BASIC OIL HEAT

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NATIONAL OILHEAT RESEARCH ALLIANCE (NORA)

BUILDING CODES & STANDARDS for FUEL OIL

- **North Carolina Building Codes: Residential, Mechanical & Fire Protection Chapters.**
- **Underwriters Laboratories (UL) Standard for Safety UL 296 Oil Burners, UL 80, UL 142, & UL 58 for heating oil tanks.**
- **National Fire Protection Association (NFPA) Pamphlet 31, Installation of Oil-Burning Equipment.**

BUILDING CODES for FUEL OIL

- **UL-80 Standard for Steel Tanks for Oil-Burner Fuels and Other Combustible Liquids**

These requirements cover steel primary, steel secondary, and steel diked type atmospheric storage tanks from 60 to 660 gallons intended primarily for the storage and supply of heating fuels for oil burning equipment, …in aboveground applications.

These tanks are intended for installation and use in accordance with the Standard for the Installation of Oil-Burning Equipment , NFPA 31, the Flammable and Combustible Liquids Code, NFPA 30, the Code for Motor Fuel Dispensing Facilities and Repair Garages, NFPA 30A, and the International Fire Code (IFC). **(INSIDE TANKS ONLY PER IFC)**

BUILDING CODES for FUEL OIL

- **UL-58 Standard for Steel Underground Tanks for Flammable and Combustible Liquids**

This Standard covers horizontal atmospheric-type steel tanks for the storage underground of flammable and combustible liquids. Covers single wall tanks, secondary containment tanks, multiple compartment single wall and multiple compartment secondary containment tanks.

These tanks are intended for installation and use in accordance with NFPA 31, NFPA 30, NFPA 30A, and International Fire Code (IFC)

This Standard does not cover corrosion protection which may be required by local, state or federal authorities. Corrosion protection systems installed at the factory on carbon steel underground storage tanks are covered in UL 1746, External Corrosion Protection System for Steel Underground Storage Tanks

BUILDING CODES for FUEL OIL

- **UL-142 Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids**

Requirements cover steel primary, secondary and diked type atmospheric storage tanks intended for noncorrosive, stable flammable and combustible liquids that have a specific gravity not exceeding 1.0 in <u>aboveground applications</u>.

Each tank type may be fabricated in a combination of various shapes (cylindrical, rectangular or obround) and orientations (horizontal, vertical) with or without multiple compartments, as covered in this Standard.

These tanks are intended for installation and use in accordance with NFPA 30; NFPA 31; NFPA 30A; and the International Fire Code.

BUILDING CODES for FUEL OIL

- 2080 Standard for Fire Resistant Tanks for Flammable and Combustible Liquids
- 2085 Standard for Protected Aboveground Tanks for Flammable and Combustible Liquids
- SU 2258-Heating Oil Tanks “Non-Metallic”
- UL 1316-Fiberglass Heating Oil Tanks for Underground installation

Rarely used in Heating Oil Storage Tank Applications.

