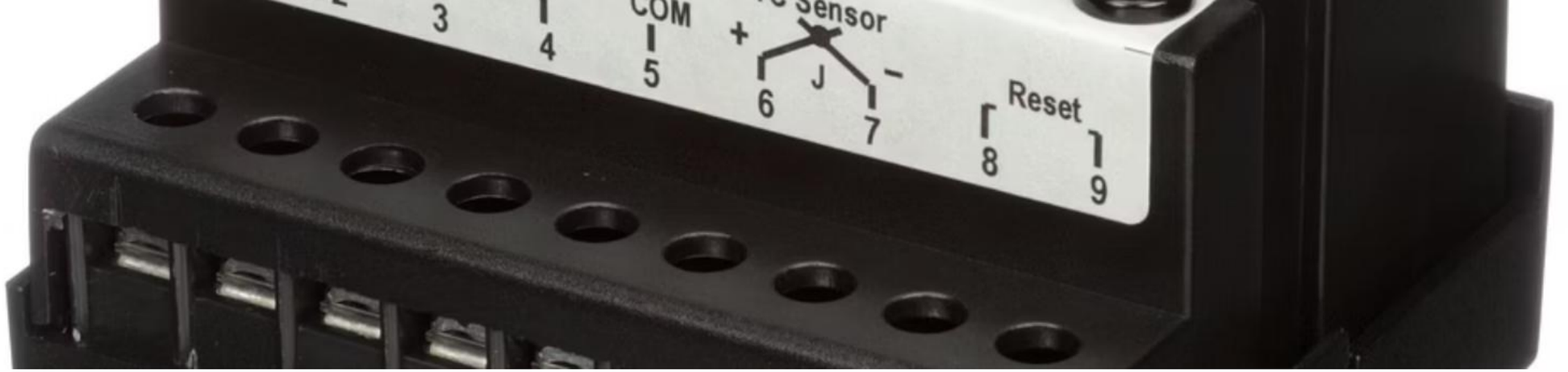
> "WARNING: THIS COMPARTMENT MUST BE CLOSED EXCEPT WHEN SERVICING"
>
> "AVERTISSEMENT: CE COMPARTMENT DOIT RESTER FERME, SAUF POUR L'ENTRETIEN"

The lettering of "WARNING" and "AVERTISSEMENT" shall be a minimum of 3/8 in (9.6 mm) in height, and the remainder of the lettering shall be in a minimum of 3/16 in (4.8 mm) in height.

Code Requirements: Conversion of Warm-Air Furnaces - Clause 7.8.5 - Flue Outlet Material

The flue outlet referred to in Clause 7.8.1 shall be made of a material at least equivalent in strength and corrosion resistance to that of No. 24 GSG (0.60 mm) galvanized steel.

This ensures the flue outlet's durability and resistance to corrosion.



Code Requirements: Conversion of Warm-Air Furnaces - Clause 7.8.6 - High-Temperature Limit Control

An automatically controlled gravity or forced-air furnace shall be equipped with a high-temperature limit control, and the maximum setting of the control shall be

- a) 350°F (175 °C) for a gravity furnace; and
- b) 250°F (120 °C) for a forced-air furnace.

This control prevents overheating and ensures safe operation.

Code Requirements: Vent Connector - Clause 8.18.11 - Clearances

Except as provided in Clause 8.18.13, the minimum clearance of a vent connector of other than Type B vent material from a combustible wall or partition shall be in accordance with Table 8.6

Appliance Vent Connector Clearances (Table 8.6)

Warm-air furnace	1 (25)*	6 (150)*
Service water heater	1 (25)*	6 (150)*
Space heater	1 (25)*	6 (150)*
Floor furnace	3 (75)†	9 (225)
Incinerator	Not permitted	18 (450)
Conversion burner (with draft hood)	6 (150)	9 (225)

* Except as otherwise certified.

† 3 in (75 mm) for a distance of not less than 3 ft (900 mm) from the outlet of the draft hood. Beyond 3 ft (900 mm), the minimum clearance shall be 1 in (25 mm).

NFPA 54 – National Fuel Gas Code
Table 10.7.4.4 Clearances for Connectors

Minimum Distance from Combustible Material		
Listed Type B Gas Vent Material	Listed Type L Vent Material	Single-Wall Metal Pipe
As listed	As listed	6 in.
6 in.	6 in.	9 in.
Not permitted	As listed	9 in.
Not permitted	As listed	As listed
Not permitted	6 in.	9 in.
Not permitted	9 in.	18 in.
Not permitted	Not permitted	36 in.

eys in residential settings = 4 in. For medium-heat equipment = 8 in. (*NFPA 211Standard for Chimney*
s)
pply unless the listing of an appliance or connector specifies different clearances, in which case the lis

Code Requirements: Vent Connector - Clause 8.18.18 - Material Restriction

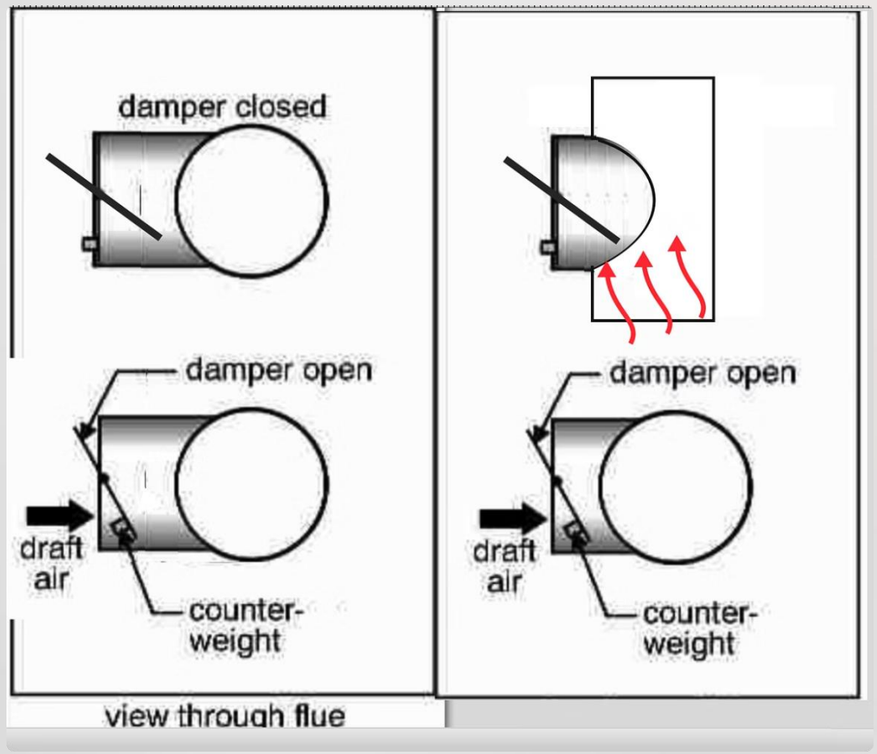
A vent connector of either Type B or Type L vent material shall not be used between the flue outlet and the draft-control device of either a converted furnace or converted boiler.

This restriction ensures the use of appropriate materials for safety and performance.

Code Requirements: Draft Hood - Clause 8.23.6 - Location

A draft hood shall be in the same room as the combustion air opening of the appliance. A draft hood shall not be installed in a false ceiling space, in a room other than the one the appliance serves, or in any manner that could permit a difference in pressure between the draft-hood relief opening and the combustion air supply. The draft hood supplied for a conversion burner shall be located so that the burner is capable of safe and efficient operation.

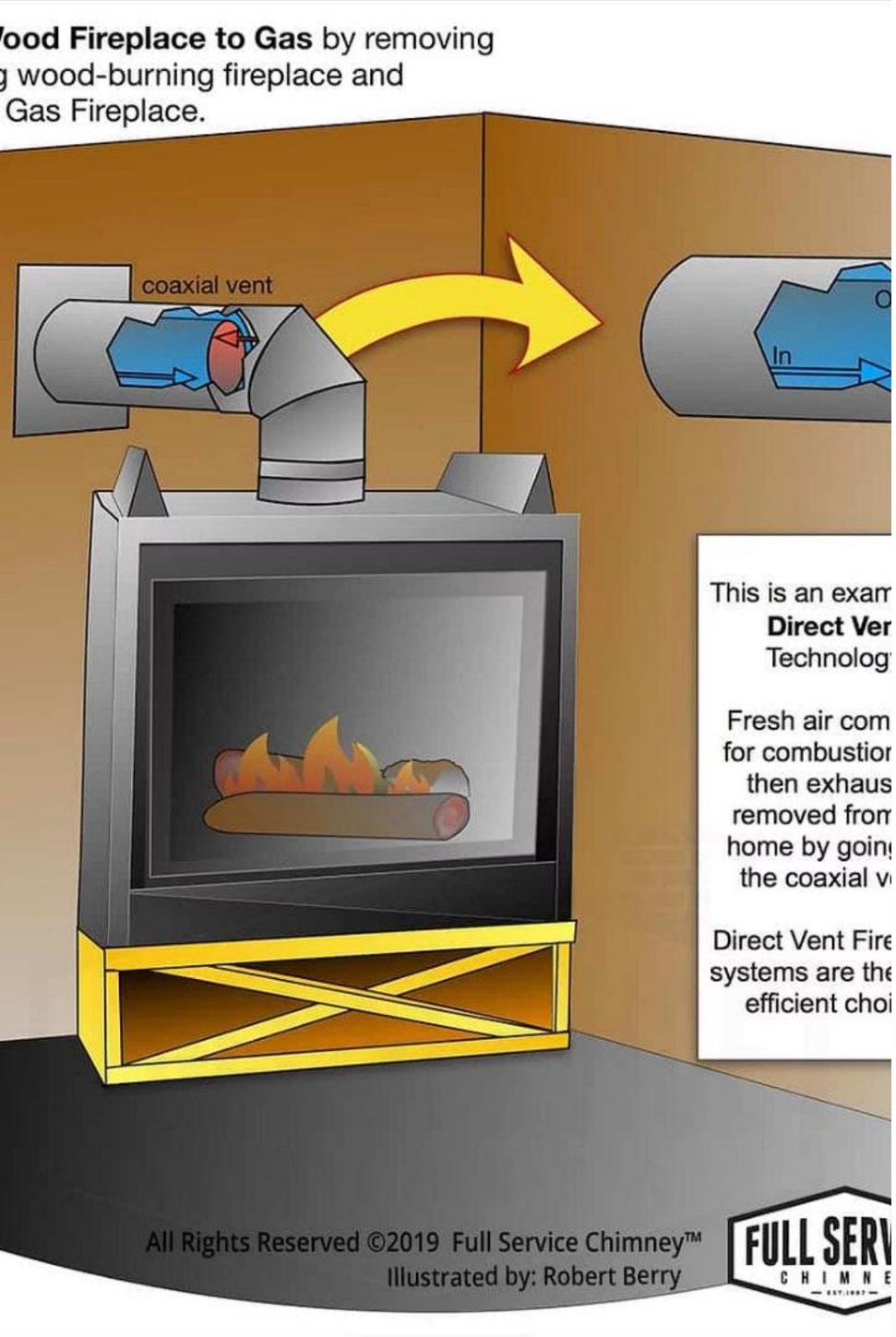
Proper draft hood location is essential for safe and efficient combustion.



Code Requirements: Draft Regulator - Clause 8.25 - Location and Type

A draft regulator, when used, shall be located so that the relief opening is not obstructed by any part of the appliance or adjacent section. When used with an incinerator, a draft regulator part of the appliance or adjacent section. When used with an incinerator, a draft regulator only at all other installations, it shall be of the double-acting type.

Note: Oil and solid-fuel appliances are usually equipped with a single-acting draft regulator. When Note. On and sold full appliance are adading the draft regulator to function as a double-acting type.



CSA Unit 17

Chapter 2
Preparation for Conversion

As solid fuel and oil appliances do not normally burn as clean as gas, and the burning temperatures are generally higher, the combustion chamber requires thorough checking and cleaning before the installation of a conversion burner. Similarly. the venting system needs checking to ensure it is in acceptable condition. Once the appliance and the venting system have undergone checking and modification as required, the choice of conversion burner systemes dependent on the combustion chamber geometry and other selection criteria.

Overview

As solid fuel and oil appliances do not normally burn as clean as gas, and the burning temperatures are generally higher, the combustion chamber requires thorough checking and cleaning before the installation of a conversion burner. Similarly. the venting system needs checking to ensure it is in acceptable condition. Once the appliance and the venting system have undergone checking and modification as required, the choice of conversion burner systemes dependent on the combustion chamber geometry and other selection criteria.

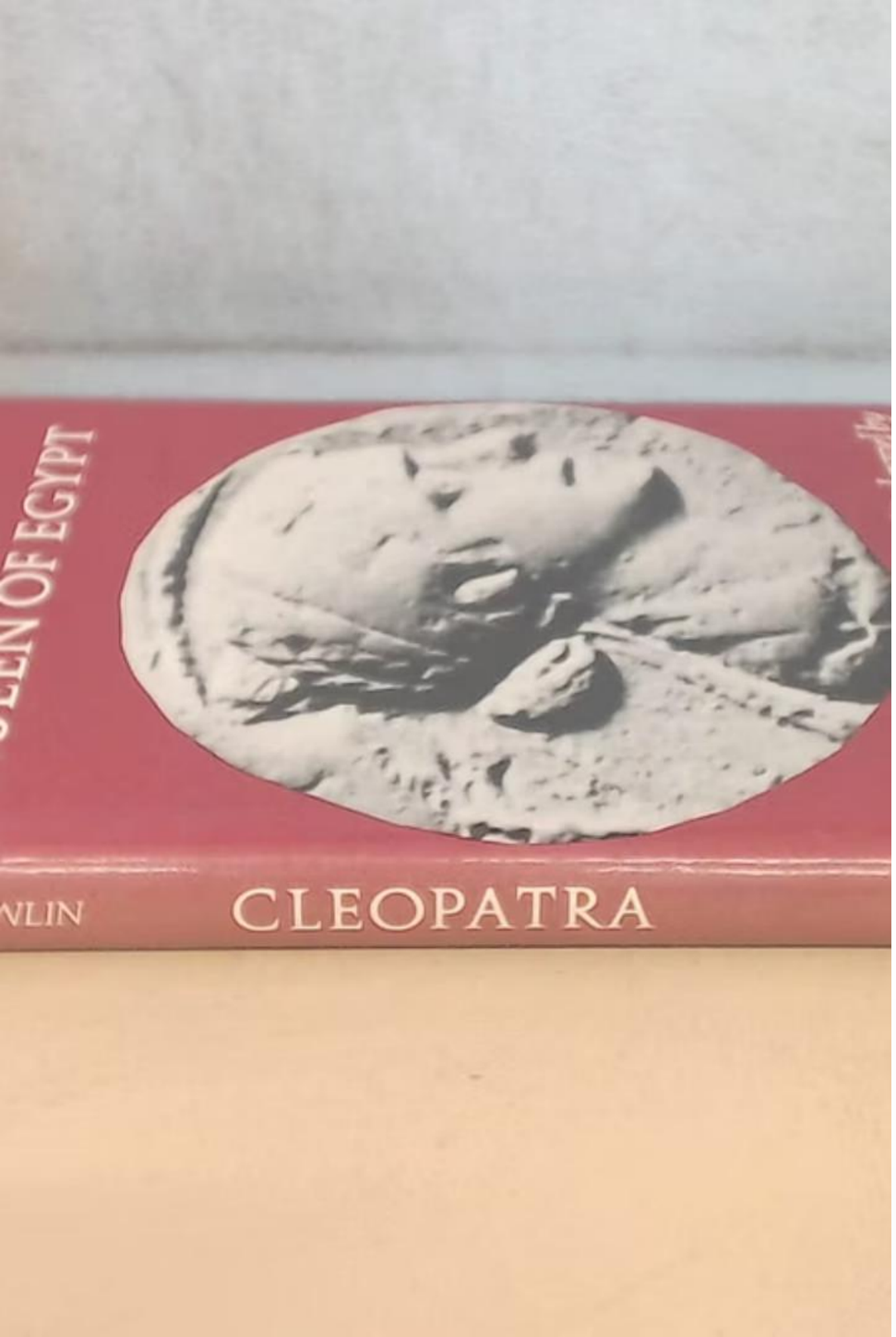
Purpose

As solid fuel and oil appliances do not normally burn as clean as gas, and the burning temperatures are generally higher, the combustion chamber requires thorough checking and cleaning before the installation of a conversion burner. Similarly. the venting system needs checking to ensure it is in acceptable condition. Once the appliance and the venting system have undergone checking and modification as required, the choice of conversion burner systemes dependent on the combustion chamber geometry and other selection criteria.

Objectives

1. Explain how to prepare a boiler for conversion
2. Explain how to prepare a furnace for conversion
3. Explain how to prepare a venting system for conversion
4. Describe the criteria used to choose a conversion burner

KITCHEN APPLIANCES CHECKLIST	
	Fridge
	Hod/Stove/Cooker
	Hood
	Oven/Microwave Oven
	Microwave
	Dishwasher
	Toaster
	Rice cooker
	Pressure cooker
	Water Filter/Heater
	Coffee Machine
	Blender
	Juicer
	Food Processor



Terminology

Term	Abbreviation (Symbol)	Definition
Boiler horsepower	BHP	A unit for measuring the power of a steam boiler One BHP denotes ability to produce 34.5 pounds of dry steam per hour at 100 °C (212°F) Equivalent values of 33 475 Btu/h or 9.809 kilowatts (kW)
Cerafelt		A soft fiber ceramic material used in modern oil appliances
Flame geometry		Shape of the flame

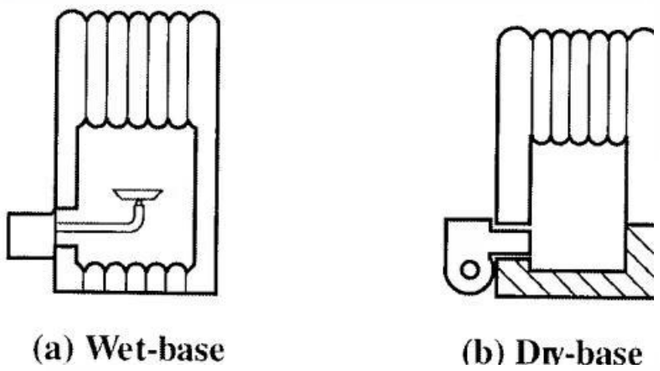
Terminology (Continued)

Term	Abbreviation (Symbol)	Definition
Inshot burner		Burner that fires horizontally into the combustion chamber May have a spreader or target plate downstream of the burner head to direct the flame Is mainly intended to replace oil burners
Upshot burner		Burner that fires vertically with the flame being diverted by a spreader Flame is generally circular in shape and has a uniform cross-section Is mainly used with furnaces or boilers originally manufactured for coal-burning use

Preparing a Boiler for Conversion

Before conversion, a boiler requires careful inspection for cracks or loose cement in the heating sections, warped doors and door frames, and any other defects that might permit uncontrolled sootions, warpour acore and and er. All conditions of this type must be corrected before installing a gas conversion burner.

Types of Boilers



(a) Wet-base

(b) Dry-base

Wet-base boiler

- In a wet-base boiler [Figure 2-1(a)], the return lines enter the boiler at its base.
- When converting this type of boiler, there is usually no firepot required if the proper burner is selected. Check with the manufacturer.

Dry-base boiler

- A dry-base boiler [Figure 2-1(b)] is one where the boiler water connections enter at the base of the boiler sections that sit on top of a dry base.

Boilers sometimes require a firepot to protect against the conversion burner flame impinging on the combustion chamber's metal sides, back or top. If you are unsure about whether the unit requires a firepot, consult with the manufacturer.

Boiler Inspection Procedure

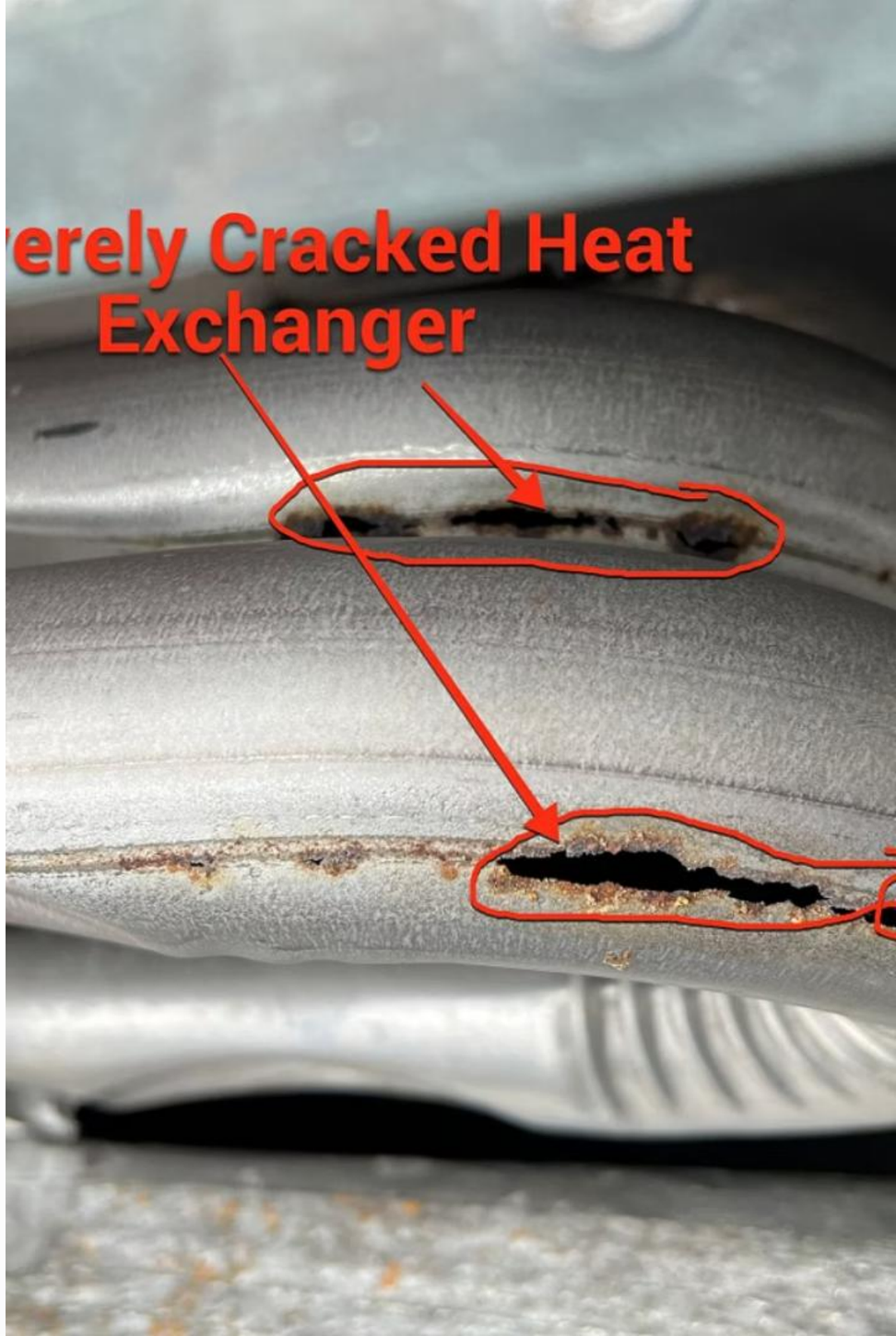
The following inspection procedure should determine that there are no conditions that make the converted appliance uneconomical or unsafe.