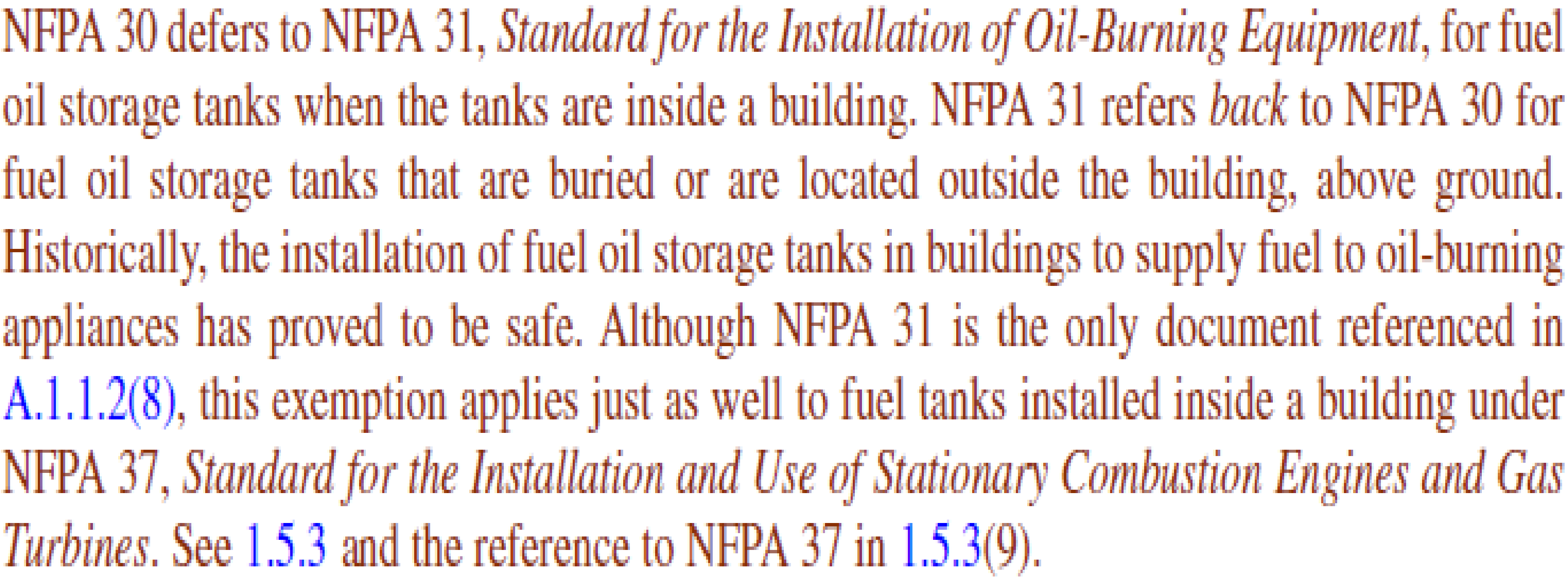
BUILDING CODES for FUEL OIL

- **NFPA 30: Flammable and Combustible Liquids Code:** This code shall apply to the storage, handling, and use of flammable and combustible liquids, including waste liquids as defined and classified.
- This code shall not apply to the following:..(8)*****
Storage, handling, and use of fuel oil tanks and containers connected with oil-burning equipment

  See A.1.1.1

BUILDING CODES for FUEL OIL

- **NFPA 30: Flammable and Combustible Liquids Code:**



NFPA 30 defers to NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, for fuel oil storage tanks when the tanks are inside a building. NFPA 31 refers *back* to NFPA 30 for fuel oil storage tanks that are buried or are located outside the building, above ground. Historically, the installation of fuel oil storage tanks in buildings to supply fuel to oil-burning appliances has proved to be safe. Although NFPA 31 is the only document referenced in A.1.1.2(8), this exemption applies just as well to fuel tanks installed inside a building under NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*. See 1.5.3 and the reference to NFPA 37 in 1.5.3(9).

BUILDING CODES for FUEL OIL

- NFPA 30A: Code for Motor Fuel Dispensing Facilities and Repair Garages

This code shall apply to motor fuel dispensing facilities; marine/motor fuel dispensing facilities; and motor fuel dispensing facilities located Inside buildings, at fleet vehicle motor fuel facilities, and at farms and isolated construction sites. This code shall also apply to motor vehicle repair garages.

BUILDING CODES for FUEL OIL

- **NFPA 31: Standard for the Installation of Oil-Burning Equipment**

This standard shall apply to the installation of stationary oil-burning equipment and appliances, including but not limited to industrial-, commercial-, and **residential**-type steam, hot water, or warm air heating plants; domestic-type range burners and space heaters; and portable oil-burning equipment.

This standard shall also apply to all accessory equipment and control systems, whether electric, thermostatic, or mechanical, and all electrical wiring connected to oil-fired equipment.

BUILDING CODES for FUEL OIL

- **NFPA 31: Standard for the Installation of Oil-Burning Equipment**

This standard shall also apply to the installation of **oil storage** and supply systems connected to oil fired equipment and appliances.

This standard shall also apply to those multi-fueled appliances in which fuel oil is one of the optional fuels.

This standard shall not apply to internal combustion engines, oil lamps, or portable devices not specifically covered in this standard. (See Chapter 11 for portable devices that are covered in this standard.)

BUILDING CODES for FUEL OIL

- **NFPA 31: Standard for the Installation of Oil-Burning Equipment**

7.4 Installation of Underground Tanks (including Buried Tanks Under Buildings). (Up to 35,000 gals. limit)

7.4.5 The distance from any part of the tank to the nearest wall of any basement, pit, or property line shall not be less than 1 ft (0.3 m).

7.4.11 An underground tank shall be provided with means for gauging. *(See Section 8.8.)*

BUILDING CODES for FUEL OIL

- **NFPA 31: Standard for the Installation of Oil-Burning Equipment**

7.5 Installation of Tanks Inside Buildings.

7.5.6 A maximum of 660 gal (2500 L) of storage tank capacity shall be permitted to be installed on a higher floor provided the following conditions are met:

7.5.8 Tanks of a capacity between 10 gal and 1320 gal shall not be placed within 5 ft horizontally from any source of heat, either in or external to any liquid fuel burning appliance, unless separated from the source of heat by a barrier having a 1-hour fire resistance rating extending horizontally at least 1 ft (0.3 m) past the oil burner or oil tank, whichever is greater, and extending vertically from floor to ceiling.

BUILDING CODES for FUEL OIL

- **NFPA 31: Standard for the Installation of Oil-Burning Equipment**

7.5.9 A tank of a capacity between 10 gal and 330 gal that is provided with an opening in the bottom for use as an appliance supply connection or as a drain shall be arranged as follows:

(1) The tank shall be pitched toward the opening with a slope of not less than 1⁄4 in. for every 5 ft of length.

(2) The supply line shall be provided with a readily accessible, thermally operated spring-loaded shutoff valve installed as close as practical to the tank. *(See also 8.6.4.)*

(3) A properly sized and rated oil filter or strainer shall be installed in the oil supply line to an oil burner immediately after the thermally operated spring-loaded shutoff valve required by 7.5.9(2).

(4) Where three or more tanks are installed as part of a fuel storage system, each burner supply line shall be provided with a readily accessible oil safety valve.

BUILDING CODES for FUEL OIL

- **NFPA 31: Standard for the Installation of Oil-Burning Equipment**

7.9 Installation of Outside Aboveground Tanks.

7.9.2 A tank or tanks whose capacity does not exceed 660 gal shall be permitted to be installed outside of and adjacent to a building, provided they are separated from the nearest line of adjoining property by the following minimum distance:

(1) 5 ft for tanks not exceeding 275 gal capacity

(2) 10 ft (3 m) for tanks greater than 275 gal capacity, but not exceeding 660 gal capacity

7.9.3 A tank or tanks whose capacity exceeds 660 gal shall be installed in accordance with all applicable requirements of NFPA 30, *Flammable and Combustible Liquids Code.*

7.9.4 Outside aboveground tanks and their appurtenances and supports shall be protected from external corrosion.

BUILDING CODES for FUEL OIL

- NFPA 31: Standard for the Installation of Oil-Burning Equipment

7.9.5 Cross-connection of two tanks to the same burner or the same group of burners shall be permitted. The tanks shall be permitted to have a single fill pipe and a single vent and shall be rigidly secured to a common slab or foundation.

7.9.6 Tanks shall be securely supported by rigid noncombustible supports to prevent settling, sliding, or lifting.

7.9.7 Each oil burner supply line connected to the gravity feed connection of the supply tank shall be provided with a shutoff valve at the tank.

7.9.7.1 Where this supply line passes through a foundation immediately inside the building, a readily accessible thermally operated spring-loaded valve shall be installed before the oil filter.

7.9.9 Each tank shall be provided with a means to determine

the liquid level. *(See Section 8.8.)*

BUILDING CODES for FUEL OIL

North Carolina Department of Insurance

1201 Mail Service Center

Raleigh, NC 27699-1201

800-546-5664 – NC Toll Free Only

web site: **http://www.ncdoi.com/**

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322 Chapanoke Road, Suite 200

Raleigh, NC 27603

919-661-5880 or (800) 634-7854 (NC Toll Free Only) web site: **http://www.ncdoi.com/osfm/Default.asp**