1. Shut off the fuel.
2. Remove the burner.
3. Remove the flue pipe.
4. Remove the domestic hot water coils (if any) from the combustion chamber.
5. Thoroughly clean all heating surfaces and flue passages with brushes or scrapers to loosen scale and dirt.
6. Clean any residue from low-water cut-off.
7. Vacuum the boiler. Take precautions to preserve the cleanliness and neatness of the premises while removing soot and debris.
8. Examine the firepot, if any, to determine its condition. Carefully clean the firepot if it is to remain. Be careful not to damage a fibre-type pot. Resize, replace, reshape, or repair the firepot as required.

Boiler Inspection: Cracks

Visually inspect boiler for cracks in the seams and body. If you detect cracks, first repair by re-cementing (or replacing) it and then perform a leak test.

- Check cast-iron sectional boilers for sealing between the boiler sections. If there are cracks, replace or repair the boiler with furnace cement in accordance with the manufacturer's instructions.
- Examine steel boilers for distortion of the side walls. Do not convert if distortion is severe.



Re-conditioning Boiler Joints

When repairing cracks with furnace cement, be sure to follow the directions on the label.

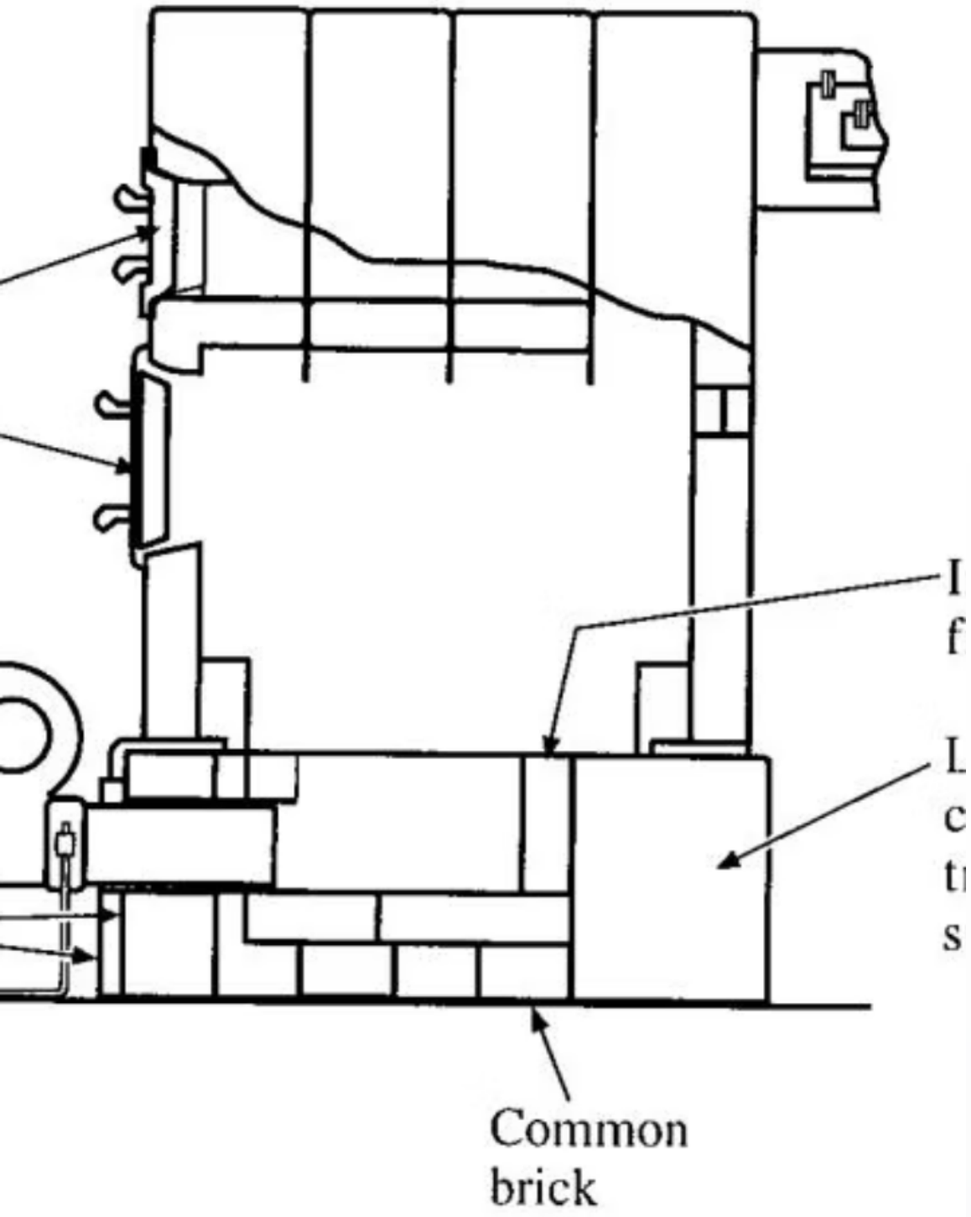
1. Re-cement joints around the boiler base to prevent air leakage into the combustion chamber. First loosen old joint compound.
2. Cement all joints between boiler sections.
3. Seal the following areas with furnace cement:
    - grate openings; and
    - cracks around door frames,

Boiler Leak Test

Boilers require a leak test to ensure that the boiler is watertight.

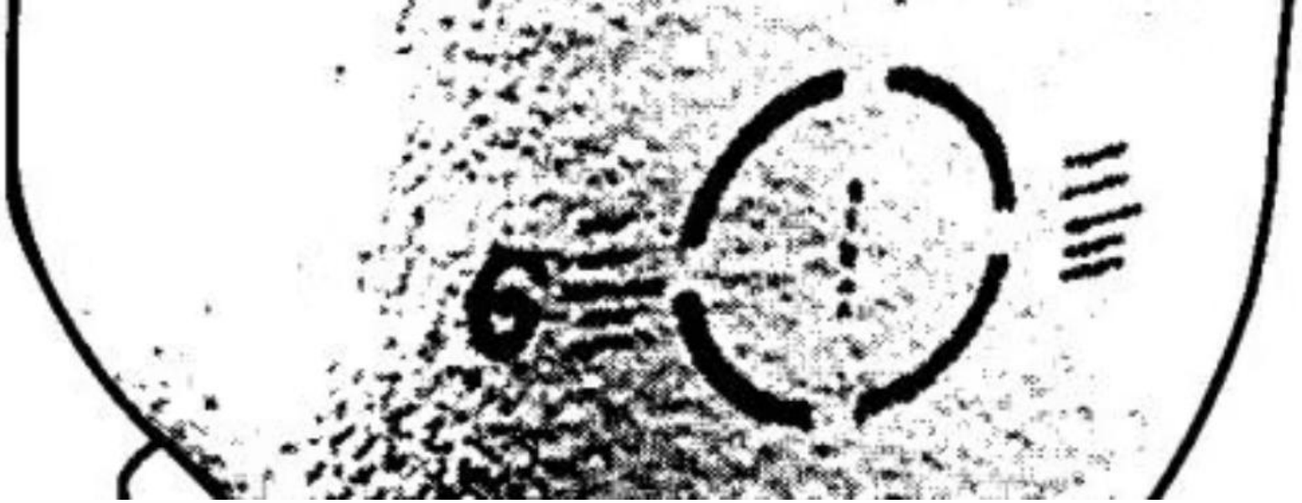
1. Test the boiler with pressurized water. Dampness at any of the joints is a sign of a crack.
2. Open drain at bottom of boiler and flush out chamber until water is clear. Sediment on the bottom affects heat transfer and can hide a small crack.
3. Repair any cracks found during the leak test in accordance with the appliance manufacturer's instructions and local regulations.

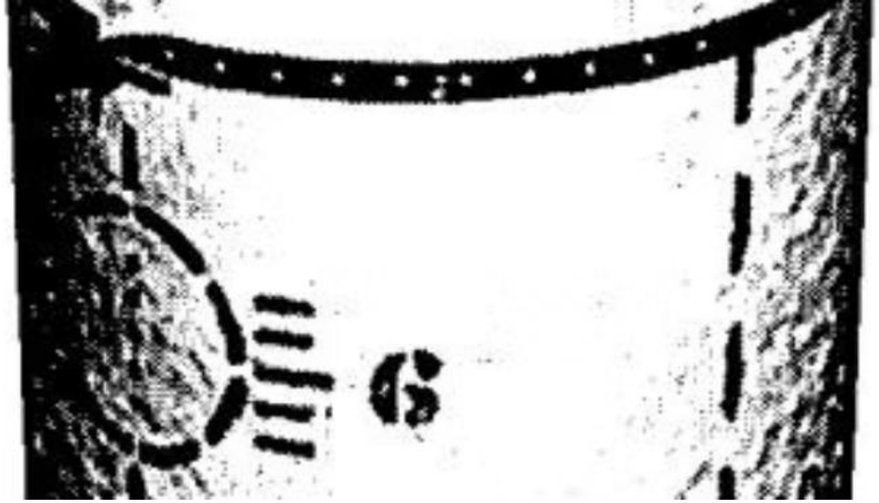
Figure 2-2
Combustion chamber lining



Combustion Chamber Lining

Examine the combustion chamber lining for fractures or deterioration and determine if repair is necessary. If it is in good condition, you can use the existing chamber liner. If you have to build up a firebrick chamber, use field-built insulating firebrick rated for service exposure to 2300°F (674 ° C) combustion products (Figure 2-2). A precast or formed-in-place Cerafelt combustion chamber is recommended (Figure 2-3). Cerafelt is a soft fibre ceramic material used in modern oil appliances.





Purpose of Combustion Chamber Lining

The lining is required for three reasons:

- to protect surfaces that do not transfer heat (e.g., the steel outer wall of a boiler);
- to provide a radiant bed for rapid heat transfer to the primary surfaces of the heat exchanger; and
- to prevent flame contact on the heat exchanger walls if the firing chamber is unusually short.

Combustion Chamber Lining (Continued)

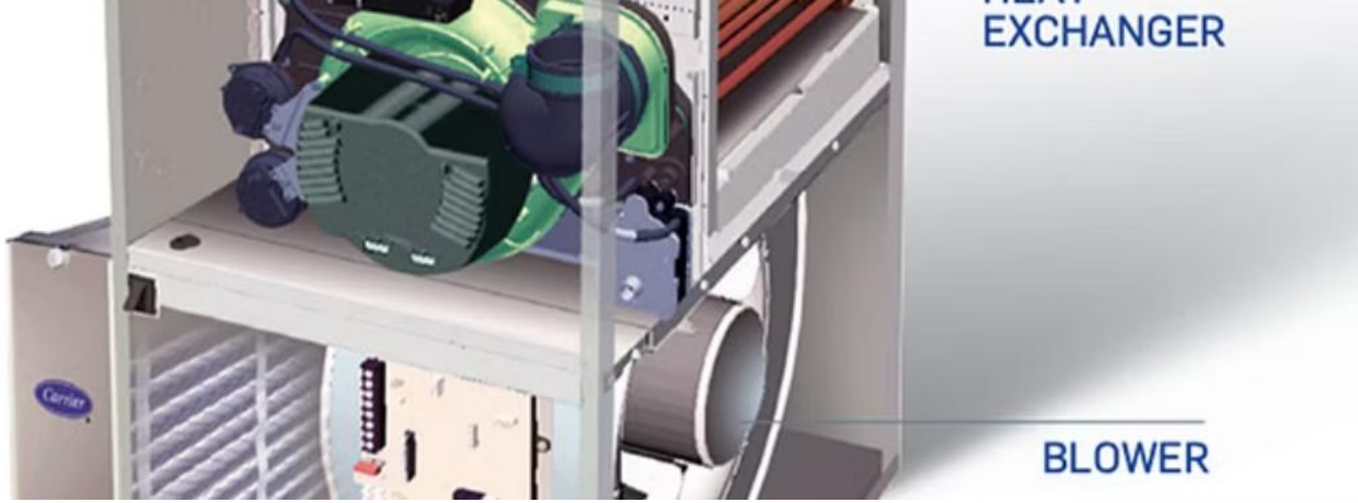
In some cases, required to reduce the size of the combustion chamber for the new gas fired burner.

The combustion chamber lining in some boilers (such as Type B*) require insulation all around to prevent excessive heat loss through the non-heated exchanging surfaces. Insulation should be rated for service to at least 1800°F (528 °C).

For more information on Type B combustion chambers, see "Combustion chamber geometry" and Figure 2-13 in the Choosing a conversion burner section.

Other Boiler Preparation Tasks

1. If the firing door is badly distorted, it cannot be tightly sealed. You must then replace the door.
2. Check location and condition of ductwork. Inspect the condition of sealing and insulation (if required).
3. Verify that the heating unit conforms to Code requirements in terms of clearance from combustibles.



Preparing a Furnace for Conversion

Preparing a gas conversion burner for installation in a furnace requires placing the burner first in first-class condition. One of the first steps is to make sure that:

- inner steel heat exchanger sections have not rusted through; and
- connections between heat exchanger and combustion chamber are airtight.

Defects of this type are not readily visible to the naked eye, so a heat exchanger leak test is recommended to make sure that products of combustion do not escape from the furnace into the house.

Furnace Inspection Procedure

The following inspection of the furnace should determine that there are no conditions that make the converted appliance uneconomical or unsafe.

1. Shut off power to furnace (if electric).
2. Shut off fuel.
3. Remove burner.
4. Remove flue pipe.
5. Thoroughly clean all heating surfaces and flue passages with brushes or scrapers to loosen scale and dirt.
6. Vacuum furnace. Take precautions to preserve the cleanliness and neatness of the premises while removing soot and debris.
7. Check gaskets on joints between heat exchanger and combustion chamber.
8. Check for cracks in heat exchanger. Replace if cracks are discovered.

Furnace Inspection: Visual Crack Check

Visually inspect furnace for cracks.

- Some hairline cracks open and shut with the heat of the furnace.
- These cracks may not appear during the smoke test, so do a very careful visual inspection.

Steps to Check for Cracks Visually

1. Examine the body with a flashlight.
2. Check through the burner opening with a mirror.
3. Remove fan assembly from blower compartment.
4. Remove draft regulator and plug outlet.
5. Check via fan compartment opening, using a light and mirror, for:
    - cracks on seams (or elsewhere);
    - warping and distortion of heat exchanger; in the event of a defective heat exchanger, consult the Code to determine if a repair is possible or if it requires replacement; and
    - rust spots.
6. Inspect all other surfaces you could not see from below through the fan compartment. - You can inspect through the humidifier opening (if any), inspect opening in the warm air plenum, or, in extreme cases, dismantle the furnace.

Furnace Crack Detection and Replacement

1. If joints seem tight, you can perform a smoke test if allowed by the appliance manufacturer and/or local regulations.
2. If you detect cracks in the heat exchanger, it must be replaced. It is usually more cost effective to replace the entire appliance.

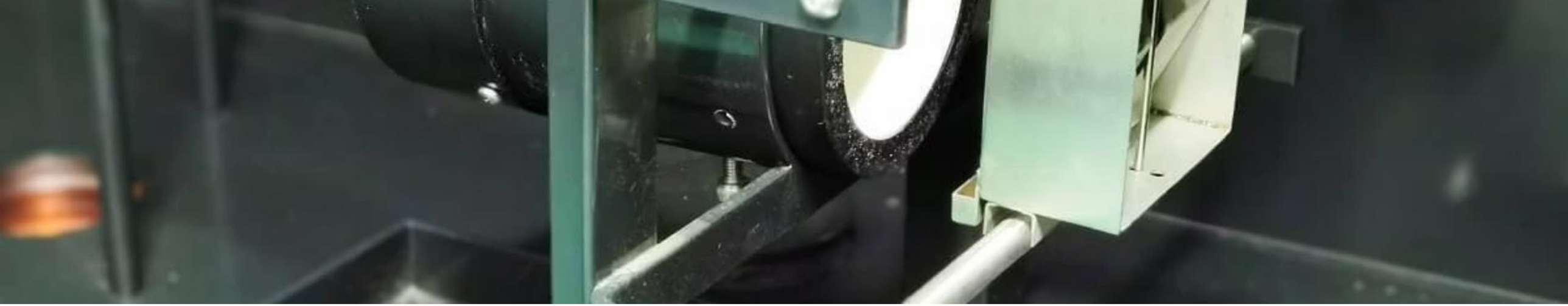
Re-conditioning Furnace Casings and Leaks

If cracks or fractures, especially above the grate level, are found in any of the casings following cleaning, the casings require replacement.

Repairable leaks around inspection doors, burner mounting plates, or heat exchanger sections should have a sealing of furnace cement or high temperature gasket material as recommended by the manufacturer. Follow the directions on the label.

Re-conditioning Furnace Joints and Openings

1. Cement all joints between sections.
2. Tightly grout ash pit to the floor.
3. Seal the following areas with furnace cement:
    - openings for grate shaker bars;
    - cracks around door frames; and
    - under clinker door.



Furnace Smoke Test

Test the airtightness of the combustion chamber to ensure that no unwanted air leaks in. Conduct a smoke test only if allowed by the appliance manufacturer and/or local regulations.

1. Block the furnace flue outlet.
2. Light smoke generator and place in fire chamber.
3. Quickly close feed door and observe whether any smoke or odour escapes from the registers upstairs.

Other Furnace Preparation Tasks

1. Check the location and condition of ductwork. Inspect the condition of sealing and insulation, if required.
2. Verify that the heating unit conforms to Code requirements in terms of clearance from combustibles.

Preparing Venting System for Conversion

Upon checking and repairing the boiler or furnace as necessary, check and prepare the combustion air and venting system for the conversion.

Air Requirements for Venting System

If the automatic oil burner operated trouble-free, the area around the heating plant could have enough air infiltration for combustion and for diluting the flue gases.

However, you must make sure that the new installation conforms to the local Codes and Regulations.

1. Check that combustion air ducts or openings are provided and that they meet local Code requirements.
2. Check whether ventilation openings are required. If so, ensure they meet local Code requirements.

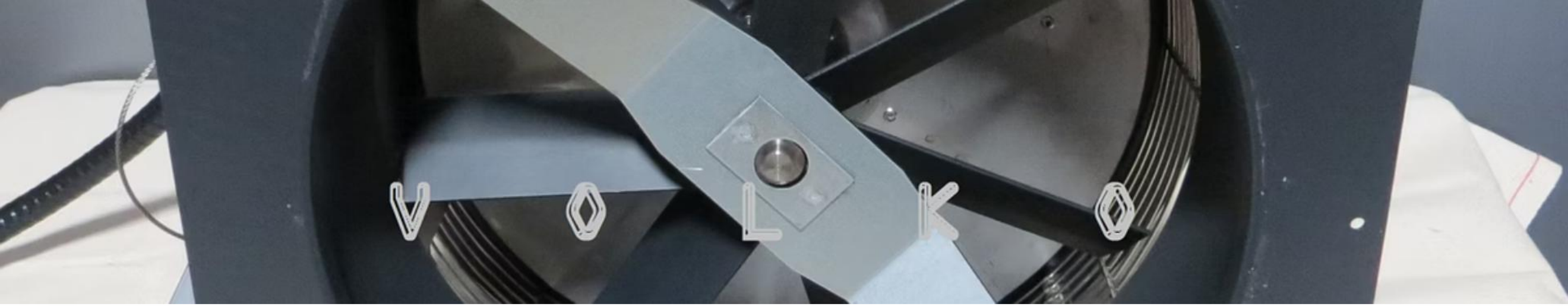
Note: Make sure there are no return-air outlets in the furnace area.

Venting System Inspection

Prior to installation of the venting system of the oil-fired appliance, your task is to ensure that it meets the requirements of CSA B149.1.

Note: Movable flue pipe dampers are not permitted on any gas conversion installation.

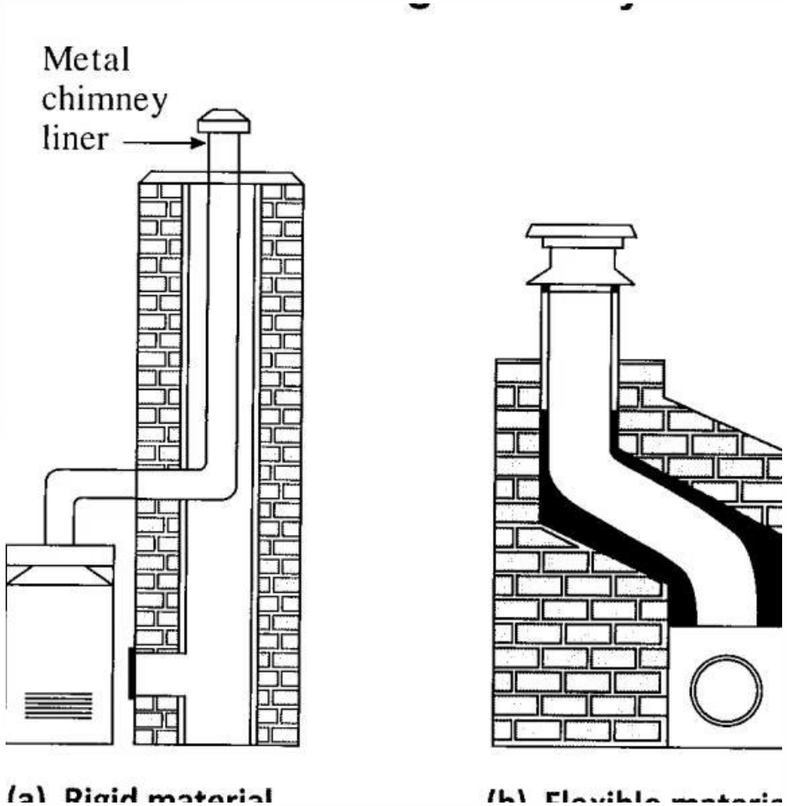
1. Inspect the chimney for unsafe conditions such as:
    - no liner;
    - deteriorated masonry;
    - excessive soot;
    - other blockage.
2. Inspect the vent connector for proper gauge, size, and condition.
3. Size the vent connector based on the size of the draft hood or according to the Code.
4. Ensure that the clearance between the flue pipe and combustible material strictly adheres to the Code. Table 8.6 of the Code identifies special clearance to combustible requirements for vent connectors serving a conversion burner with a draft hood.



Venting System: Interference Check

1. Check whether an exhaust fan, kitchen ventilation system, clothes dryer, and/or fireplace is installed in the building. If so, ensure that the venting of these appliances does not interfere with the conversion burner operation.
   - Turn on all the exhaust fans of the appliances in the common vent.
   - Cycle the conversion burner.
   - Check the draft in the venting system with a draft gauge to ensure there is adequate draft as specified by the appliance manufacturer.