BUILDING CODES for FUEL OIL

- Building Codes online: **The Engineering and Codes Division is comprised of the following sections: Interpretations, Enforcement Service, Evaluation Services, , Home Inspectors Licensing Board and Private Plan Review. This page contains menus and links to assist you with NC Building Code Council, NC Code Official Qualifications Board and NC Home Inspectors Licensing Board as well as Staff information.**
- **WEB SITE-**

http://www.ncdoi.com/OSFM/Engineering_and_Codes.aspx

BUILDING CODES for FUEL OIL

- **NC FIRE CODE:-Chapter 34**

3401.2 Non applicability. This chapter shall not apply to liquids as otherwise provided in other laws or regulations or chapters of this code, including:…

3. Storage and use of fuel oil tanks and containers connected to oil-burning equipment. Such storage and use shall be in accordance with Section 603. For abandonment of fuel oil tanks, this chapter applies.

BUILDING CODES for FUEL OIL

- **NC FIRE CODE:-Chapter 34**

3404.2.13.1.4 Tanks abandoned in place.

Tanks abandoned in place shall be abandoned as follows:

1. Flammable and combustible liquids shall be removed from the tank and connected piping. 2. The suction, inlet, gauge, vapor return and vapor lines shall be disconnected. 3. The tank shall be filled completely with an approved, inert solid material.

Exception: Residential heating oil tanks of 1,100 gallons (4164 L) or less, provided the fill line is permanently capped or plugged, below grade, to prevent refilling of the tank.

4. Remaining underground piping shall be capped or plugged.

5. A record of tank size, location and date of abandonment shall be retained.

BUILDING CODES for FUEL OIL

- **NC FIRE CODE: Chapter 6**

603.3 Fuel oil storage systems.

Fuel oil storage systems shall be installed in accordance with this code. Fuel oil piping systems shall be installed in accordance with the *International Mechanical Code*.

603.3.1 Maximum outside fuel oil storage above ground.

Where connected to a fuel-oil piping system, the maximum amount of fuel oil storage allowed outside above ground without additional protection shall be 660 gallons. The storage of fuel oil above ground in quantities exceeding 660 gallons shall comply with NFPA 31.

BUILDING CODES for FUEL OIL

- **NC FIRE CODE: Chapter 6**

603.3.2 Maximum inside fuel oil storage.

Where connected to a fuel-oil piping system, the maximum amount of fuel oil storage allowed inside any building shall be 660 gallons. Where the amount of fuel oil stored inside a building exceeds 660 gallons, the storage area shall be in compliance with the *International Building Code*.

603.3.3 Underground storage of fuel oil.

The storage of fuel oil in underground storage tanks shall comply with NFPA 31.

BUILDING CODES for FUEL OIL

- ## NC FIRE CODE:-Chapter 34

3404.2.13.2 Above-ground tanks

3404.2.13.2.2 Out of service for 90 days. Above-ground tanks not used for a period of 90 days shall be safeguarded in accordance with Section 3404.2.13.1.2 or removed in accordance with Section 3404.2.14.

Exceptions: 1. Tanks and containers connected to oil burners that are not in use during the warm season of the year or are used as a backup heating system to gas.

3404.2.13.2.3 Out of service for 1 year. Above-ground tanks that have been out of service for a period of 1 year shall be removed in accordance with Section 3404.2.14.

Exception: Tanks within operating facilities.

BUILDING CODES for FUEL OIL

- **NC MECHANICAL CODE: Chapter 13**

FUEL OIL PIPING AND STORAGE, SECTION 1309 OIL TANKS FOR ONE-AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

1309.1 Materials. Supply tanks shall be listed and labeled and shall conform to UL 142 for aboveground tanks, UL 58 for underground tanks, and UL 80 for inside tanks.

BUILDING CODES for FUEL OIL

- **NC MECHANICAL CODE: Chapter 13**

FUEL OIL PIPING AND STORAGE, SECTION 1309 OIL TANKS FOR ONE-AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

1309.2 Above-ground tanks. The maximum amount of fuel oil stored above ground or inside of a building shall be 660 gallons. The supply tank shall be supported on rigid noncombustible supports to prevent settling or shifting.

BUILDING CODES for FUEL OIL

- **NC MECHANICAL CODE: Chapter 13**

FUEL OIL PIPING AND STORAGE, SECTION 1309 OIL TANKS FOR ONE-AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

1309.2.1 Tanks with buildings.

Supply tanks for use inside of buildings shall be of such size and shape to permit installation and removal from dwellings as whole units. Supply tanks larger than 10 gallons shall be placed not less than 5 feet from any fire or flame either within or external to any fuel-burning appliance.

BUILDING CODES for FUEL OIL

- **NC MECHANICAL CODE: Chapter 13**

FUEL OIL PIPING AND STORAGE, SECTION 1309 OIL TANKS FOR ONE-AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

1309.2.2 Outside above-ground tanks. **Tanks installed outside above ground shall be a minimum of 5 feet from an adjoining property line. Such tanks shall be suitably protected from the weather and from physical damage.**

BUILDING CODES for FUEL OIL

- ## NC MECHANICAL CODE: Chapter 13

FUEL OIL PIPING AND STORAGE, SECTION 1309 OIL TANKS FOR ONE-AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

1309.3 Underground Tanks. Excavations for underground tanks shall not undermine the foundations of existing structures. The clearance from the tank to the nearest wall of a basement, pit or property line shall not be less than 1 foot (305 mm). Tanks shall be set on and surrounded with non-corrosive inert materials such as clean earth, sand or gravel well tamped in place. Tanks shall be covered with not less than1 foot (305mm) of earth. **Corrosion protection shall be provided in accordance with section 1309.8.**

BUILDING CODES for FUEL OIL

- **NC MECHANICAL CODE: Chapter 13**

FUEL OIL PIPING AND STORAGE, SECTION 1309 OIL TANKS FOR ONE-AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

1309.4 Multiple tanks. Cross connection of two supply tanks shall be permitted in accordance with Section 1309.7.

1309.5 Oil Gauges. Inside tanks shall be provided with a device to indicate when the oil in the tank has reached a predetermined safe level. Glass gauges or a gauge subject to breakage that could result in the escape of oil from the tank shall not be used.

BUILDING CODES for FUEL OIL

- **NC MECHANICAL CODE: Chapter 13**

FUEL OIL PIPING AND STORAGE, SECTION 1309 OIL TANKS FOR ONE-AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

1309.6 Flood-resistant installation. In areas prone to flooding as established by Table R301.2(1) of the International Residential Code, tanks shall be installed at or above the design flood elevation established in Section R324 of the International Residential Code or shall be anchored to prevent flotation, collapse and lateral movement under conditions of the design flood.

BUILDING CODES for FUEL OIL

- NC MECHANICAL CODE: Chapter 13

FUEL OIL PIPING AND STORAGE, SECTION 1309 OIL TANKS FOR ONE-AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

- 1309.7 Cross connection of tanks. Cross connection of supply tanks, not exceeding 660 gallons (2498 L) aggregate capacity, with gravity flow from one tank to another, shall be acceptable provided that the two tanks are on the same horizontal plane.

BUILDING CODES for FUEL OIL

- **NC MECHANICAL CODE: Chapter 13**

FUEL OIL PIPING AND STORAGE, SECTION 1309 OIL TANKS FOR ONE-AND TWO-FAMILY DWELLINGS AND TOWNHOUSES

- **1309.8 Corrosion protection. Underground tanks and buried piping shall be protected by corrosion resistant coatings or special alloys or fiberglass-reinforced plastic.**

  (**UL-1746** Standard for External Corrosion Protection Systems For Steel Underground Storage Tanks)