Sizing a Chimney



(a) Rigid material (b) Flexible materia

Most oil and solid-fuel appliances use a masonry chimney to exhaust the flue products; however, since these chimneys are designed to exhaust flue products that are hotter than those of a gas burner, it may be too large and not draft properly, causing the flue products to condense. If venting a conversion burner uses a masonry chimney, it must meet the Code requirements for construction standards and size. To size a chimney, follow this procedure:

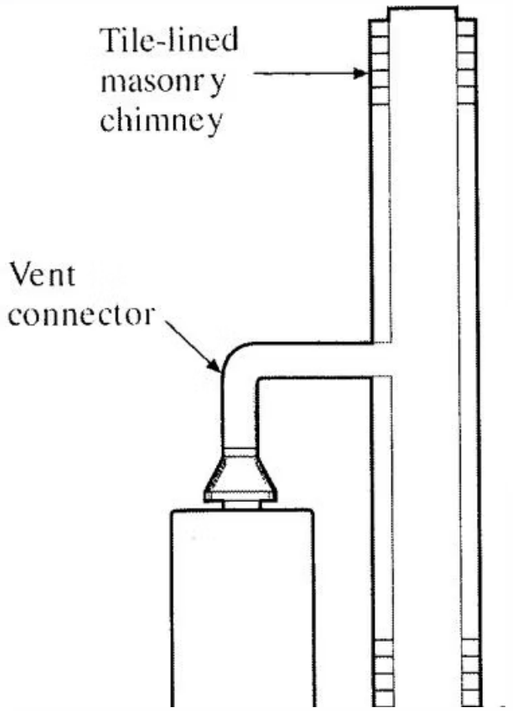
1. Size the chimney or flue pipe using good engineering practise or the Code.
2. The masonry chimney is the correct size and is lined with clay tile or transite (which protects the mortar from the flue gases). It can be used if it meets the requirements of the National Building Code or a local building code. Ensure there is a cleanout.
3. If the masonry chimney is too large, install an approved liner (Figure 2-4).

Figure 2-5
ppliance vented to lined (ti

Venting Requirements for Chimneys

Determine the layout and configuration of the venting system before proceeding with the gas conversion to ensure that it can be installed according to the general venting requirements in Annex C of CSA B149.1.

Chimney Venting Configurations



An appliance

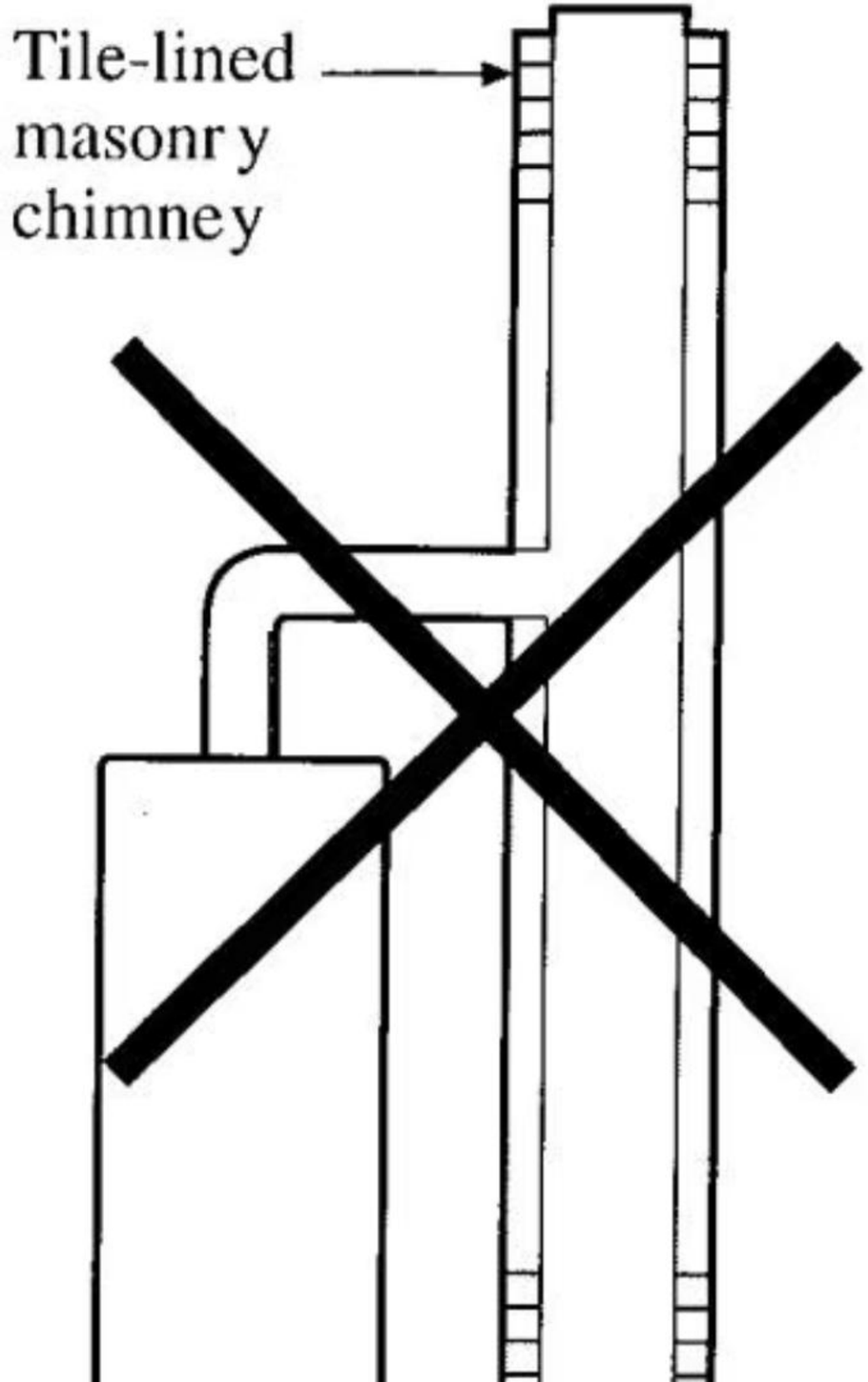
Can be individually vented into a chimney equipped with a draft hood and the chimney is sized and lined (Figure 2-5)

An appliance with fan-assist burner

Can be vented into chimney if there is a draft-hood appliance also vented into the same chimney (Figure 2-6).

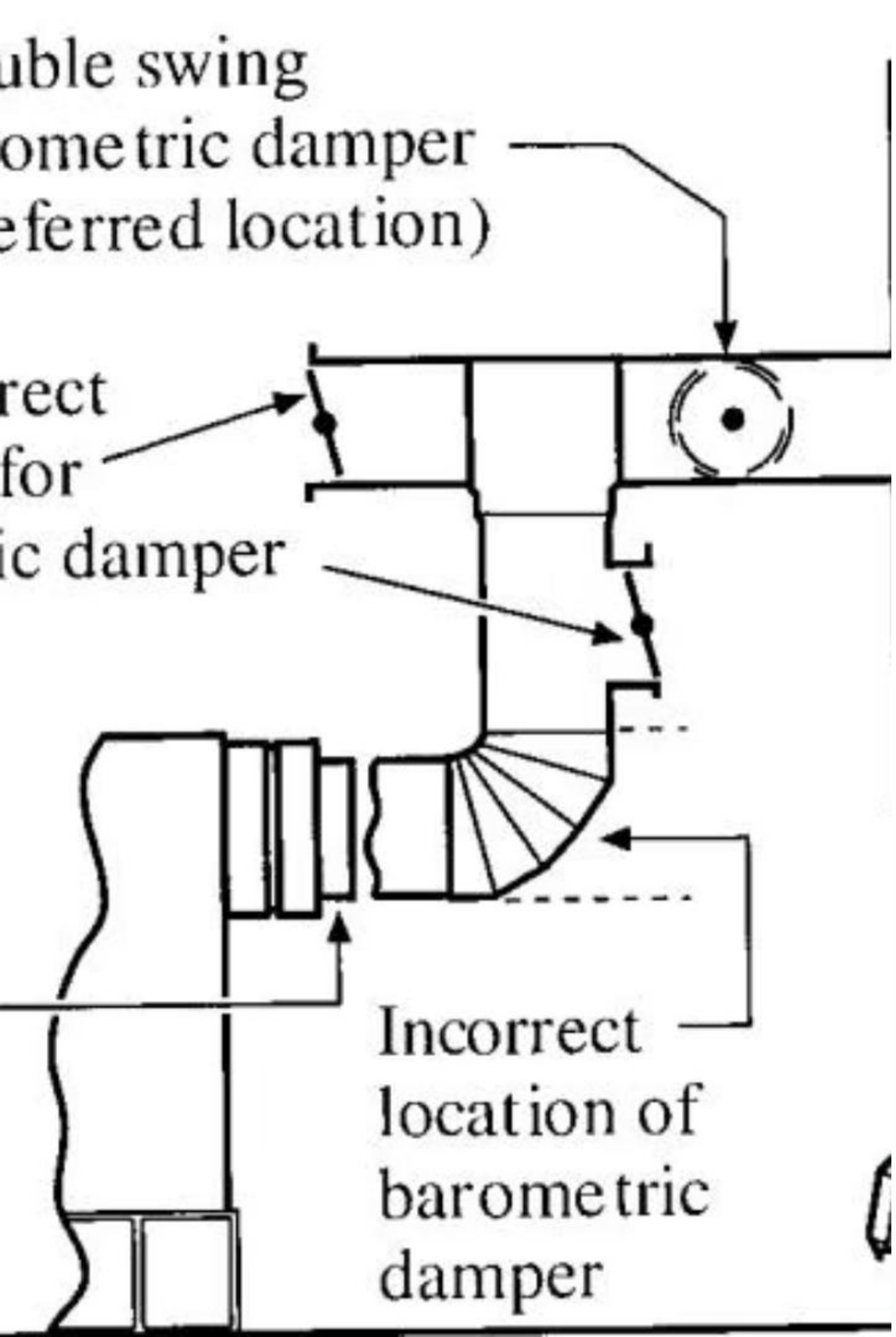
An appliance with fan-assist burner

Cannot be vented into a chimney on its own. This configuration is prohibited (Figure 2-7).



Prohibited Installation

Figure 2-7 Prohibited installation (single fan-assist appliance vented to chimney)



Draft Control Devices

The type of conversion burner selected determines the choice of draft control device. Read the manufacturer's instructions and the Code requirements. Follow the procedure below i hen installing a draft control device.

1. Determine which type of draft control device (if any) is required:

Draft Control Device Selection

Burner type	Draft control device
Atmospheric conversion burner applications	Require draft hoods.
Power burner applications	Must use double-acting barometric draft regulators if specified by the manufacturer. · In semi-revertible appliances, install a double- acting barometric damper so relief opening is at least 12 inches (30 cm) above the highest flue passage. · Figure 2-8 shows the correct and incorrect locations in which to place a barometric damper in a power burner conversion.

Draft Control Device Installation

1. Install the draft control device in the same room as the heating appliance. This ensures that the same atmospheric pressure is acting on the heat exchanger and the draft control device.

Choosing a Conversion Burner

There are numerous criteria for selecting the correct conversion burner, such as:

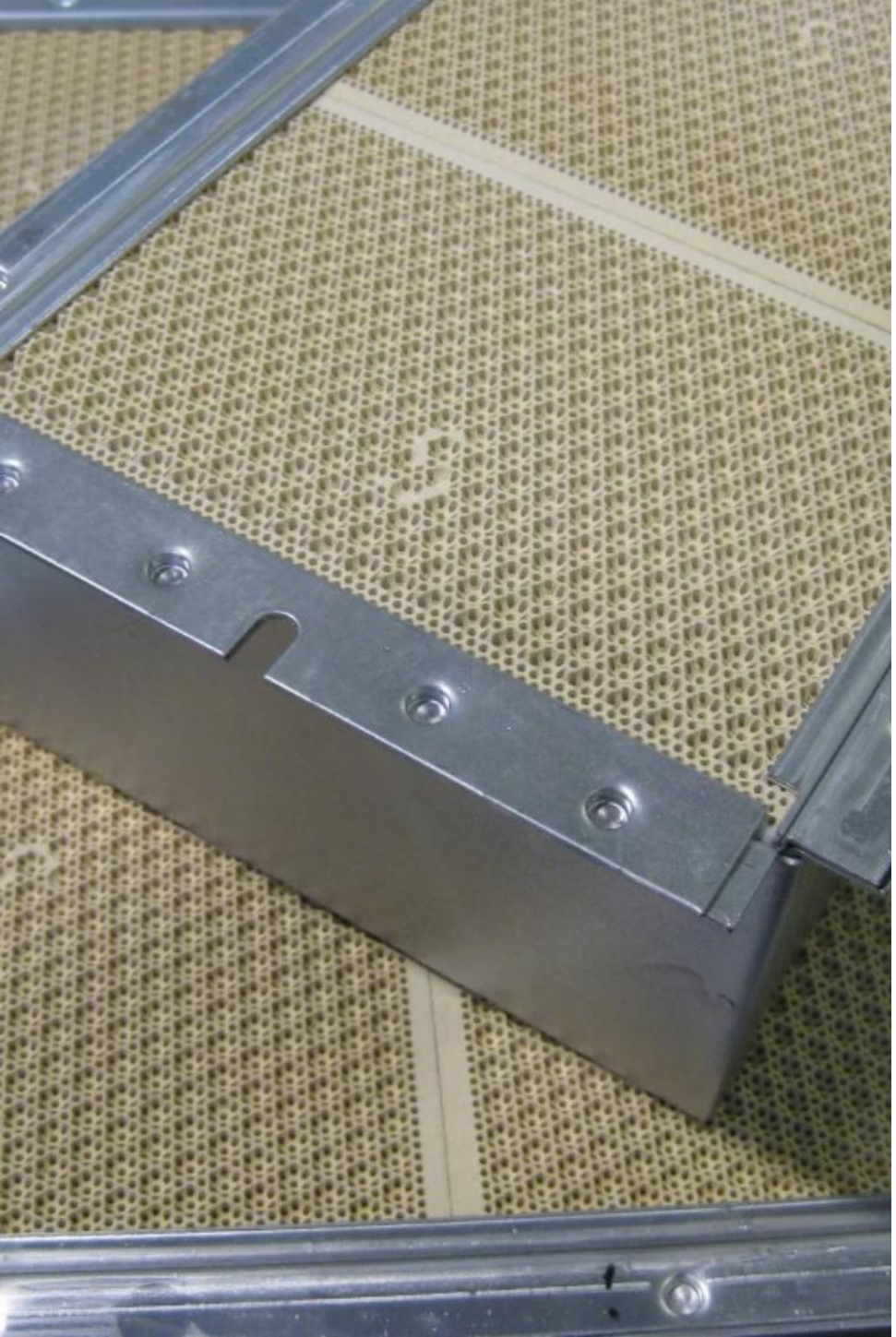
- basic design of the appliance (combustion chamber size and shape);
- input requirement; and
- type of gas.

Burner Selection Considerations

When selecting a specific type of burner, investigate the capabilities of the burner since design variations among manufacturers provide varying performance levels for the same type of burner. vanations among manufacturers are made by the same manufacturers of oil burners and look similar.

Review the manufacturer's specifications and recommendations before specifying any particular burner model.

Each conversion burner should bear the seal of approved testing body certifying compliance with ANSI Z21.8.



Types of Conversion Burners

There are two main types of conversion burners, classified according to how the combustion air is distributed:

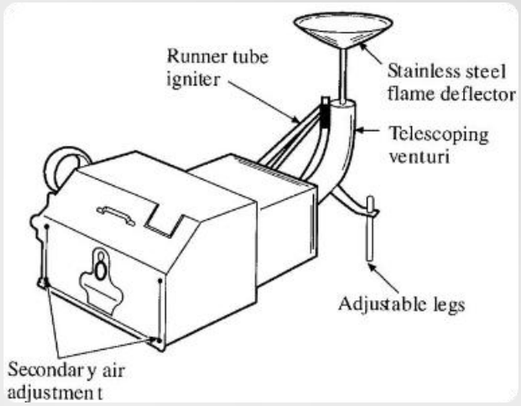
Conversion burner	Description
Natural draft (atmospheric) burners	Use the combustion air naturally supplied to the combustion chamber
Power burners	Use a mechanical device to supply combustion air at varying pressures

Natural Draft (Atmospheric) Burners

CSA B149.1 defines a natural draft burner as "a burner not equipped with a mechanical device for supplying combustion air".

There are two main types of atmospheric burners, designed to provide the required flame geometry (shape of the flame);

- upshot; and
- inshot



Upshot Burner

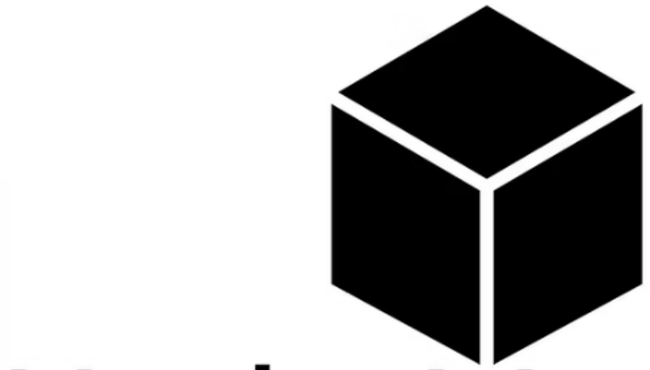
The upshot burner (Figure 2-9) fires vertically with the flame being diverted by a spreader. The flame is generally circular in shape and has a uniform cross-section.

This type of burner is mainly used with furnaces or boilers originally manufactured for coalburning use.

By removing grates and ashpit doors, the conversion burner can be installed in the ashpit section and the flame spreader distributes the heat from the firepot up to the dome and heating surfoces.

Upshot Atmospheric Burner Design

The atmospheric upshot burner design consists of a series of ports, slots, or ribbons whereby the flames fire vertically—generally uniform in height—in the combustion chamber.



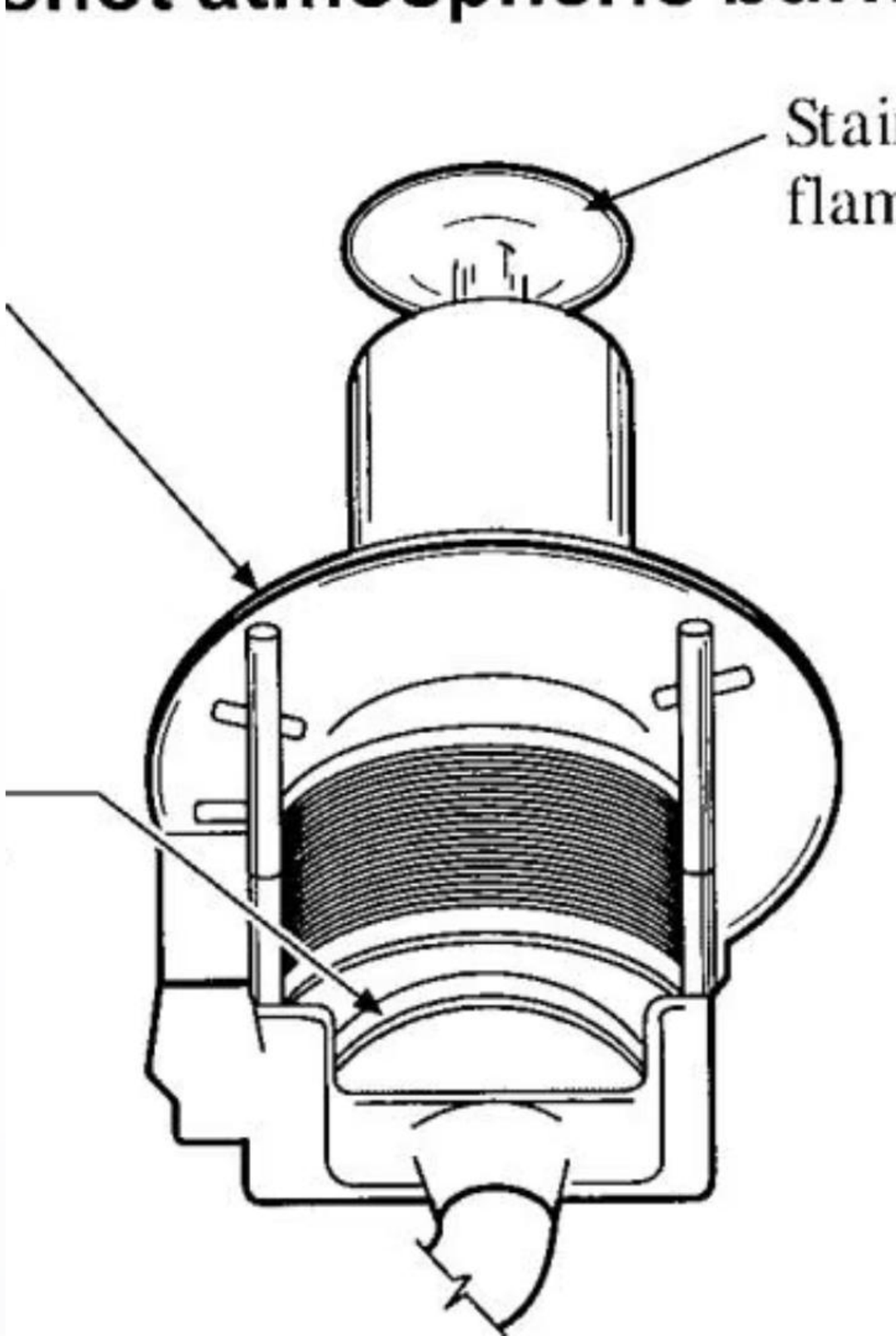
Upshot Imaging

AERIAL AND ARCHITECTURAL PHOTOGRAPHY

Inshot Burner

An inshot burner (Figure 2-10) fires horizontally into the combustion chamber. It may have a spreader or target plate downstream of the burner head to direct the flame.

Inshot conversion burners are mainly intended to replace oil burners.