What is a BTU

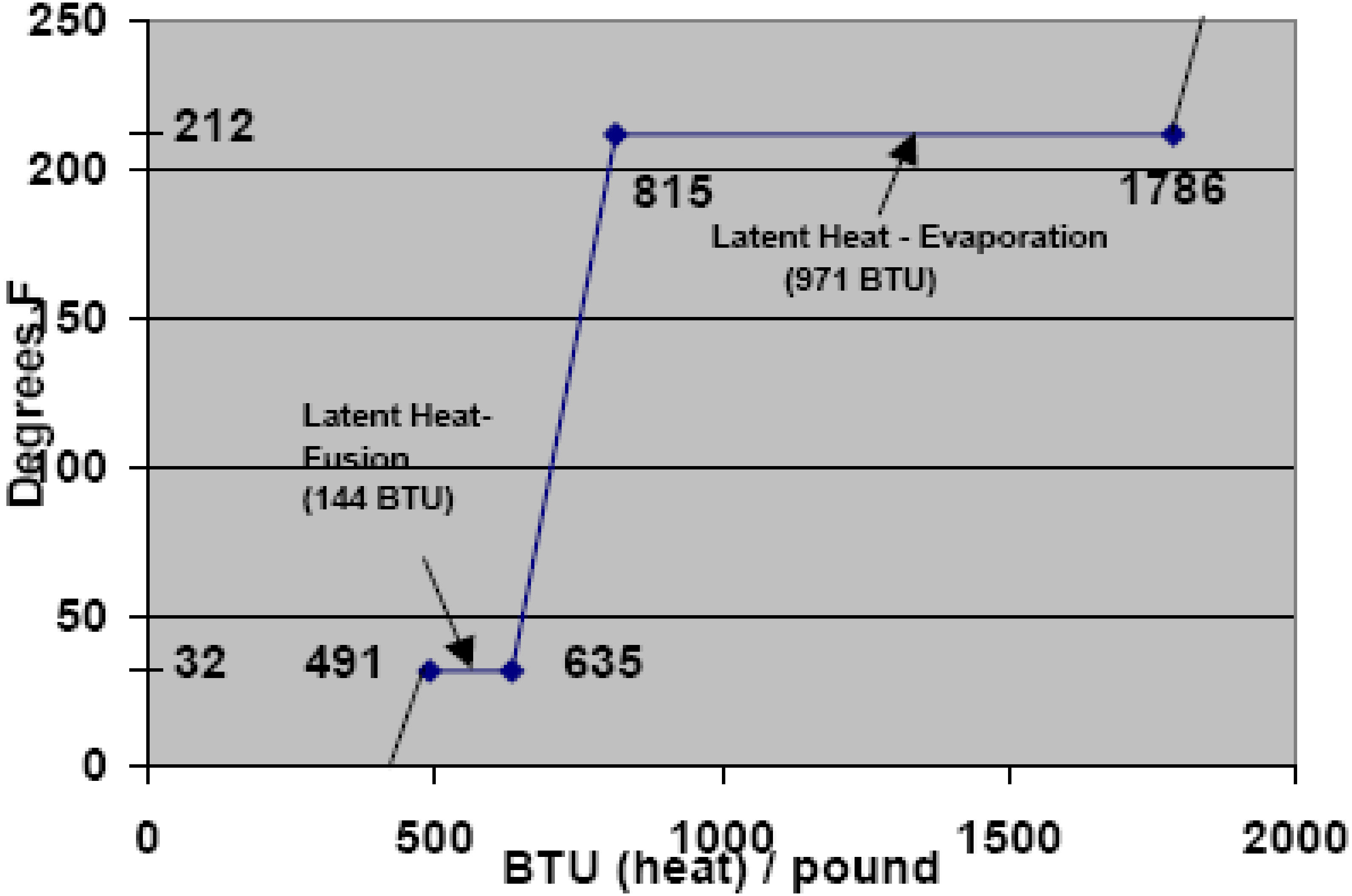
- British Thermal Unit
- The amount of heat required to heat or raise 1 pound of water 1 degree Fahrenheit
- About the heat from a Kitchen Match Stick

Change of State Energy

(For 1 pound of water)

- Change of 32 ICE to 32 water takes 144 BTUs. **Latent Heat of Fusion.**
- Change 32 water to 212 water takes 180 BTUs. 212-32 = 180   **Sensible Heat**
- Change 212 water to 212 stream takes 970 BTUs. **Latent Heat of Vaporization**
- To change 32 water to 212 steam takes 1,150 BTUs

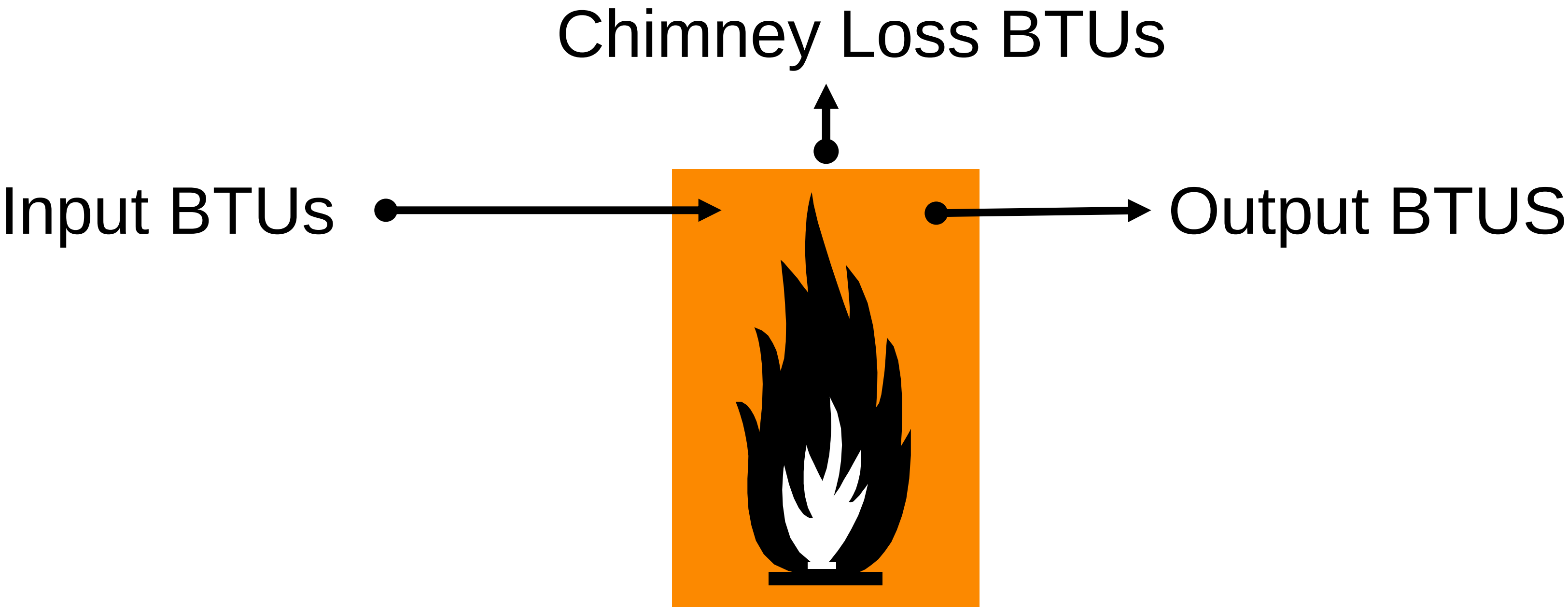
Change of State Energy



Three means of Heat Transfer

- **Radiation:** Heat transfer by direct rays from hot object to cold object.
- **Convection:** Heat Transfer by movement of air.
- **Evaporation:** Heat Transfer by evaporation.
- Most people feel comfortable in wintertime by an effective temperature of 68 with a relative humidity of 100%