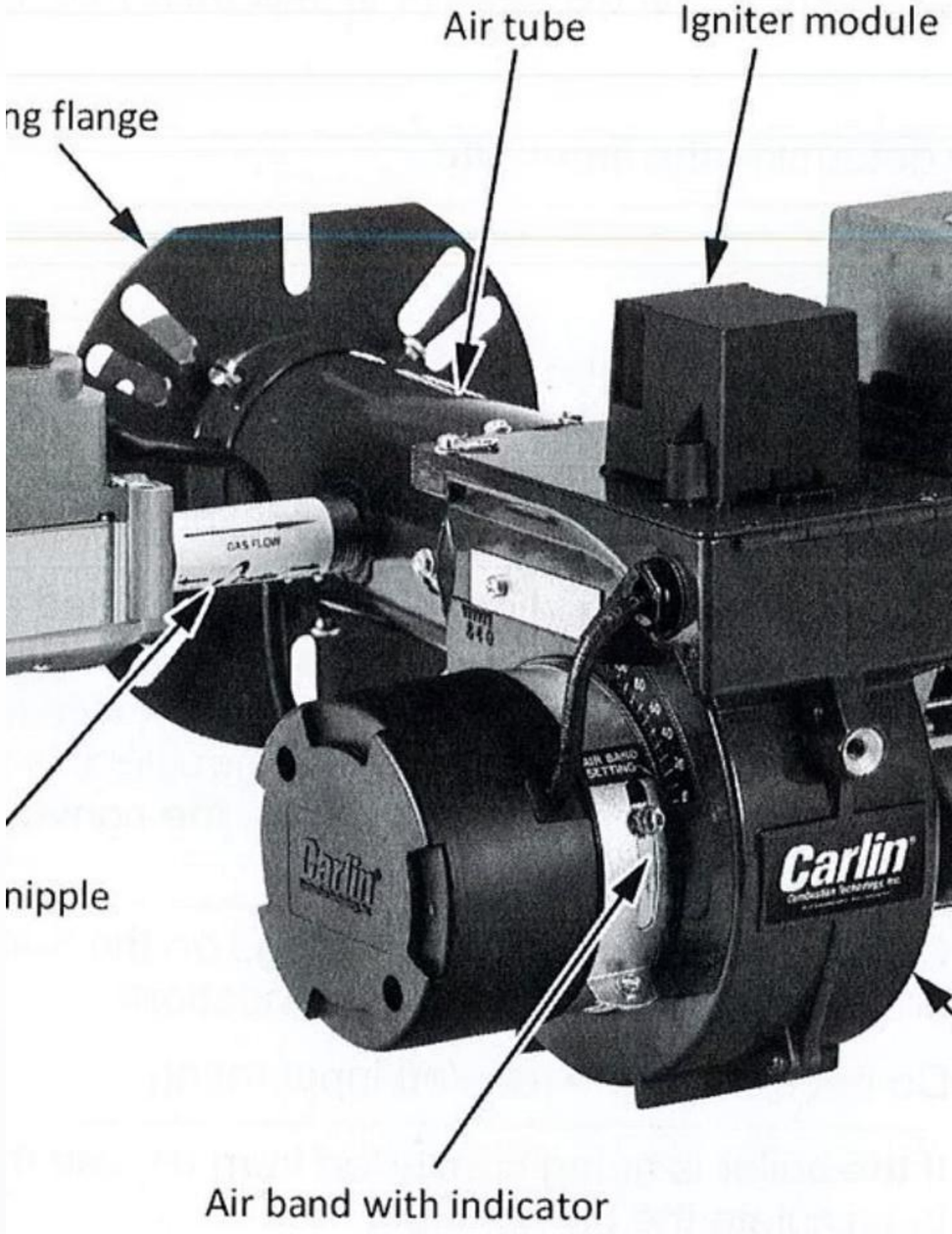
Oil Burner Mounting

Oil burners are generally flange-mounted and fire into a refractory or stainless-steel combustion chamber within a furnace body.

Power Burners

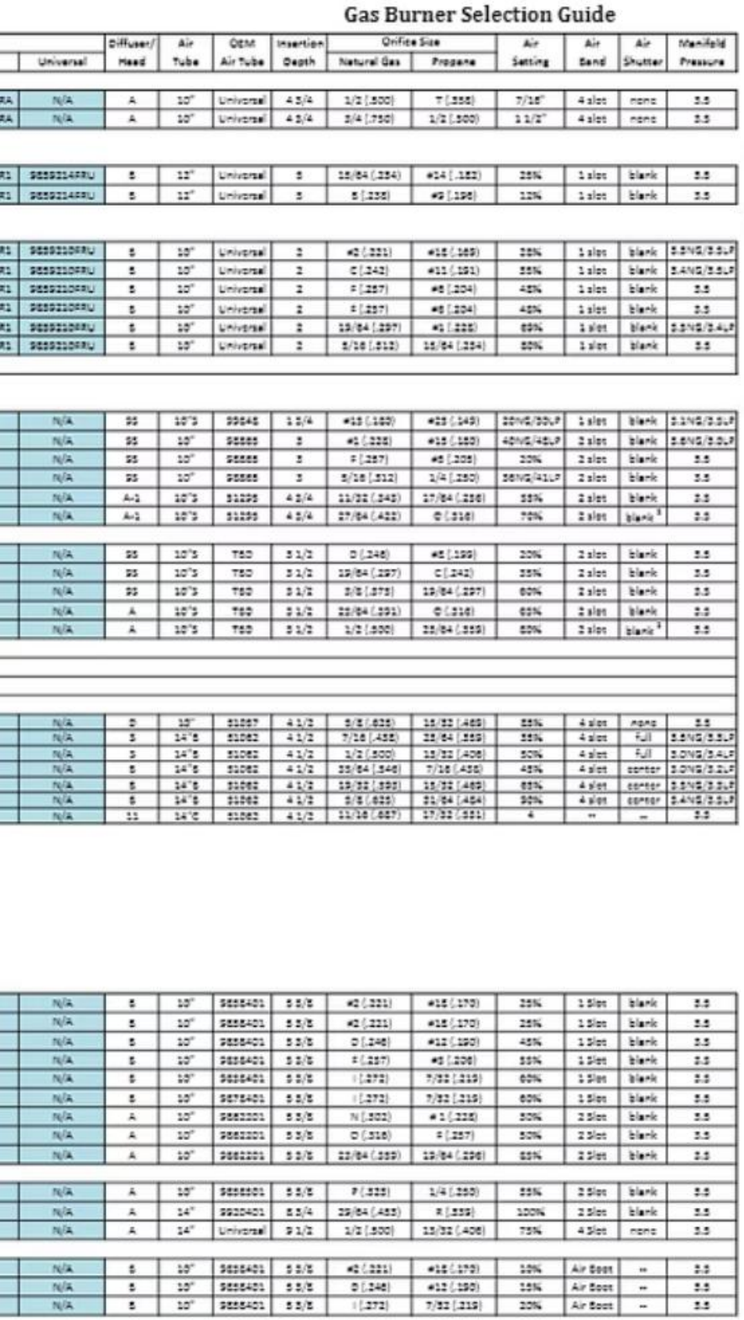
Power burners (Figure 2-11) come with a mechanical device, such as a fan or blower, to provide pressurized combustion air to the burner. This allows better control of the combustion process and a high input for a given volume of combustion space. The pressure, at which the air is delivered, as well as the burner design, provides the flame geometry.

Figure 2-11
Typical fan-assist power burner



Power Burner Types

Burner type	Fire description	Combustion air supply	Other name
Low-pressure upshot	Fires vertically into the combustion zone; flame is generally round and symmetrical.	At a pressure sufficient to overcome the resistance of the burner only	Fan-assist burner
Low-pressure inshot	Fires horizontally into the combustion zone	At a pressure sufficient to overcome the resistance of the burner only	Fan-assist burner
High-pressure inshot	Fires horizontally into the combustion zone	At a pressure sufficient to overcome the resistance of the burner and the appliance	Forced-draft burner



Gas Burner Selection Guide

	Universal	Diffuser/ Head	Air Tube	OEM Air Tube	Insertion Depth	Orifice Size		Air Setting	Air Band	Air Shutter	Manifold Pressure
						Natural Gas	Propane				
RA	N/A	A	10"	Universal	4 3/4	1/2 (.500)	T (.358)	7/16"	4 slot	none	3.5
RA	N/A	A	10"	Universal	4 3/4	3/4 (.750)	1/2 (.500)	1 1/2"	4 slot	none	3.5
R1	9859214FRU	B	12"	Universal	5	15/64 (.234)	#14 (.182)	25%	1 slot	blank	3.5
R1	9859214FRU	B	12"	Universal	5	B (.238)	#9 (.196)	10%	1 slot	blank	3.5
R1	9859210FRU	B	10"	Universal	3	#2 (.221)	#16 (.169)	25%	1 slot	blank	3.5NG/3.5LP
R1	9859210FRU	B	10"	Universal	3	C (.242)	#11 (.191)	35%	1 slot	blank	3.4NG/3.5LP
R1	9859210FRU	B	10"	Universal	3	F (.257)	#8 (.204)	45%	1 slot	blank	3.5
R1	9859210FRU	B	10"	Universal	3	F (.257)	#8 (.204)	45%	1 slot	blank	3.5
R1	9859210FRU	B	10"	Universal	3	13/64 (.297)	#1 (.228)	65%	1 slot	blank	3.5NG/3.4LP
R1	9859210FRU	B	10"	Universal	3	5/16 (.312)	15/64 (.234)	80%	1 slot	blank	3.5
	N/A	95	10"S	95645	1 1/4	#19 (.160)	#23 (.149)	20%NG/30LP	1 slot	blank	3.1NG/3.5LP
	N/A	95	10"	95665	3	#1 (.228)	#19 (.160)	40%NG/45LP	2 slot	blank	3.6NG/3.5LP
	N/A	95	10"	95665	3	F (.257)	#8 (.205)	20%	2 slot	blank	3.5
	N/A	95	10"	95665	3	5/16 (.312)	1/4 (.250)	36%NG/41LP	2 slot	blank	3.5
	N/A	A-1	10"S	91295	4 3/4	11/32 (.343)	17/64 (.266)	55%	2 slot	blank	3.5
	N/A	A-1	10"S	91295	4 3/4	27/64 (.422)	O (.316)	70%	2 slot	blank [1]	3.5
	N/A	95	10"S	T60	3 1/2	D (.246)	#6 (.199)	20%	2 slot	blank	3.5
	N/A	95	10"S	T60	3 1/2	13/64 (.297)	C (.242)	35%	2 slot	blank	3.5
	N/A	95	10"S	T60	3 1/2	3/8 (.373)	13/64 (.297)	60%	2 slot	blank	3.5
	N/A	A	10"S	T60	3 1/2	29/64 (.391)	O (.316)	65%	2 slot	blank	3.5
	N/A	A	10"S	T60	3 1/2	1/2 (.500)	25/64 (.359)	80%	2 slot	blank [1]	3.5
	N/A	D	15"	91067	4 1/2	5/8 (.625)	15/32 (.469)	55%	4 slot	none	3.5
	N/A	B	14"S	91062	4 1/2	7/16 (.438)	25/64 (.359)	35%	4 slot	Full	3.5NG/3.5LP
	N/A	B	14"S	91062	4 1/2	1/2 (.500)	13/32 (.406)	50%	4 slot	Full	3.0NG/3.4LP
	N/A	B	14"S	91062	4 1/2	25/64 (.546)	7/16 (.438)	45%	4 slot	center	3.0NG/3.2LP
	N/A	B	14"S	91062	4 1/2	19/32 (.593)	15/32 (.469)	65%	4 slot	center	3.5NG/3.2LP
	N/A	B	14"S	91062	4 1/2	5/8 (.625)	31/64 (.484)	90%	4 slot	center	3.4NG/3.5LP
	N/A	11	14"C	91062	4 1/2	11/16 (.687)	17/32 (.531)	4	--	--	3.5
	N/A	B	10"	9858401	5 3/8	#2 (.221)	#16 (.170)	25%	1 Slot	blank	3.5
	N/A	B	10"	9858401	5 3/8	#2 (.221)	#16 (.170)	25%	1 Slot	blank	3.5
	N/A	B	10"	9858401	5 3/8	D (.246)	#12 (.190)	45%	1 Slot	blank	3.5
	N/A	B	10"	9858401	5 3/8	F (.257)	#8 (.206)	55%	1 Slot	blank	3.5
	N/A	B	10"	9858401	5 3/8	I (.272)	7/32 (.219)	60%	1 Slot	blank	3.5
	N/A	B	10"	9878401	5 3/8	I (.272)	7/32 (.219)	60%	1 Slot	blank	3.5
	N/A	A	10"	9883201	5 3/8	N (.302)	# 1 (.228)	50%	2 Slot	blank	3.5
	N/A	A	10"	9883201	5 3/8	O (.316)	F (.257)	50%	2 Slot	blank	3.5
	N/A	A	10"	9883201	5 3/8	22/64 (.359)	19/64 (.296)	65%	2 Slot	blank	3.5
	N/A	A	10"	9858301	5 3/8	P (.323)	1/4 (.250)	55%	2 Slot	blank	3.5
	N/A	A	14"	9910401	5 3/4	29/64 (.453)	R (.339)	100%	2 Slot	blank	3.5
	N/A	A	14"	Universal	9 1/2	1/2 (.500)	13/32 (.406)	75%	4 Slot	none	3.5
	N/A	B	10"	9858401	5 3/8	#2 (.221)	#16 (.170)	10%	Air Boot	--	3.5
	N/A	B	10"	9858401	5 3/8	D (.246)	#12 (.190)	15%	Air Boot	--	3.5
	N/A	B	10"	9858401	5 3/8	I (.272)	7/32 (.219)	20%	Air Boot	--	3.5

Burner Selection Criteria

Before reaching the final decision as to what burner is best suited for the appliance, consider the following conditions to ensure proper selection and application of the burner to the appliance:

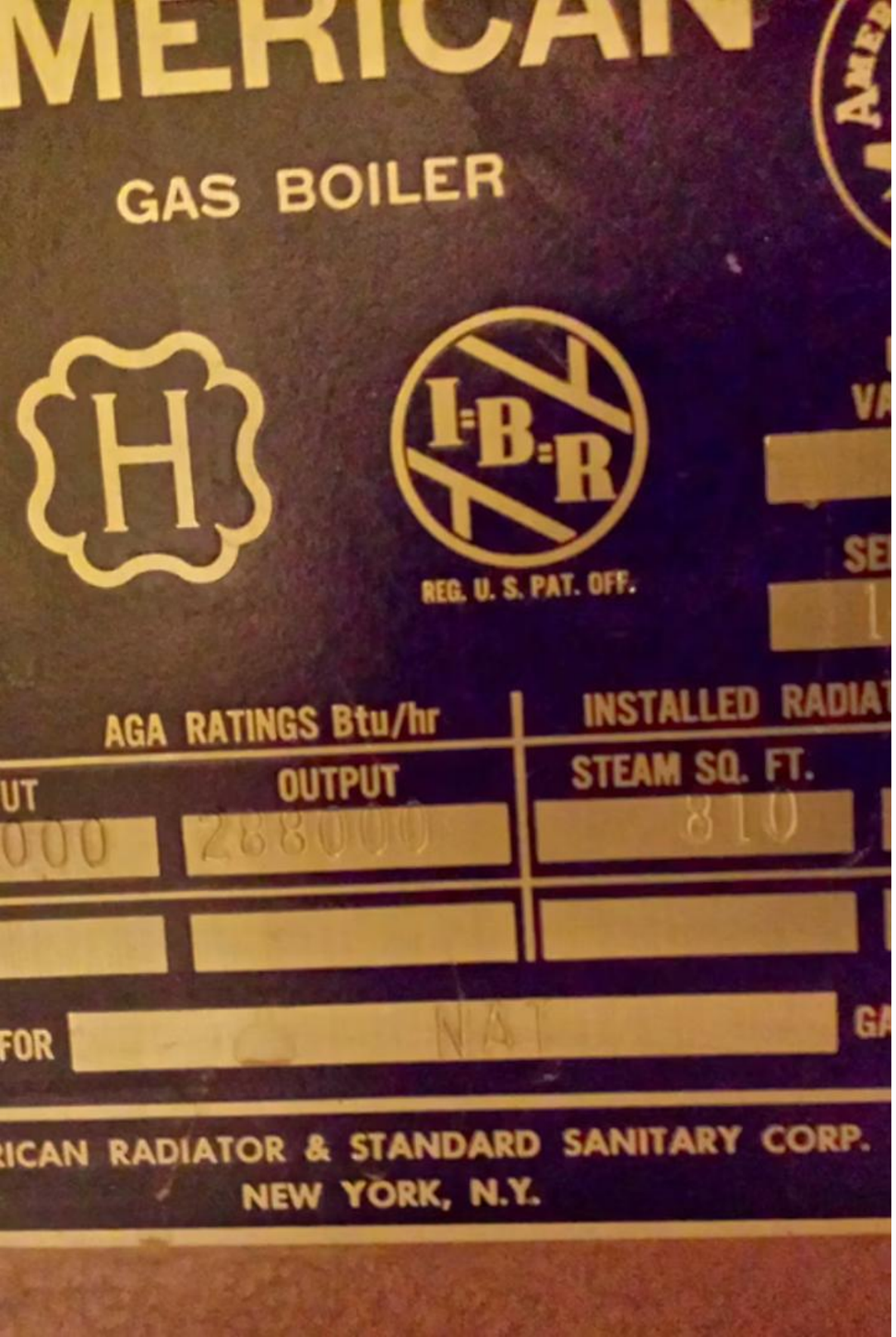
- firing rate (input range) of the burner;
- flue gas travel; and
- combustion chamber geometry.

Calculating Firing Rate

The firing rate of the burner must match the input of the appliance being converted, and in no The liming fate of the burner be set at a firing rate that exceeds or is less than that specified by the manufacturer.

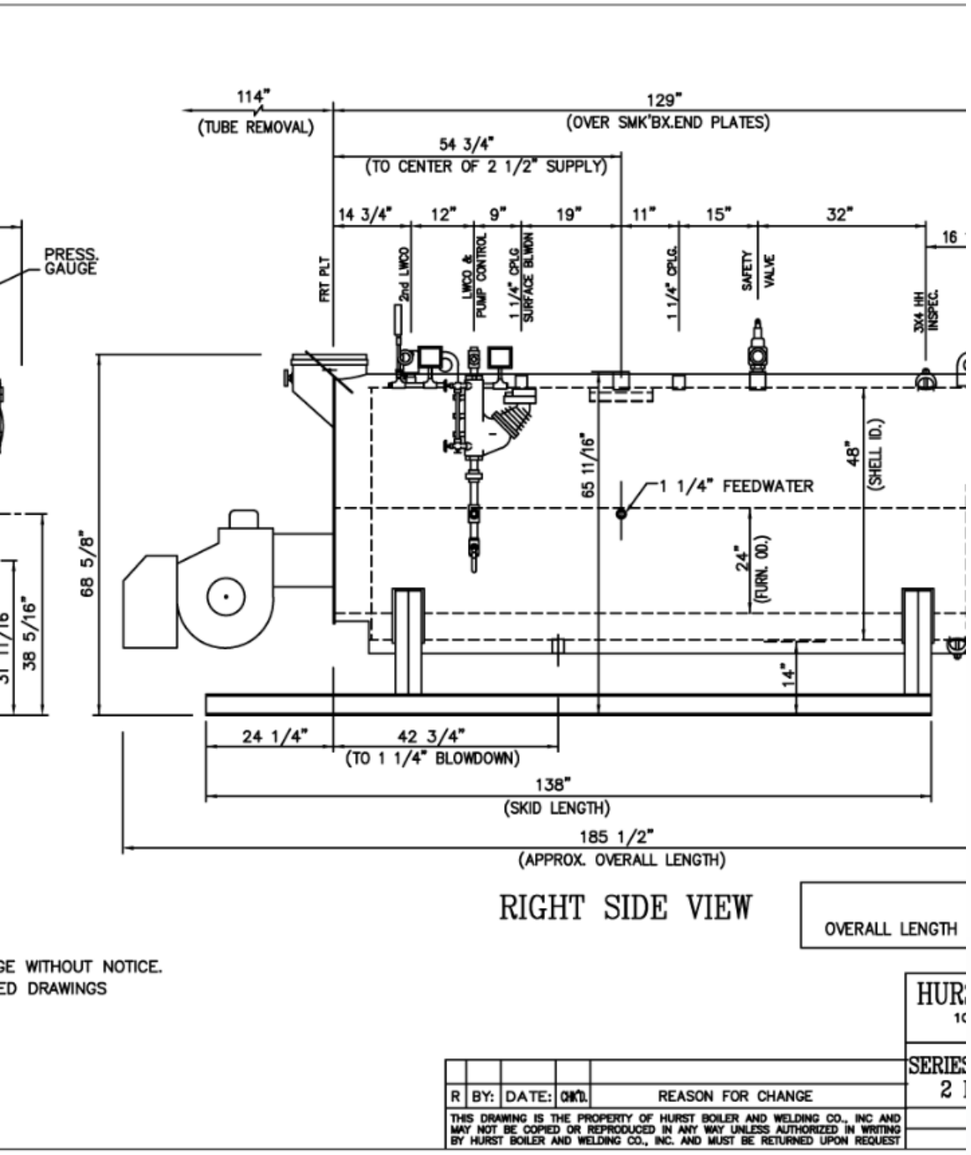
There are several methods to determine the firing rate.

Method	Description
Heat loss of the building	The heat loss of the building can be calculated using the principles and guidelines established in the ASHRAE Handbook-Fundamentals or in the Heating, Refrigeration, and Air Conditioning Institute of Canada's (HRAI) guidelines. When a proper building survey is completed and the hourly heat loss calculated, set the conversion burner Btu input at this calculated amount after the appliance efficiency rating is factored in. For example, if the calculated heat loss is 100 000 Btu/h and the appliance efficiency rating is 80%, the conversion burner input should be 125 000 Btu/h.



Calculating Firing Rate (Continued)

Method	Description
Rating plate	Check the input and output ratings on the rating plate (if available) or the manufacturer's recommendations. Do not exceed the marked input rating.
Burner nozzle size	If the boiler is being converted from oil, use the burner nozzle size to calculate the burner input. You can calculate the required input using the following formula: · Burner nozzles are rated in US gallons/h. · One US gallon of No. 2 fuel oil equals 140 000 Btu. · Input = Nozzle rating × 140 000 Btu.



Calculating Firing Rate (Continued)

Method	Description
Boiler horsepower rating	If the boiler's rating is written in boiler horsepower (BHP), you can calculate the input on the horsepower rating and projected efficiency. You can calculate the required input using the following formula: · One BHP equals 33 475 Btu/h. · Input = BHP × 33 475 Btu/h.

Calculating Firing Rate: Grate Area

Coal-fired furnaces have a definite ratio of output to grate area, with the grate area representing the capacity of coal that could be burned in the unit.

For conversion purposes, you can base the input of atmospheric burners on the area of the grate (Table 2-1):

- Measure round grates by their diameter.
- Measure rectangular grates by their area.

Maximum Permissible Firing Rates for Atmospheric Burners

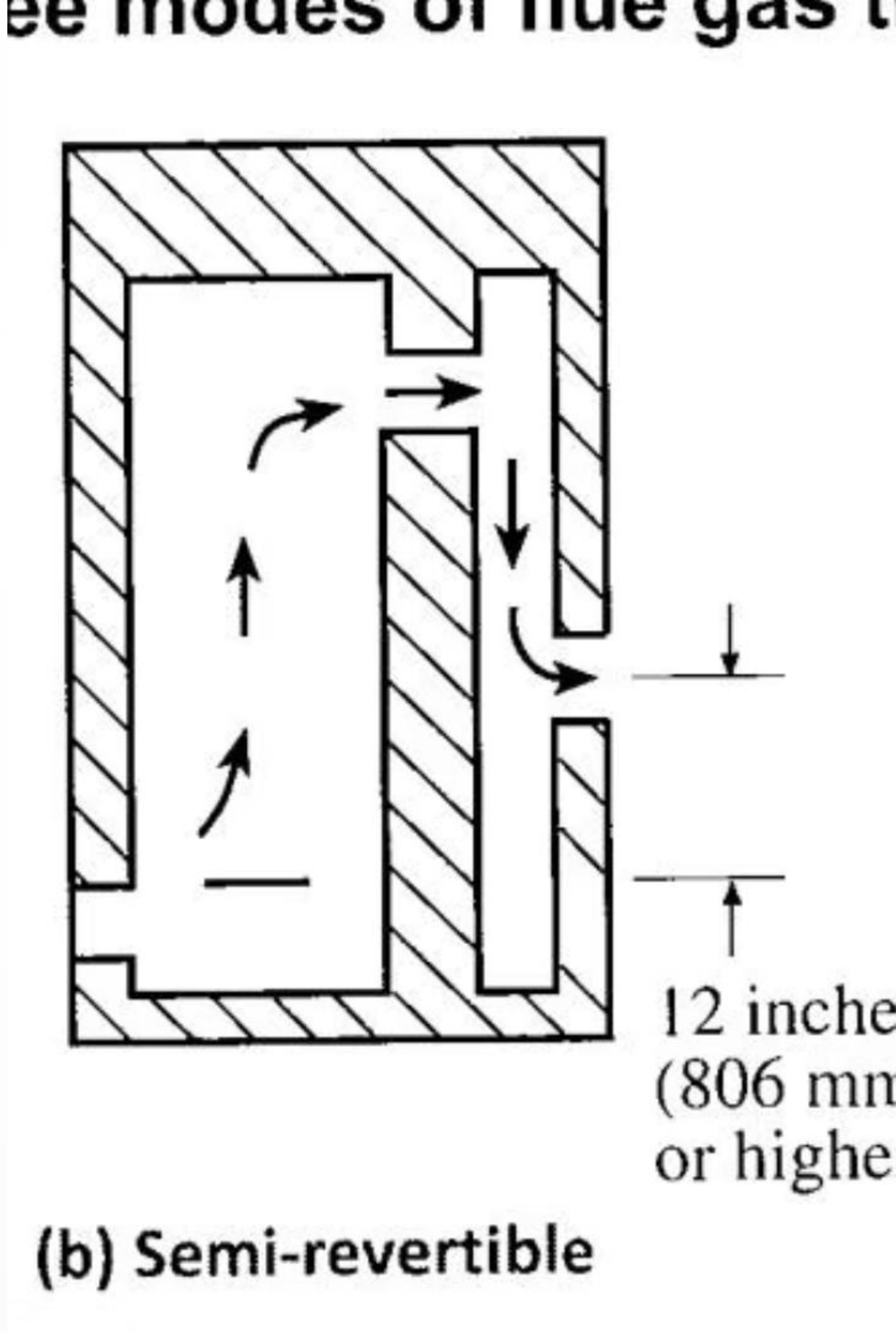
Round grates (diameter)		Rectangular grates (area)	
Inches (mm)	Btu/h (kW)	Inches (mm)	Btu/h (kW)
14 (350)	75 000 (23)	18 × 18 (450 × 450)	165 000 (48)
16 (400)	100 000 (30)	18 × 22 (450 × 559)	195 000 (57)
18 (450)	125 000 (37)	18 × 28 (450 × 711)	245 000 (72)
20 (500)	150 000 (45)	20 × 20 (500 × 500)	195 000 (57)
22 (550)	185 000 (54)	20 × 24 (500 × 600)	235 000 (69)
24 (600)	220 000 (64)	20 × 28 (500 × 700)	270 000 (79)
26 (660)	260 000 (76)	22 × 22 (550 × 550)	235 000 (69)
28 (711)	300 000 (90)	24 × 24 (600 × 600)	280 000 (82)
		24 × 28 (600 × 700)	300 000 (90)

Setting Manifold Pressure and Orifice Size

Once you have determined the input, you can set the manifold pressure and orifice size according to manufacturer's input tables.

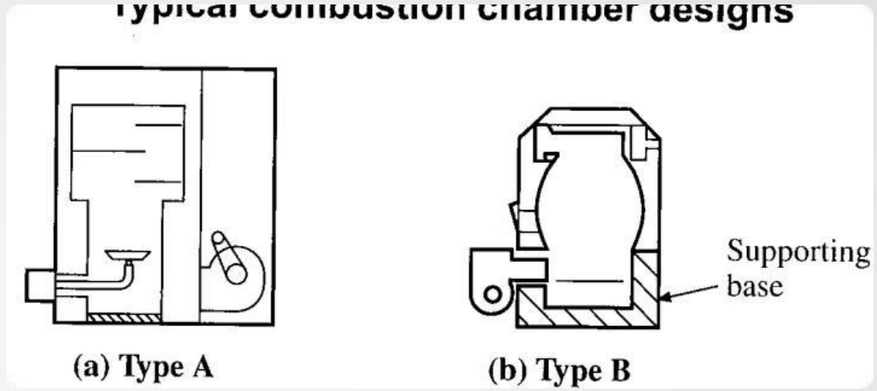
Flue Gas Travel Modes

As previously mentioned, oil and solid-fuel appliances have three basic modes of flue gas travel. These are shown in Figure 2-12.



Flue Gas Travel Mode Descriptions

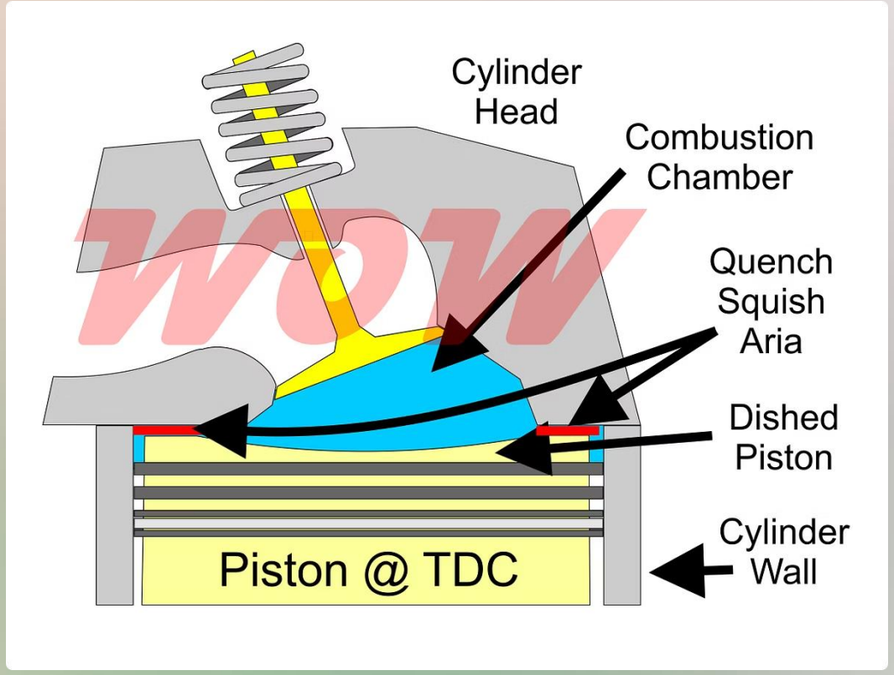
Flue gas travel mode	Description	Conversion
Updraft	Flue gas travel is constantly upward with flue products exiting at or very near the highest point of the heat exchanger.	All burner types may be considered for this conversion.
Semi-revertible	Flue gas travel is upward initially, then downward to exit the appliance. The centerline of the flue outlet is 12 inches (30 cm) or more above the burner port level.	Some atmospheric and all power burners may be considered for this conversion.
Revertible	Flue gas travel is upward initially, then downward to exit the appliance. The centerline of the flue outlet is located from less than 12 inches (30 cm) above burner port level.	Revertible appliances are only to be converted according to Clause 7.8.1 of CSA B149.1. See Chapter 1. Guidelines for converting appliances, Code requirements.



Combustion Chamber Geometry

Certain types of burners are better adapted to one boiler than another.

For example, where short fireboxes are encountered, it is often better to use a burner with a r of onamply, while avoid long flames that impinge upon metal surfaces. Similarly, the might noat release and to are and match that of the combustion chamber whenever possible (i. geomory offame for a round chamber, an elongated flame for a rectangular chamber).



Combustion Chamber Designs

There are two basic types of chamber geometry.

Type	Include	Heat transfer surfaces
Type A designs	Combustion chambers at the base of the heating zone [Figure 2-13(a)]	Are at, below, and above flame level
Type B designs	Combustion chambers and heat exchangers on a supporting base [Figure 2-13(b)]	Are above flame level only Note: For Type B combustion chambers, inshot burners are acceptable only if a combustion chamber liner and insulation are installed.

Figure 2-14
Air tubes

Mounting Flanges

The burner air tube may be available in different lengths or with an adjustable flange (Figure 2-14). The length of the air tube must be selected according to the instructions provided hy the manufacturer of the boiler, and it must match the thickness of the boiler wall complete with its insulation.

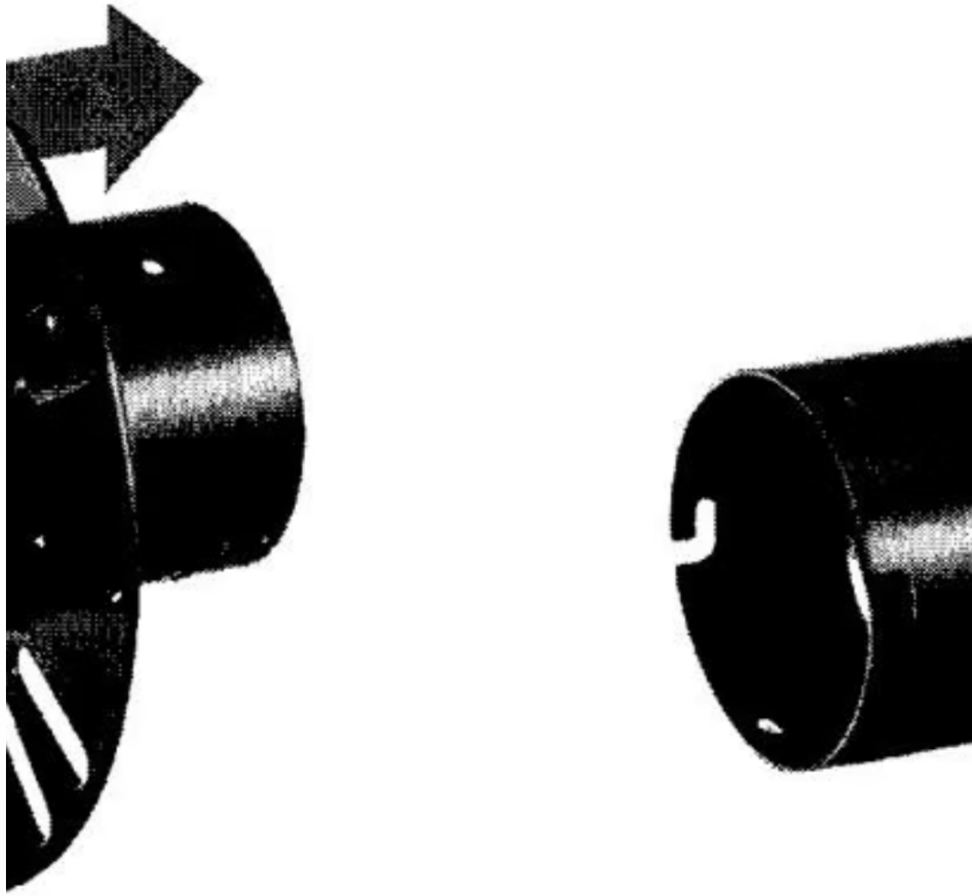
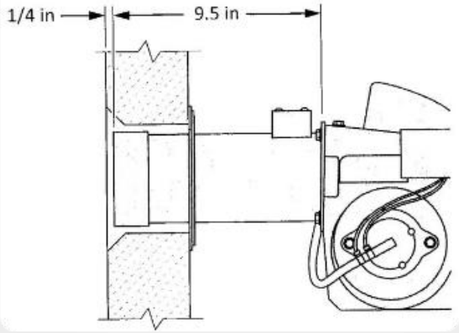


Figure 2-15
Air tube mounting depth



Air Tube and Mounting Plate Sizing

Select an air tube and mounting plate sized so that the end of the air tube will be flushed with, or no more than 1/4 inch short of, the inside of the appliance combustion chamber front wall when the burner is mounted. If it extends into the combustion chamber, there may be damage from overheating (Figure 2-15). The seal between the burner and the boiler must be airtight.

Air Tube Overheating Prevention

If the air tube extends into the combustion chamber, there may be damage from overheating (Figure 2-15). The seal between the burner and the boiler must be airtight.

CSA Unit 17

Chapter 3
Burner Installation and Flue Gas Analysis

After installing the burner, a gas technician/fitter must do the start-up checks and conduct a flue gas analysis for reasons of combustion efficiency and for the safety of the dwelling occupants. An accurate flue gas analysis determine the levels of carbon dioxide, excess air, stack temperature, and whether the combustion process is complete.

Objectives

1. Describe the theory of combustion
2. Describe flue gas analysis
3. Describe the procedure to install a burner and perform start-up checks
4. Describe how to complete an installation

Terminology: Aldehyde and AFUE

Term	Abbreviation (Symbol)	Definition
Aldehyde		A group of transparent, colourless toxic gases that are irritating to the eyes, throat, and nose and are easily detected because of their suffocating smell, produced by the partial oxidation of fuel gas

Term	Abbreviation (Symbol)	Definition
Annual fuel utilization efficiency	AFUE	Overall annual efficiency based on usage over a one-year period (see Seasonal efficiency)

Terminology: Breeching and Flue Gases

Term	Abbreviation (Symbol)	Definition
Breeching		The flue gas exhaust pipe that connects directly to the outlet of the oil or gas fired furnace, boiler, or water heater

Term	Abbreviation (Symbol)	Definition
Flue gases		Products formed in the combustion process that are exhausted through the flue or chimney stack

Terminology: Net Stack Temperature and Perfect Combustion

Term	Abbreviation (Symbol)	Definition
Net stack temperature		The difference between the flue gas temperature and the ambient (room) temperature

Term	Abbreviation (Symbol)	Definition
Perfect combustion		The process of combining chemically exact amounts of fuel and oxygen so that both components are totally consumed, with no combustibles or uncombined oxygen remaining in the flue gases

Terminology: Seasonal Efficiency, Steady State Efficiency, Stoichiometric Combustion, and Ultimate % CO2

Term	Abbreviation (Symbol)	Definition
Seasonal efficiency		Efficiency of the appliance based on one season of usage (see Annual fuel utilization efficiency)

Term	Abbreviation (Symbol)	Definition
Steady state efficiency		Relationship between input and output

Term	Abbreviation (Symbol)	Definition
Stoichiometric combustion		Same as perfect combustion

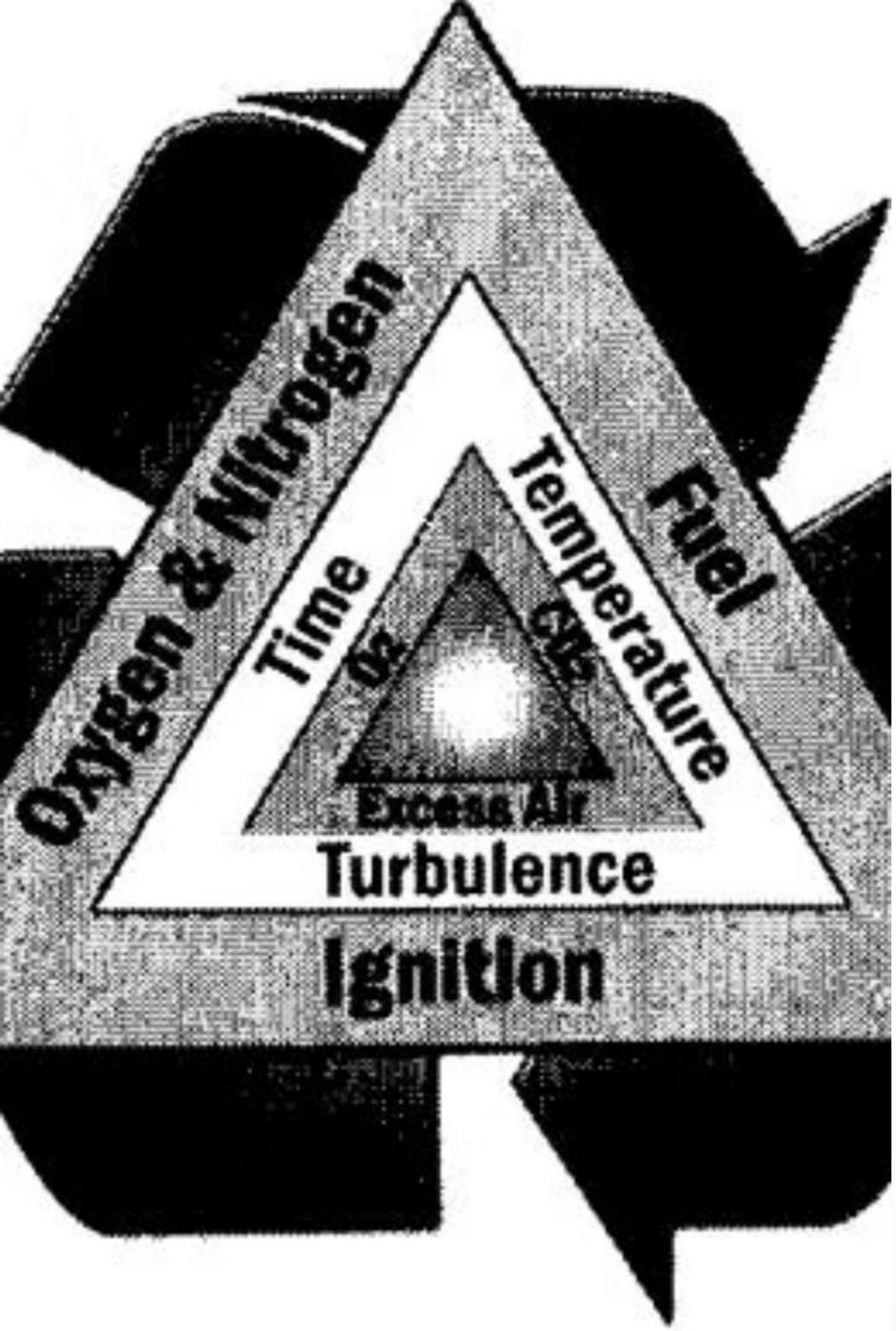
Term	Abbreviation (Symbol)	Definition
Ultimate % CO2		Percentage of carbon dioxide in the flue gas sample at perfect combustion

Theory of Combustion

Combustion is a chemical process in which the rapid oxidation of fuel results in the production of energy (heat). To start and sustain combustion, you must have ingredients mixed together in the correct proportions:

- fuel, usually natural gas or liquid petroleum gases;
- oxygen, obtained from the air surrounding a burner;
- heat, enough to bring the fuel to ignition point; and
- uninhibited chemical chain reaction.

If any one of these elements is absent, combustion will not take place nor will it support itself after an element is removed. This relationship is commonly referred to as the combustion triangle (Figure 3-1).



The Combustion Triangle and the Advanced Combustion Triangle

Content on the Combustion Triangle and the Advanced Combustion Triangle is excerpted from the "Combustion Analysis and Fuel Efficiency" manual courtesy of ESCO Group. For a more thorough understanding of combustion analysis, visit www.escogroup.org

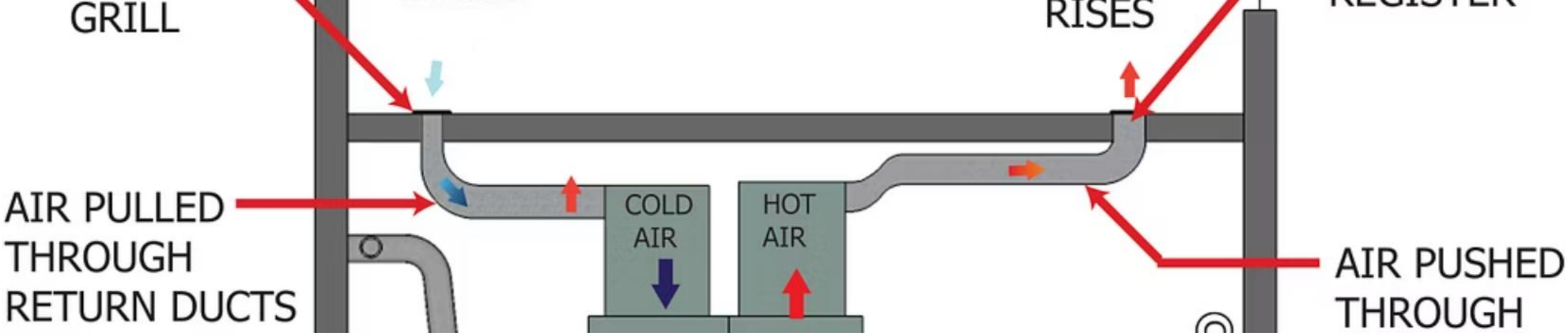
Stoichiometric or Perfect Combustion

Stoichiometric or perfect combustion is the process of combining chemically exact amounts of fuel and oxygen so that both components are totally consumed, with no combustibles or uncombined oxygen remaining in the flue gases.

The ratio of oxygen to fuel in perfect combustion is as follows:

Amount of cu ft of oxygen	Required to burn 1 ft3 of	Ratio	Perfect combustion chemical formula
2 ff3	Natural gas	2:1	For natural gas and oxygen: CH4 + 2O2 -> CO2 + 2H2O + Heat
5 ff3	Propane	5:1	For propane and oxygen: C3H8 + 5O2 -> 3CO2 + 4H2O + Heat

Remember that because perfect mixing of gases is only theoretically possible, perfect combustion cannot actually be maintained in a combustion chamber.



Complete Combustion

Because air is 20% oxygen (O2) and 80% nitrogen (N2), you need to supply more air to the burner than perfect combustion with pure oxygen would require.

You can express the air requirements for burning natural gas and propane in the following ratios:

Amount of cu ft of air	Required to burn 1 cu ft of	Ratio
10 cu ft	Natural gas	10:1
25 cu ft	Propane	25:1

Ensuring Complete Combustion with Excess Air

A way to ensure that these ratios are maintained is by introducing excess air into the combustion chamber. The quantity of excess air is often one and a half times the air needed for stoichiometric combustion.

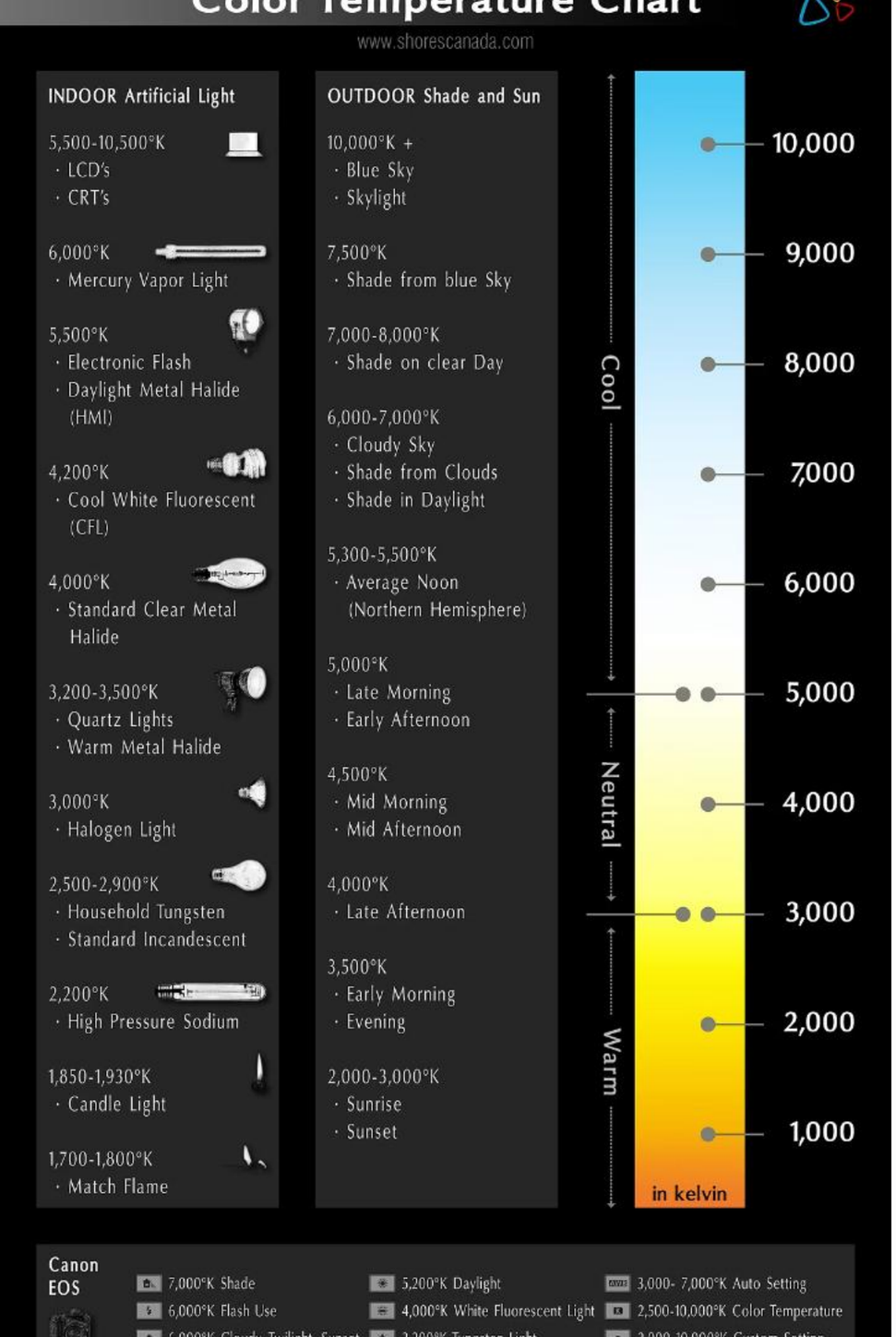
When excess air is introduced, however, more gases require heating by the same amount of Btu. At the same time, a larger volume of flue gas is forced through the heat exchanger in a shorter period of time, causing a decrease in heating efficiency due to higher flue gas temperature.

By analyzing the amount of carbon dioxide and oxygen in the flue gas, you can adjust the amount of excess air to achieve combustion with minimal loss of heating efficiency. Flue gas temperature is also an indication of combustion efficiency.

Products of Complete Combustion: Natural Gas

The products of complete combustion are produced in the following ratios. 1 ft3 of natural gas (CH4) produces the following products:

Natural gas (CH4)	ft3	Of	Ratios expressed in chemical formula
1 ft3 of natural gas (CH4) produces	1 ff3	carbon dioxide (CO2)	CH4 + 2O2 + 8N2 + Excess air → CO2 + 2H2O + 8N2 + Excess air + Heat
	2 ff3	water vapour (H2O)	
	8 43	nitrogen (N2)	



Products of Complete Combustion: Propane

1 ft3 of propane (C3H8) produces the following products:

Propane (C3H8)	Cu ft	Of	Ratios expressed in chemical formula
1 ft3 propane (C3H8) produces	3 ff3	carbon dioxide (CO2)	C3H8 + 5O2 + 20N2 + Excess air -> 3CO2 + 4H2O + 20N2 + Excess air + Heat
	4 ff3	water vapour (H2O)	
	20 ff3	nitrogen (N2)	

For more information on the theory of combustion, refer to Unit 3 Properties, characteristics, and safe handling of fuel gases.

Flue Gas Analysis

The combustion process forms products that are exhausted through the flue or chimney stack. These are referred to as flue gases. Analyzing the contents of the flue gases can help determine whether the conversion burner is properly installed and is operating safely.

The two main reasons for analyzing the flue products are:

- to determine appliance efficiency; and
- to ensure the burner is operating safely.

Flue gas measurement is always taken as close as possible to the flue collar and before any draft control devices.

For more information on instruments for flue gas measurement, refer to Unit 2 Fasteners, tools, and testing instruments.

About Appliance Efficiency

An appliance is most efficient when the greatest amount of usable heat is produced in its combustion chamber for a given amount of fuel being burned. Essentially, an appliance is most efficient when the amount of its input is near to the amount of its output.

> Combustion efficiency = The relationship between input and output is also called steady state efficiency.

Seasonal Efficiency and AFUE

To determine the overall efficiency of an appliance under actual usage conditions, the other energy losses to consider are:

- off cycle losses such as standby losses;
- room air escaping up the venting system; and
- the input consumed by a standing pilot.

The more standby losses that occur, the more often the appliance has to cycle on and the longer it takes to reach the setpoint temperature.

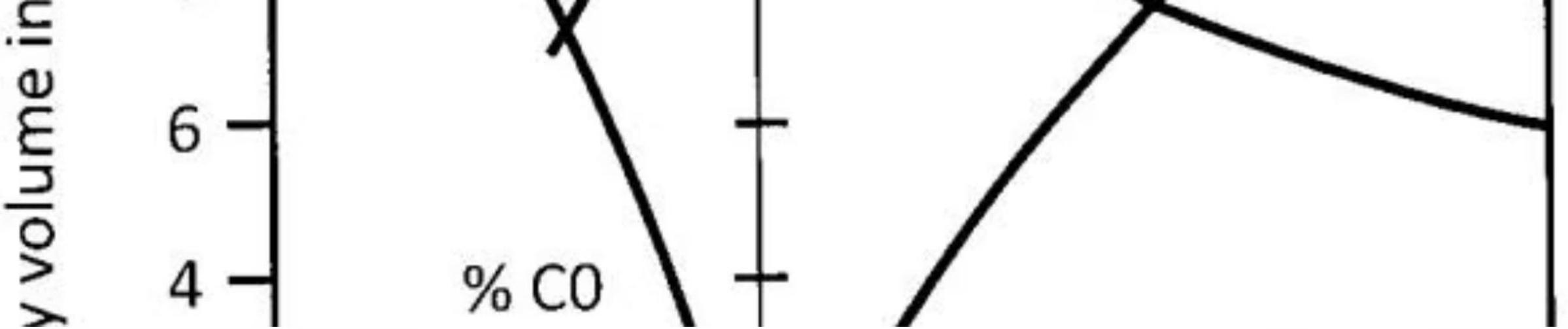
Overall annual efficiency is called the annual fuel utilization efficiency (AFUE). Seasonal efficiency is the efficiency of the appliance based on one season of usage, whereas AFUE is based on usage over a one-year period.

Analyzing for Efficiency

Analyzing the flue gas is a way to determine the appliance combustion efficiency. This analysis comprises the measurement of two items from the same location at the same time:

- the percent of carbon dioxide (or the percent of oxygen); and
- the net stack temperature.

With these two measurements, you can obtain the combustion efficiency of the appliance from a chart. Electronic flue gas analyzers are capable of continuously measuring the levels of O2 and the flue gas temperature and then calculating the appliance's efficiency.



Percent of CO2 in Flue Gas

The percentage of carbon dioxide in the flue gas sample at perfect combustion is known as the ultimate % CO2.

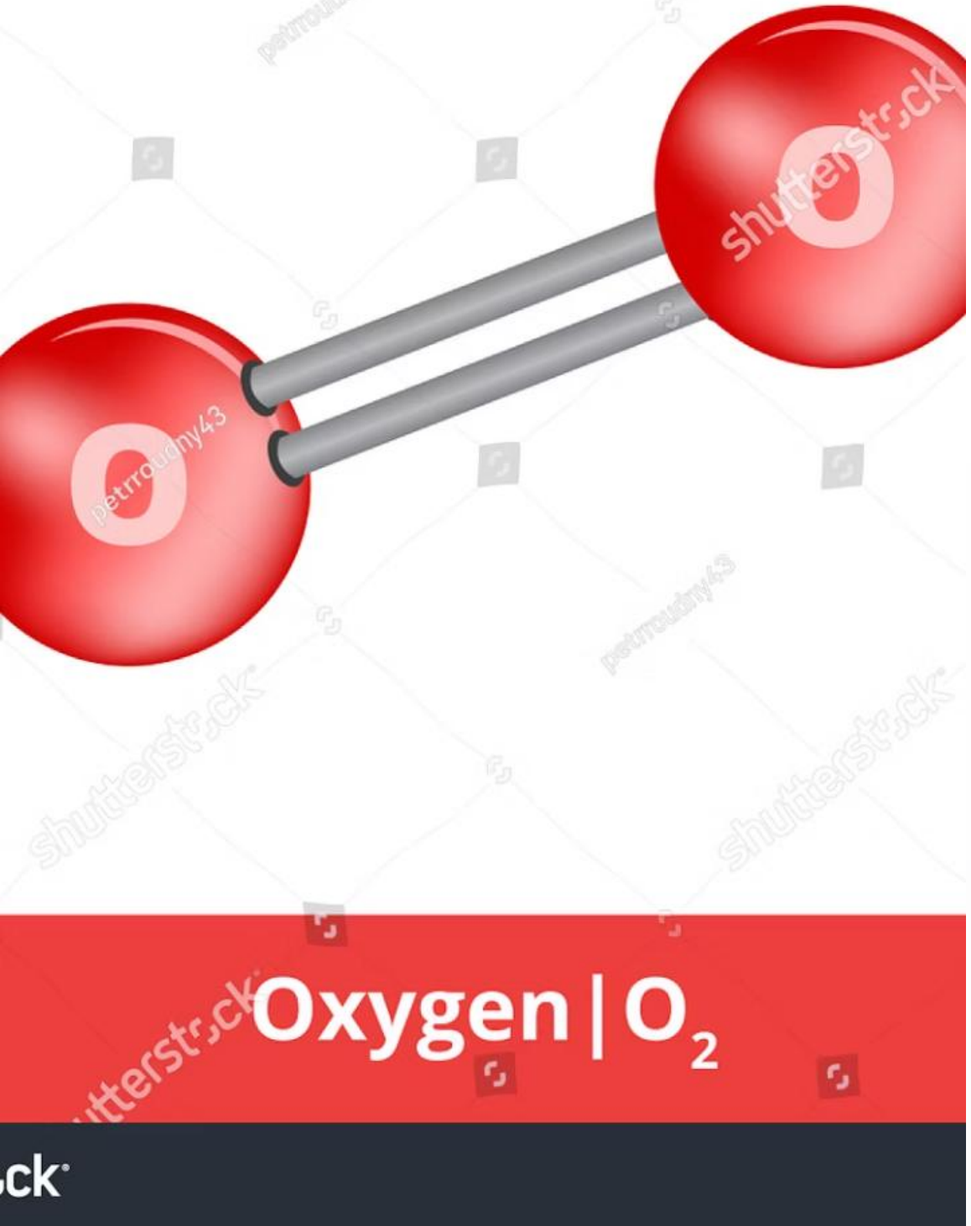
This percentage is based on comparing the volume of CO2 to the volume of remaining dry flue gases. At perfect combustion and with no excess air, the theoretical percentage of CO2 will be at its highest possible level (Figure 3-2).

Ultimate % CO2 of Natural Gas and Propane

Since the chemical makeup of each fuel gas is different, each fuel gas produces different amounts of CO2.

Table 3-1 compares the ultimate % CO2 ratings between natural gas and propane.

Gas	Ultimate % CO2
Natural gas	11.9%
Propane	13.9%



Oxygen (O2) in Flue Gas

Another option for measuring the combustion efficiency is to use the percent of oxygen in the flue gas to evaluate the combustion process. Since there is a direct relationship between amounts of CO2 and O2 in the flue gas, you can use either one to determine the combustion efficiency.

During complete combustion as shown in Figure 3-2, as O2 goes higher, CO2 goes lower. Notice that at approximately 50% excess air, the quantities of CO2 and O2 are equal.

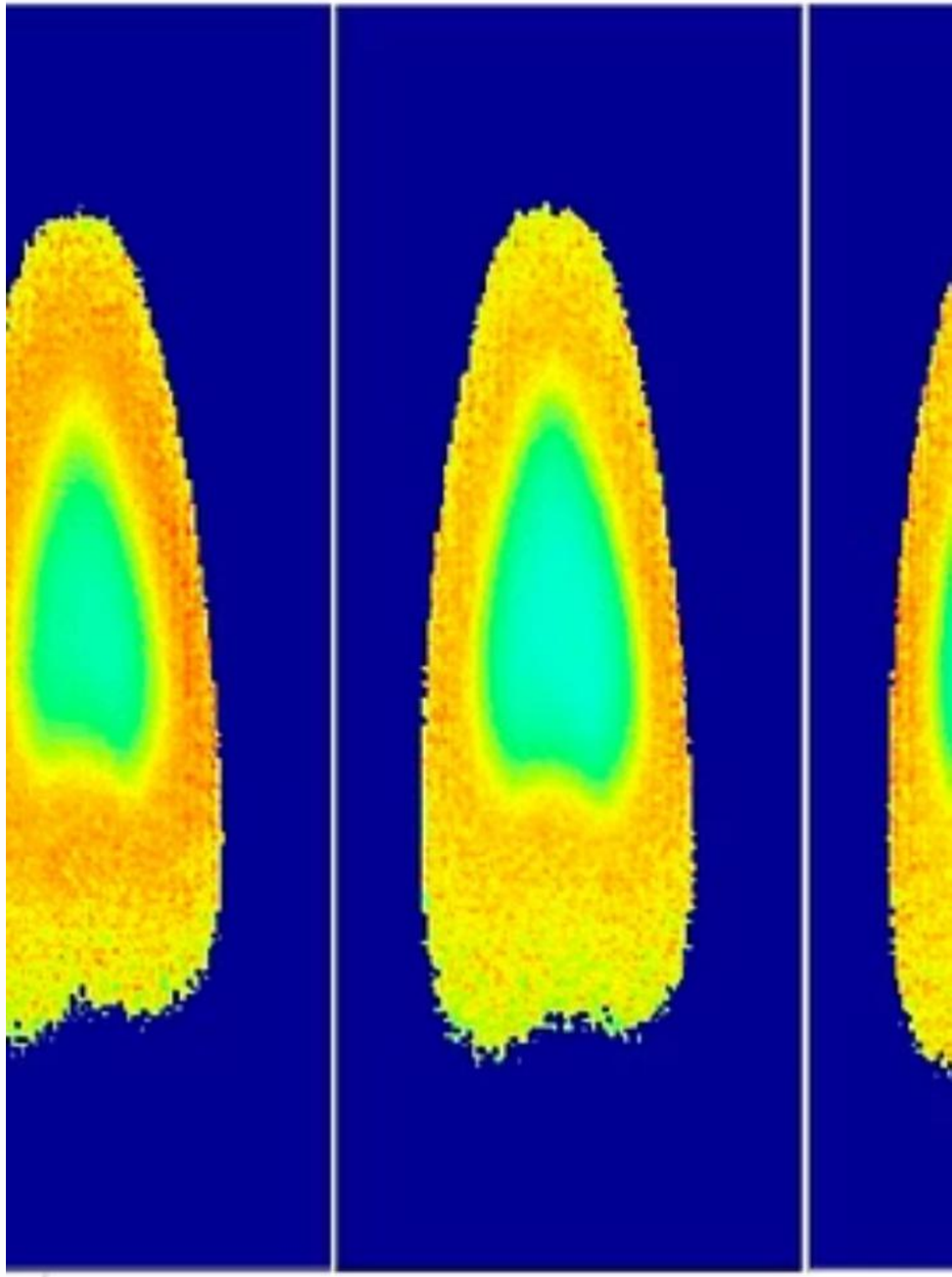
Flue Gas Temperature

The second reading required for an efficiency test is the flue gas temperature. This temperature indicates the amount of heat absorbed by the heat exchanger, which is in turn affected by how much air is passing through the combustion chamber. By measuring flue gas temperature, you can gauge the amount of energy lost to the atmosphere. The difference between the flue gas temperature and the ambient (room) temperature is the net stack temperature.

Ideally, for an appliance or heating plant to be 100% efficient, the temperature of the flue gas would have to be equal to room temperature. In other words, all of the heat produced during combustion would have been absorbed by the heat exchanger and transferred to its application.

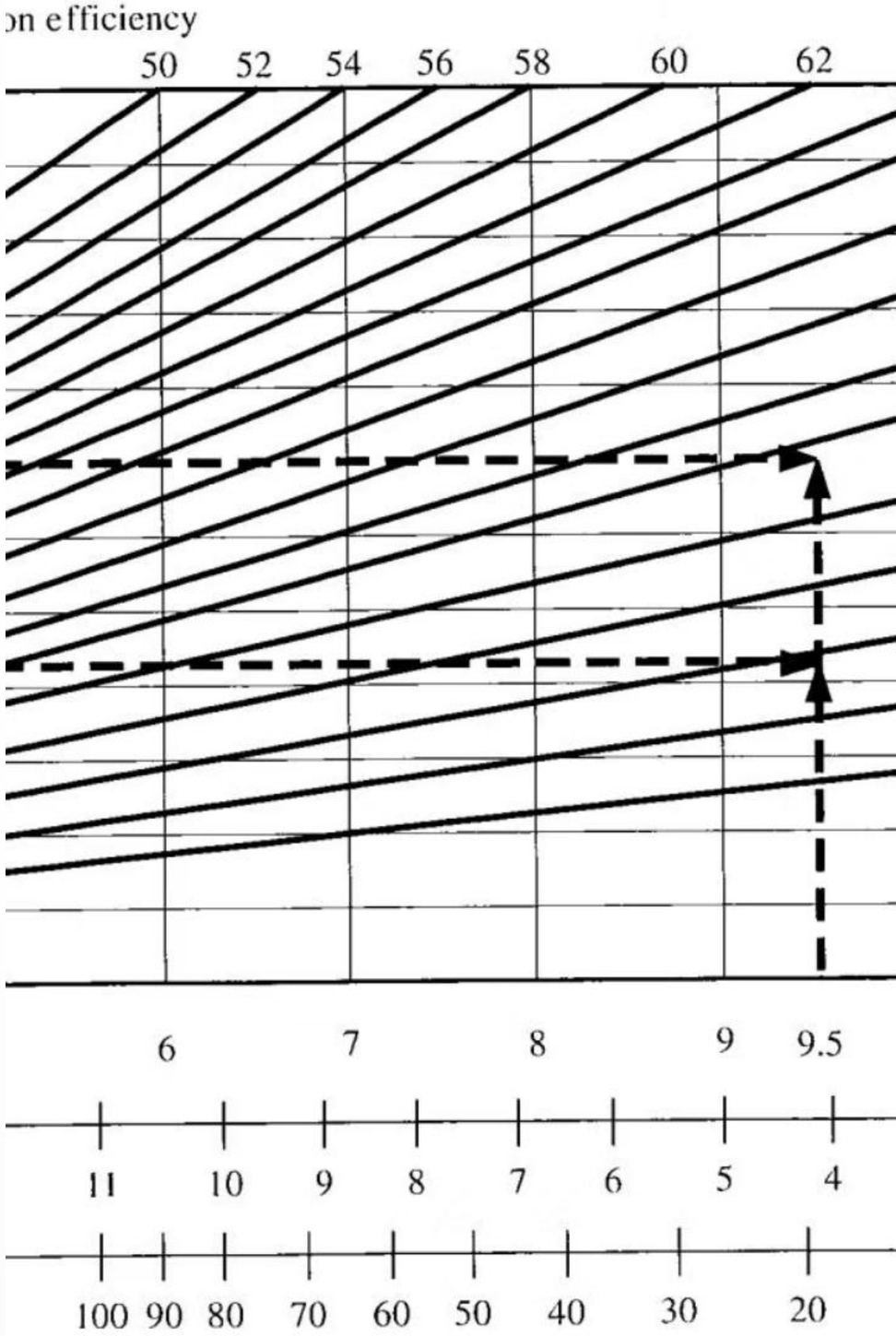
Flame Temperature Reduction with Air and Excess Air

For example, at perfect combustion, the temperature of the combustion process involving natural gas and oxygen is around 5000°F (2760 °C). When air is introduced, the flame temperature is reduced to around 3550°F (1950 °C) because of the dilution effect of the nitrogen passing through the combustion process. As more excess air is added to ensure complete combustion, the flame temperature is further reduced.



Plotting Combustion Efficiency

Once you have the levels of CO2 (or the levels of O2) and the net stack temperature, you can use a combustion efficiency chart as shown in Figure 3-3 to determine the level of appliance efficiency. Electronic flue gas analyzers automatically calculate the appliance efficiency based on measured readings of O2 and net stack temperature.



Natural Gas Combustion Efficiency Example

You can use the chart in Figure 3-3 to plot the combustion efficiency of a boiler burning natural gas under the following conditions:

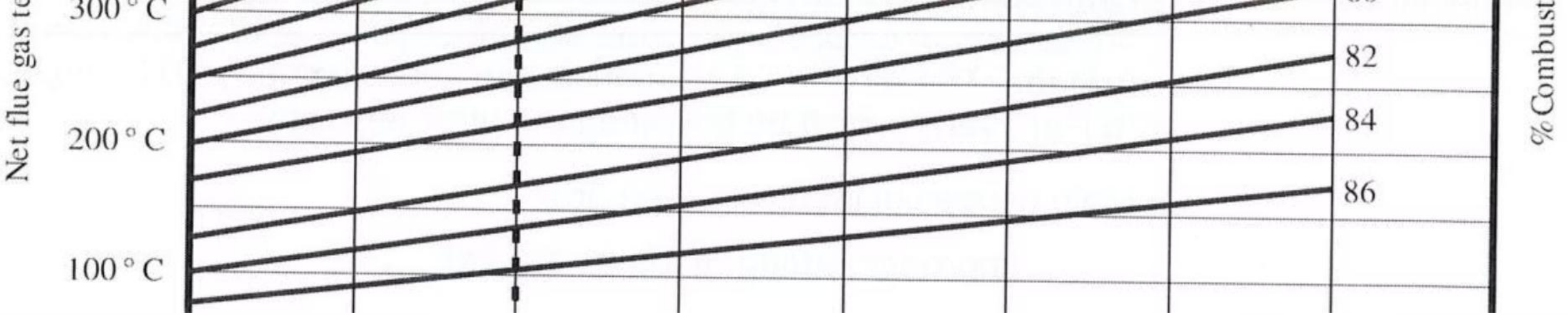
- CO2 is 9.5% (O2 reading is 4%).
- Flue gas temperature is 365 °C (690°F).
- Room temperature is 15 °C (59°F).

To plot the combustion efficiency, use the following procedure:

1. Establish the net stack temperature (365 °C 15 °C = 350 °C).
2. Draw a vertical line (dotted) from the 9.5% point on the CO2 scale.
3. Draw a horizontal line (dotted) from the net flue gas temperature line at 350 °C (662°F).
4. The two lines meet on the % combustion efficiency curve at 75.
5. Thus, the combustion efficiency for this appliance is 75%.

Impact of Adjustments on Efficiency

Notice if adjustments were made (for example, reducing the draft) and maintained all the conditions but lowered the net stack temperature to 220 ℃ (428°F), the efficiency increases to 80%.



Propane Combustion Efficiency Example

You can use the chart in Figure 3-4 to plot the combustion efficiency of a boiler burning propane under the following conditions:

- CO2 is 8% (O2 reading is 6.8%).
- Flue gas temperature is 475 °C (887°F).
- Room temperature is 75 °C (167°F).

Plotting Propane Combustion Efficiency

To plot the combustion efficiency, use the following procedure:

1. Establish the net stack temperature (475 °C = 75 °C = 400 °C).
2. Draw a vertical line (dotted) from the 8% point on the CO2 scale.
3. Draw a horizontal line (dotted) from the net flue gas temperature line at 400 °C (752°F).
4. The two lines meet on the % combustion efficiency curve at 69.
5. Thus, the combustion efficiency for this appliance is 69%.

Reasons for Poor Efficiency

In general, the higher the flue gas temperature, the lower the efficiency.

The following conditions reduce heat efficiency because they raise the temperature of the flue gas.

Condition	Description
Over firing of burner	A heating appliance is designed to produce a certain amount of heat. Over firing creates additional heat that cannot be recovered and, hence, escapes up the flue. This causes a rise in the stack temperature because it is unable to exchange the extra heat.
Insufficient air flow across heat exchanger	Reduces the heat transfer and increases the fuel consumption

Incorrect Excess Air Supply

Condition	Description
Incorrect excess air supply	The levels of excess air can be measured by the quantity of oxygen in the flue gases. Can cause: lazy flame - incomplete combustion and sooting

Too much excess air can cause:

- raised stack temperature by allowing flue gases to escape too fast for heat exchanger to absorb the heat
- flame impingement
- noise in combustion process leading to customer complaints

Draft Conditions and Dirty Heat Exchangers

Condition	Description
Draft conditions	Draft conditions can result in high or low flue gas temperatures, the production of carbon monoxide and aldehydes, and/or flue gas spillage. The air should be adjusted to approximately -0.02 inch w.c. (5 Pa) overfire draft by adjusting the draft regulator.
Dirty heat exchangers	A dirty heat exchanger surface insulates the equipment and prevents effective heat transfer, increasing fuel consumption.

Main causes of incorrect draft are:

- improper setting of the air shutter
- wrong barometric setting
- long horizontal vent connector
- poor vent design

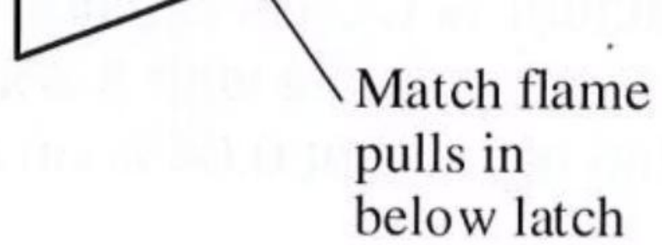


Figure 3-6

Incorrect Neutral Pressure Point Setting and Dirty Filters

Condition	Description
Incorrect neutral pressure point setting (over fire pressure)	An incorrect draft control device or an incorrectly adjusted draft control device can lead to a neutral pressure point setting that disturbs the draft and velocity of the flue products.
Dirty filters	Dirty filters on a forced-air furnace reduce the air flow across the heat exchanger, decreasing the heat exchange capabilities of the appliance.

Analyzing for Safety: Carbon Monoxide and Aldehydes

The main reason for analyzing the flue products is for safety reasons. Make sure that there is complete combustion and that there is no carbon monoxide (CO) being emitted.

Even though the appliance is operating efficiently and there is enough excess air being introduced (i.e., the CO2, O2, and stack temperatures are within acceptable range), the burner can still be emitting CO and aldehydes.

Aldehydes are a group of transparent, colourless gases with a suffocating smell, produced by the partial oxidation of fuel gas. Because of this, they are easily detected. They are toxic and irritating to the eyes, throat, and nose.

Often when CO is produced, it is accompanied by aldehydes.

Carbon Monoxide Levels and Safety Caution

Generally speaking, as you adjust the appliance to obtain higher combustion efficiencies, there is a danger that CO levels will increase. CO should be maintained at very low levels and should not exceed 50 ppm (on an air-free basis2).

> **Caution!** Carbon monoxide is toxic, odour-free, and life-threatening. It is very important to use the flue gas analyzer to check for levels of CO after installing a conversion burner.

2Since the flue gas contains varying quantities of air (depending on percent excess air), the CO limit is usually specified on an air-free basis. The air-free factor is the ratio of the ultimate % CO2 of the gas being burned to the actual % CO_2 in the flue gas sample. For example, for natural gas er the gas sample with 8.8% and a flue gas sample with 8.8% CO2, a carbon monoxide concentration of 0.03% in the actual sample would represent 0.04% on an air-free basis. [(11.7 ÷ 8.8) x 0.03 = 0.041

Percentage of CO_2 in Complete Combustion

Since excess air is required for complete combustion, there will be higher levels of oxygen in the flue gas and less CO_2 than the ultimate percent.

For example, if 50% excess air were introduced, there would be additional 1 ft° of oxygen and 4 ft3 of nitrogen in the flue gas. The total flue gas would be as shown in the following formula:

$$CH_4 + 2O_2 + 8N_2 + O_2 + 4N_2 \rightarrow CO_2 + 2H_2O + 8N_2 + O_2 + 4N_2$$

The dry sample (without the water) would be one-part CO_2 in 14 total parts, and the percentage of CO_2 would only be 1/14, or just over 7%.

Note that the percent of CO_2 does not necessarily indicate complete combustion. For example, in referring to Figure 3-2, a 10% CO_2 reading can indicate either negative excess air (90%) or positive excess air (110%). It is therefore necessary to also measure the CO content to ensure complete combustion.

Reasons for Incomplete Combustion

CO and aldehydes are produced from incomplete combustion, under the following circumstances:

Circumstance	Description
Lack of excess air	This is the most common reason for the production of CO. However, if you have analyzed the flue gas for levels of CO2 and O2 and have determined that excess air is not the cause of the problem, poor mixing on the burner, chilling of the flame, or a cracked heat exchanger are possible causes.
Poor mixing on the burner	Wrong burner selection can mean poor mixing of fuel and air, causing incomplete combustion.

More Reasons for Incomplete Combustion

Circumstance	Description
Flame impingement	CO can be produced when a flame is chilled below ignition temperature. This occurs when the flame patterns allow the flame to contact heating surfaces before complete combustion has taken place.
Cracked heat exchanger	Cracked heat exchangers can cause the heated supply air to come in contact with the flue products and the flame, interrupting the combustion process.
Significant gas leak	A significant gas leak in the pilot line or in the vicinity of the combustion chamber could result in incomplete combustion.
Burner malfunction	A damaged or improperly positioned main burner could result in flame impingement and poor mixing on the burner.

Flue Gas Analysis Results: Ideal Natural Gas Combustion Efficiency

The following ideal natural gas combustion efficiency results are general guidelines only for noncondensing (less than 90% efficient) appliances. Check with the manufacturer to ensure you are using the figures designed for their conversion burners.

Flue gas	Ideal natural gas combustion efficiency results
CO2	7.5-9% for atmospheric burner
	9-10% for power burner
O2	5-8% for atmospheric burner
	3-5% for power burner

Flue Gas Analysis Results: Temperature and CO

Flue gas	Ideal natural gas combustion efficiency results
*Flue gas temperatures	165–205 °C (330 – 400°F) for atmospheric burner
	135-205 °C (275 - 400°F) for power burner
CO for atmospheric/power burner	0-under 50 ppm (air-free)

* This temperature is measured at the breach of the introduction of dilution of dilution air. Failure to maintain adequate stack temperature could result in flue gas condensing and cause chimnen damage, which could result in CO leakage into dwelling. The addition cannot bring the filter gas temperature below the dew point (approx. 54 °C or 130°F).

Modifications Based on Flue Gas Analysis

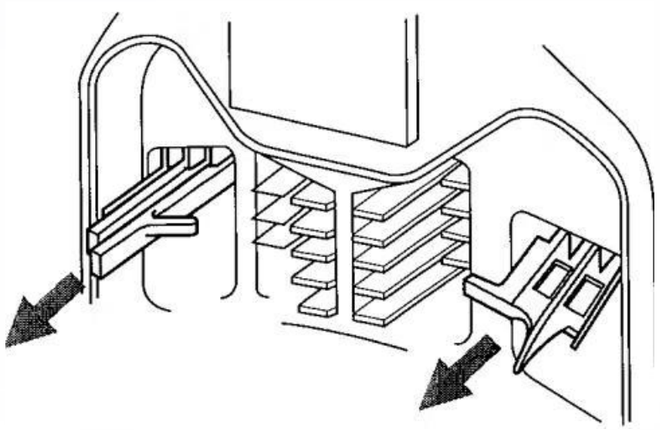
In summary:

If there is	Will
Too much excess air	Increase the amount of air required to be heated, which is then wasted as it vents up the chimney
Too little excess aır	Indicate a danger of incomplete combustion

For atmospheric, fan-assist, or power burners, the air supply openings are adjustable and must r or atmoophono, furn access, ontimal amount of air flow for energy efficient combustion.

When excess air is added to ensure complete combustion, the appliance efficiency decreases because the excess air is absorbing heat and being exhausted up the chimney.

Adjustments Based on Analysis



If	Then
Your analysis indicates incomplete combustion.	Check appliance input. Check excess air. Check primary air (on atmospheric burners). Check burner design and location.
Your analysis indicates poor efficiency.	Check appliance input. Decrease excess air. Adjust draft control (-0.02 to -0.04 inch w.c. stack draft).

Generally, a 325°F stack temperature is high enough to avoid corrosive condensation in the vent Sonomally, a 620 + etach company of a tall chimney or a tall chimney may require a system, noweren, a large combustion air and barometric damper adjustments are properly set might tomporature in the benisational measures may need to be taken to raise the una the frao gas temperature. For example, a boiler may have removable or adjustable internal heat exchanger baffles (Figure 3-7). See manufacturer's instructions.

After the adjustments, conduct another flue gas analysis to ensure you have complete combustion and good combustion efficiency.

Burner Installation and Start-up Checks

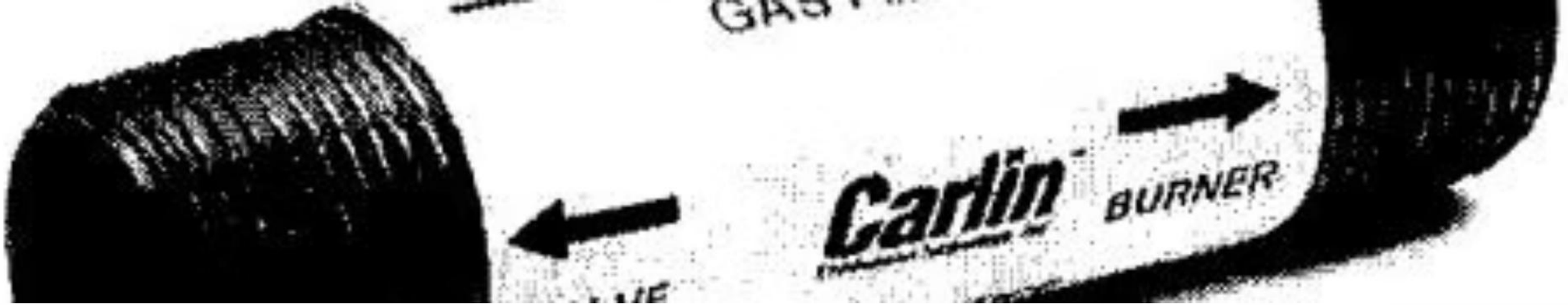
The proper installation of a conversion burner is critical to the safe and efficient operation of the appliance. The installation must be carried out as specified by the conversion burner manufacturer's installation instructions, and it must meet the Code requirements. Consequently, doing all checks and adjustments with safety and efficiency in mind is a must.

Burner Installation Steps

Plan the installation of a burner so that its controls are readily accessible for inspection, cleaning, adjustments, and repairs. Conversion burners come as a complete package, but you must:

- choose the correct orifice size and air tube components to suit the input;
- position the sleeve and burner; and
- set the air shutter or band if required.

Details of various burners differ. Be sure to follow the manufacturers' installation instructions.



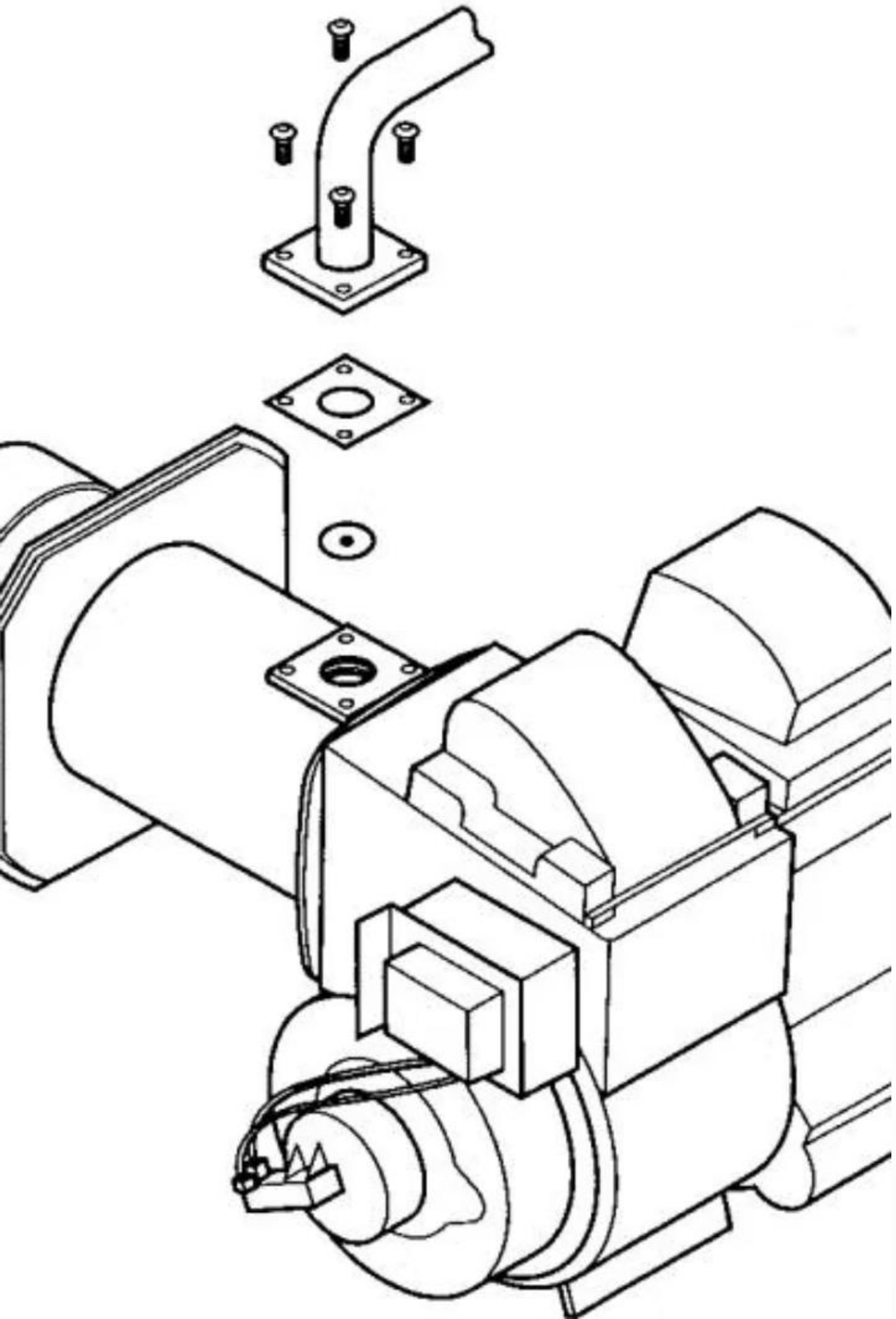
Gas Orifice Installation

Many conversion burners come with orifices for both natural gas and propane.

Install the appropriate gas orifice.

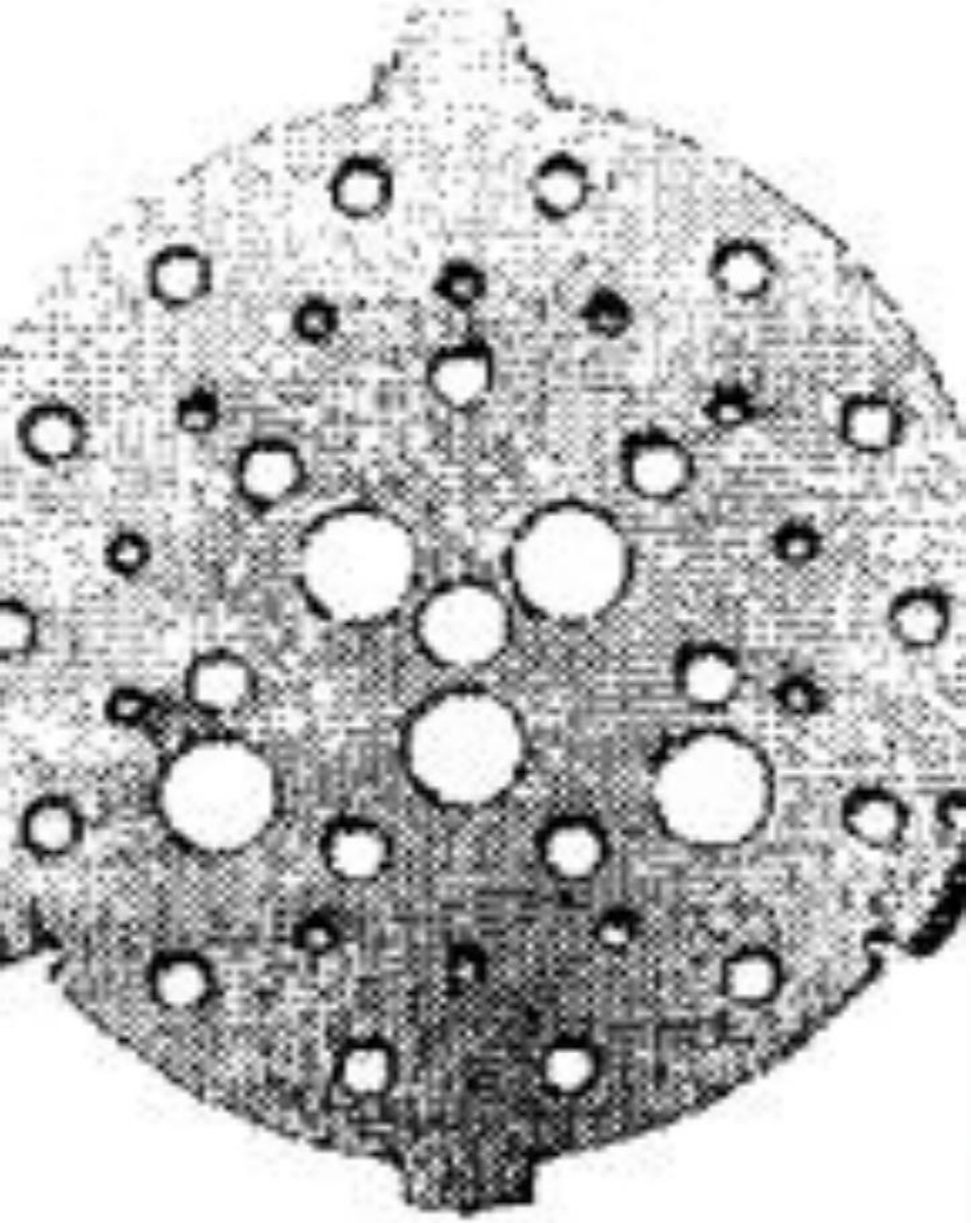
The orifice may be permanently installed into the end of an orifice nipple (Figure 3-8), which needs checking or drilling to the correct size. The nipple is installed between the gas valve and the burner. For other makes, the appropriate office plate or diaphragm needs to be selected and installed with O-rings and/or gaskets between the gas supply pipe and the air tube (Figure 3-9)

If the orifice is adjustable, follow the manufacturer's instructions and adjust the orifice for correct input.



Orifice Plate Installation

Figure 3-9 Orifice plate installation



Air Tube Components

Manufacturers have different air tube components that need to be verified or selected and assembled to match the appliance input. Different manufacturers may use some of the following air tube components:

- flame retention heads;
- air diffuser plates (Figure 3-10); and
- nozzles.

Air Tube Diffuser Plates

Figure 3-10 Air tube diffuser plates

Courtesy of Carlin Combustion Technology & Hydrolevel Company (Divisions of C. Cowles & Company)

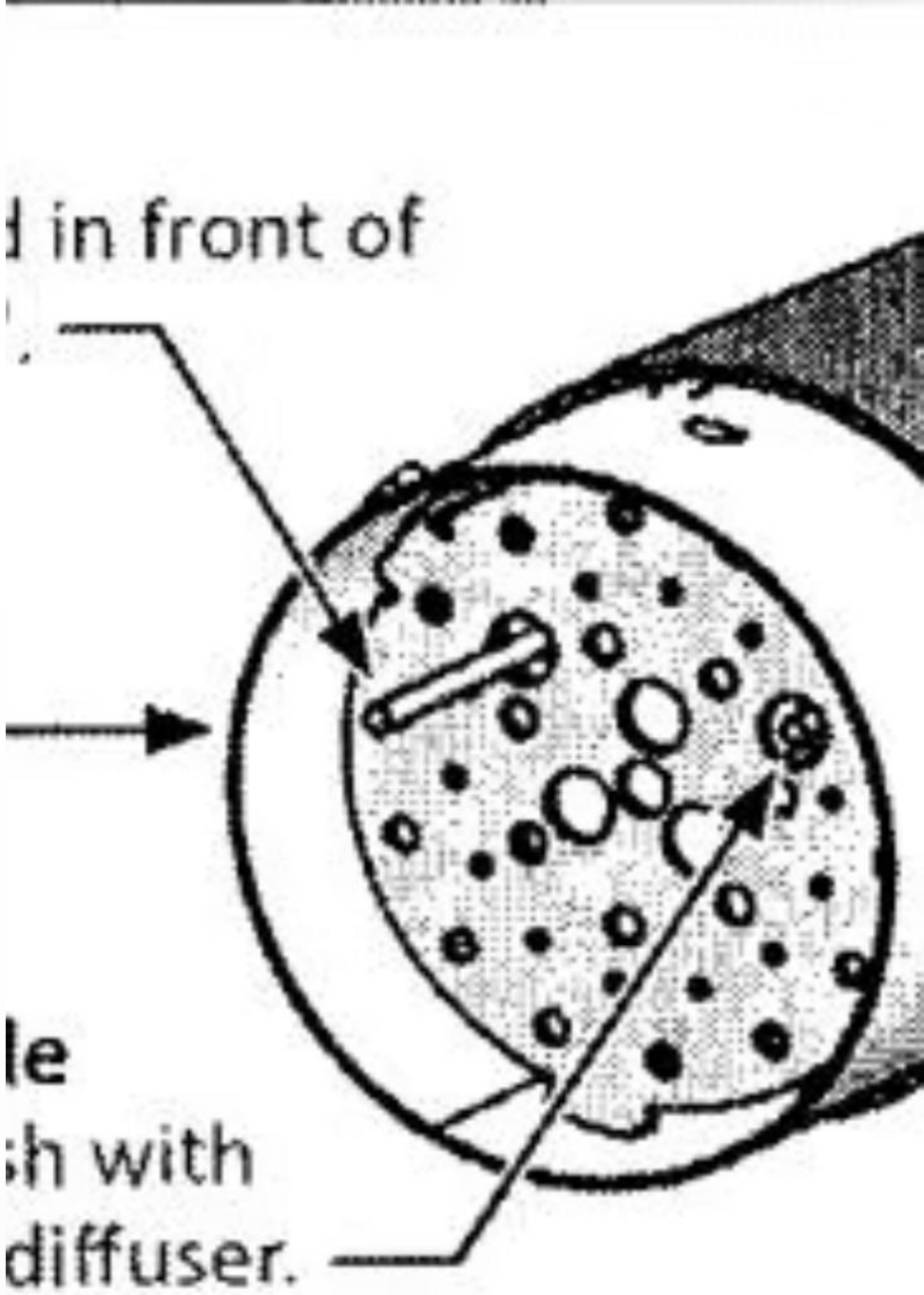


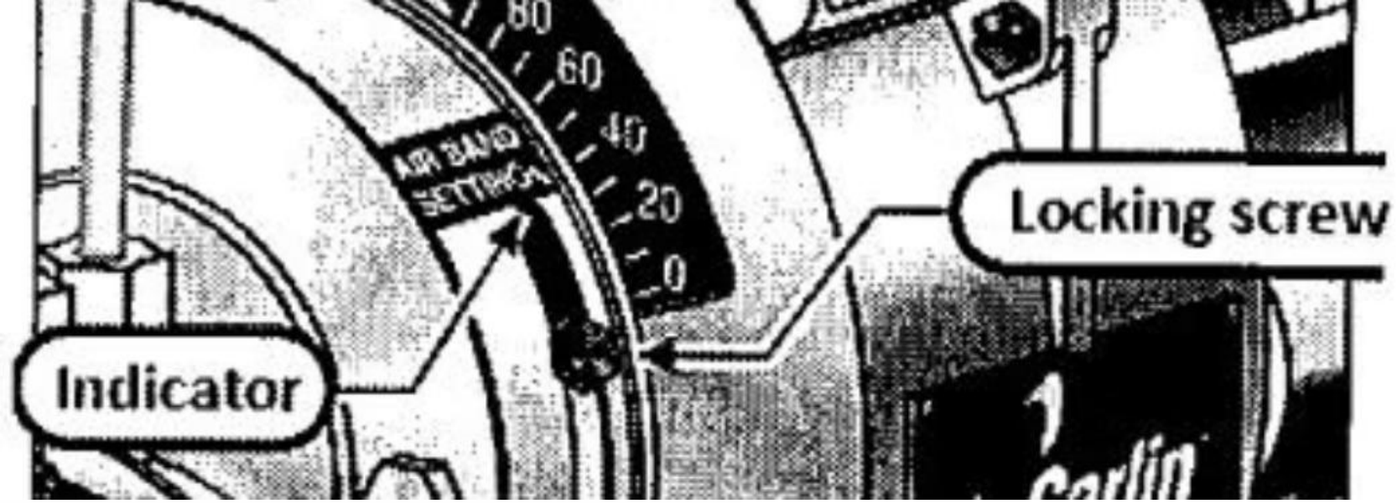
Figure 3-11

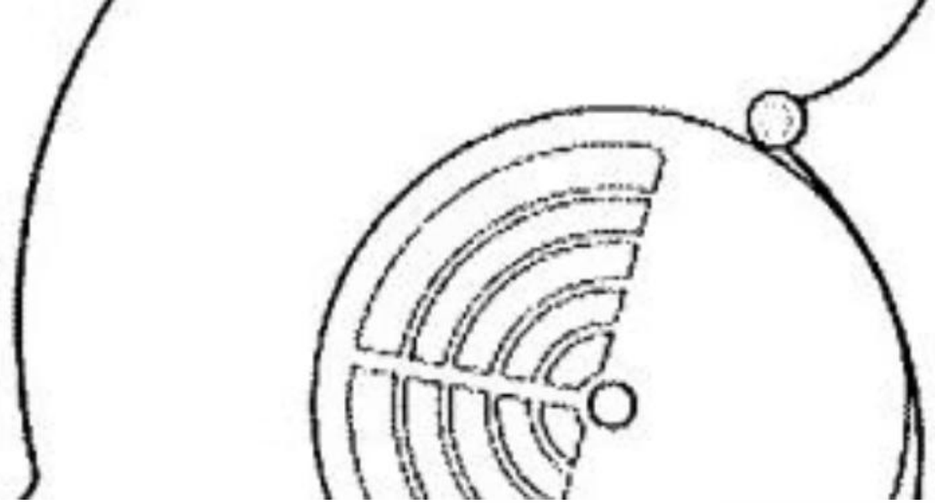
ion air devices: air band (left)and air gate or shut

Combustion Technology & Hydrolevel Company (Divisio
Company)

Air Adjustments

Figure 3-11 shows some of the typical types of devices used to adjust amount of combustion air. The burner manufacturer supplies recommended initial settings based on the firing rate of the appliance, but these are intended for use as a starting point only. Final adjustments must be made while performing a flue gas analysis.

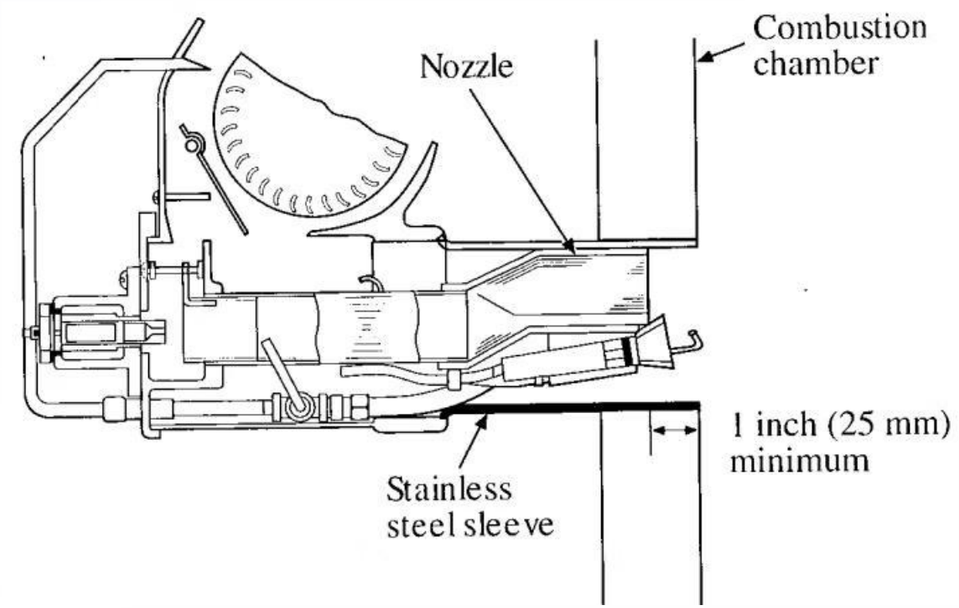




Air Shutter and Band Adjustments

Some burners come with both an air shutter and band. The primary differences between the two are their ease of adjustment and their total airflow area. On combined units, the shutter is the two suited for low rate adjustments, and the band for high rate adjustments.

Burner Sleeve Location



Conversion burners may be mounted in a sleeve that is sealed to the combustion chamber with refractory material. The burner can then be removed from the sleeve for servicing or repair.

Position the burner sleeve and nozzle 1 inch (25 mm) short of the inside of the combustion chamber (Figure 3-12). This protects the burner nozzle from the hot combustion chamber temperatures.

Do the following before permanently setting the burner in place:

1. Check that the burner nozzle and pilot are free of foreign materials.
2. Check that the spark igniter has not been damaged or displaced.

Burner Location Guidelines

The burner must have solid support on fireproof material both front and rear and be level in both directions. Table 3-2 gives typical burner location guidelines.

Exercise care when installing the burner to avoid undue strain on or distortion of the burner tube or other component that would impair its functioning.

Burner type	Appliance	Installation location
Drilled port or multi-jet upshot	Boilers	Burner ports set at least 1 inch (25 mm) above the grate level.
Single-port upshot	Boilers	Bottom of flame spreader set at least 1 inch (25 mm) above the grate level.
Drilled port or multi-jet upshot	Warm-air furnace	Burner ports set above the grate level, but not more than 1/3 the distance between the grate and the bottom level of the firing door.
Single-port upshot	Warm-air furnace	Bottom of flame spreader set above the grate level, but not more than 1/3 the distance between the grate and the bottom level of the firing door.

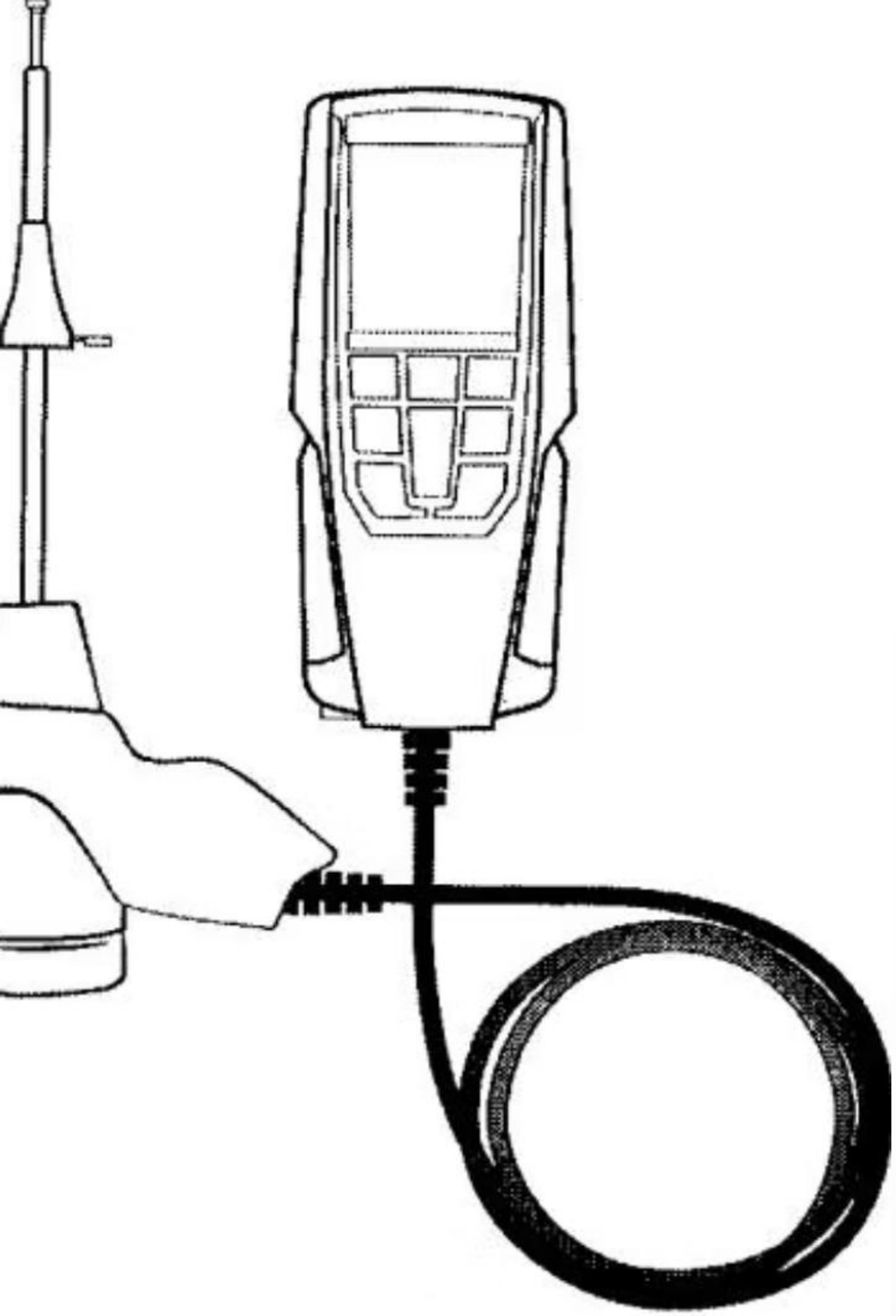
Start-up and Adjustments

After completing all the required pre-start checks (testing, purging) as required by the Code, the Atter oompleting and the ready for start-up and adjustment. In some localities, you may need to consult the authorities having jurisdiction (AHJ) regarding local start-up requirements (e.g., an inspector may need to be on site during start-up).

Burner manufacturers may supply a specification guide (Table 3-3) to assist in the initial set-up of the burner. Use this as the starting setting only. Adjust air settings, if necessary, after perfor ung combustion testing.

Sample Burner Specification Guide

Appliance input BTU	Orifice drill size Nat. gas	Propane	Diffuser plate	Air band type	Approximate air band setting C diffuser	B diffuser	Note 1	Note 2	Note 3	Note 4
50.000-75,000	5/32	1/8	C	1-slot	5%					
75.000-100,000	3/16	9/64	B or 9-slot	1-slot	10%					
100,000-125,000	7/32	11/64	B or 9-slot	1-slot	25%	35%				
125,000-150,000	1/4	13/64	B or 9-slot	1-slot	35%	45%				
150.000-175,000	9/32	7/32	B or 9-slot	1-slot	50%	75%				
175,000-200,000	5/16	1/4	A or 9-slot	2-slot	35%	50%				
200	5/16	1/4	A or 9-slot	7-slot	40%	65%				



Checking Combustion Using Instruments

Do not attempt to confirm combustion simply by inspecting the flame visually. You must use combustion test instruments (Figure 3-13). Failure to properly verify or adjust combustion could allow unsafe operation of the burner, resulting in severe personal injury, substantial property damage, or death. Modern handheld instruments allow you to adjust the burner system while watching the results on a monitor, tablet, or smartphone. You can also store, print, and create reports of the results.

Combustion Adjustment Procedure

The following are general procedures that can be used if manufacturer's instruction are not available:

1. Initiate a call for heat.
2. Adjust the draff or breech pressure to the appliance manufacturer's recommended level after flame has stabilized. A breech pressure that does not exceed -0.04 inch w.c. is generally acceptable.
3. Measure the CO level and adjust air settings, if necessary, to temporarily raise CO to about 50 ppm for a test point.
4. Measure the O2 or CO2 at the 50 ppm CO level. For this discussion, assume the O2 is 1.5% (11% CO2).
5. Open the air adjustment until the O2 level increases by at least 1% or to 3% O2 (whichever is higher). This should reduce the CO level and provide a margin of reserve air to accommodate variable conditions.
6. Sample the CO level again. It should be in the 0-20 ppm range.
7. Check the draft to ensure it still meets specifications. If a major change in draft is required, repeat the above steps.
8. Check draft regulator for spillage. Confirm the condition of the chimney if spillage is present.
9. Verify stack temperature meets appliance manufacturer's recommendations.
10. Perform any final adjustments and lock the air settings securely. Run the burner through several cycles to verify prompt ignition and stable burner operation.
11. Record the combustion performance readings, burner settings, and appliance data on a start-up form and on a start-up tag.
12. Hang the start-up tag in a prominent, safe location on or near the burner for future reference.

Limits, Controls, and Interlocks

Depending on the input and the type of appliance, the start-up checks can be very simple or very complex. The limits, controls, and interlocks that may require checking include:

- fan switch;
- flow switch;
- low-water cut-off;
- pressure gauges;
- water-fill controls;
- pressure controls;
- pressure relief valve and discharge piping;
- steam-pressure controls;
- expansion tank;
- circulator and controls;
- limits:
- thermostat location and voltage; and
- heat anticipator.

The Code requires you to leave the appliance in a safe operating condition. Therefore, you must check all safeties and interlocks before leaving. Some may be checked before start-up, others may need to be checked after start-up.

Checks After Start-up

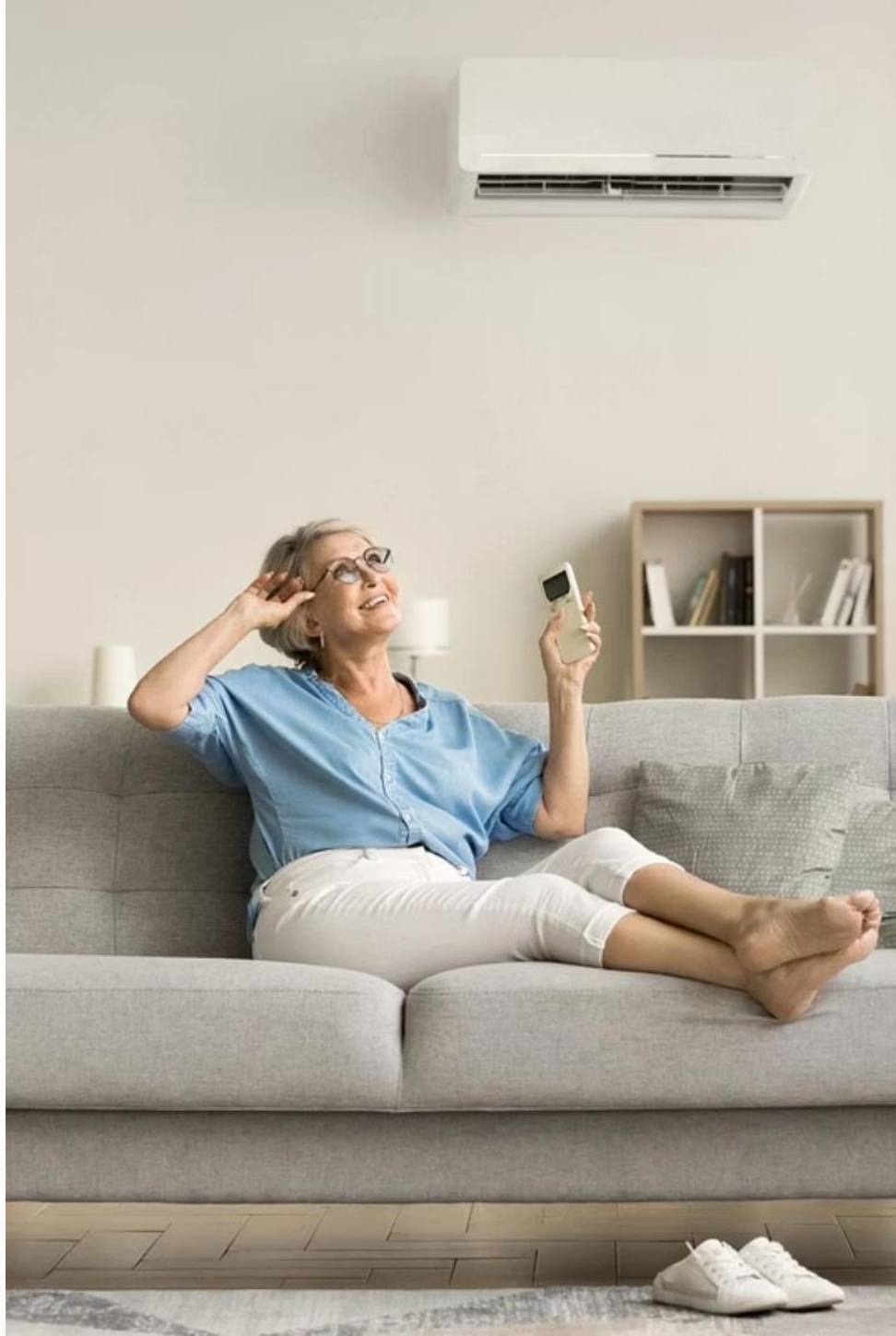
Do the following checks after start-up. Make any necessary adjustments.

1. Check burner operation.
2. To light up the burner safely, follow the start-up directions provided by the burner manufacturer.
3. Cycle the burner on and off several times with the thermostat or aquastat. Ensure sequence occurs as designed.
4. Ensure any potable water connections meet the plumbing code for required crossconnection devices.
5. Check draft control device for proper operation. If you use a barometric draft control, use a draft gauge to measure and adjust the draft as required by the appliance manufacturer.
6. Conduct flue gas analysis on all conversion burners.
7. Adjust the air shutters as required.
8. Clock the meter to ensure burner input is correct.
9. Check the fan motor, blower speed, and pulley size, if applicable.
10. Oil the motor, if required.

Completing the Installation

In some jurisdictions, upon completing the installation, the installer must immediately notify the gas supplier and the AHJ that the installation is complete.

> **Important:** CSA B149.1 clearly specifies the installer's responsibilities. Review these before, during, and after the conversion.



Removal of Old Fuel System

The contract between the installer and the customer will detail the installer's responsibilities about disposing the old fuel system.

Unless otherwise stated in the contract, all parts removed from the appliance such as the oil burner, oil lines, and valves, or grates and ash pit door, should be left on the premises for the customer to dispose.

Check Clause 4.3 of CSA B149.1 to determine the tasks involved in removing the old fuel system.

> **Note:** Some tanks were installed before basement steps were installed, so the tank may need to be cut apart to get it out. At all times, have an adequate fire extinguisher (ABC type) handy as blades can become hot and ignite vapours.

Protection of Property and Final Cleanup

At all times, protect the customer's property with an acceptable oil-absorbent material and carefully clean up all debris or spills created during the installation.

If	Then
You are to leave the tank on the customer's property.	A qualified technician/fitter should empty the tank out following all regulatory requirements for safe transportation and disposal. Shut off the tank outlet valve, remove the filter, and plug or cap the valve outlet.
You are to leave the tank indoors on the customer's property.	Remove the fill pipe and cap or plug the exposed fill pipe opening, but do not remove or plug the vent pipe.
The tank is located outdoors.	Disconnect and cap or plug the fill and vent pipes as close as practicable to the tank.

Do a final cleanup of work area before leaving the premises.

Instructions to Customer

In accordance with Clause 4.3.6 of CSA B149.1:

1. Advise the user of the appliance in writing of the procedures to be followed in discontinuing the supply of fuel oil.
2. Inform the customer about the hazards of flammable liquids and vapours and instruct them to keep flammable products away from the vicinity of the appliance.
3. Instruct the customer on how to properly and safely operate the converted unit (once the conversion is complete).
4. Inform the customer about the periodic maintenance required based on the conversion manufacturer's instructions.
5. Post the manufacturer's instructions in a prominent location near the appliance.
6. Affix a record of the installation adjustment data to the burner or the converted appliance, which contains the following data:
    - input in ft3/hr (m3/s); a)
    - manifold pressure setting; b)
    - measured flue gas temperature; c)
    - % CO2 or % 02: d)
    - CO; and e)
    - f) date and installer's name.