Indirect Firing Furnaces & Boilers



Chimney Loss BTUs

Input BTUs

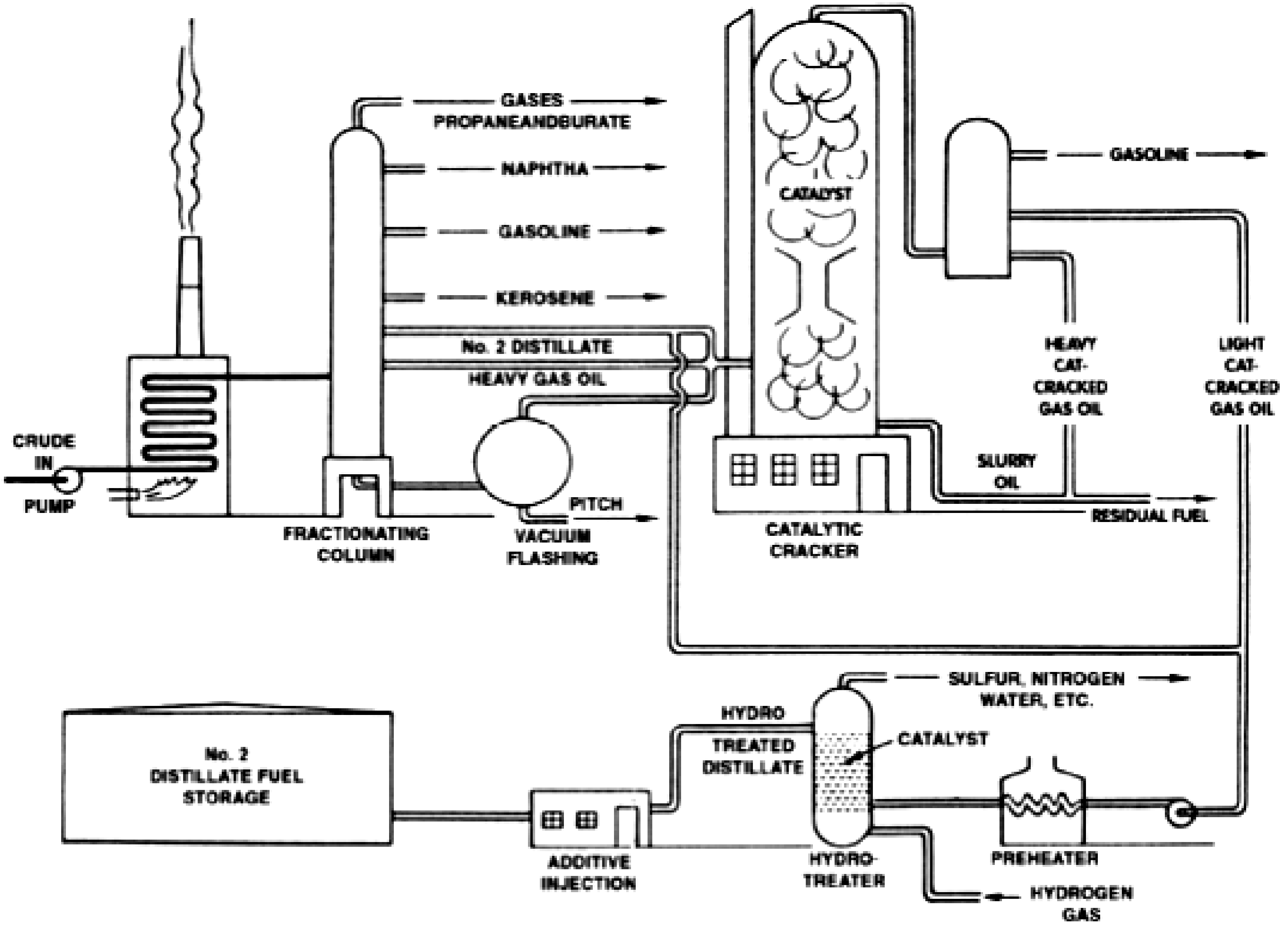
Output BTUS

OUTPUT INPUT = STEADY STATE EFFICIENCY

Energy Content and Units

- FUEL OIL NO. 2: 140,000 BTUs/gallon
- PROPANE: 91,500 BTUs/gallon
- NATURAL GAS: 100,000 BTUs/Therm
- ELECTRICITY: 3,413 BTUs/KILOWATT HR.

Fuel Oil Combustion Manual, pg. 1



FUEL OIL Combustion Manual, pg. 2

- **Kerosene (K-1):** Uses include suitability for lighting and cooking employing simple burners (wick). As of July 1, 1998, this product may be dyed. **Average of 134,000 BTUs per gallon. (ULSK)**
- **Fuel Oil No.-1**: A light liquid distillate with distillation range of about 325 to 570 °F. Use is generally in vaporizing “pot-type” burners for space heaters, but is not recommended for wick burners. As of Oct. 1, 1993, this product may be dyed. Ultra Low-Sulfur grade available. **Average of 135,000 BTUs per gallon.**
- **Fuel Oil No.-2:** A slightly heavier distillate with a maximum distillation temperature of 675 °F. Use is for mechanically atomizing type burners and where sediment in fuel and preheating are prohibited or limited. This is the general fuel for automatic oil-fired heating equipment. As of Oct. 1, 1993, this product may be dyed. Ultra Low Sulfur Grade available. **Average of 140,000 BTUs per gallon.**

FUEL OIL Combustion Manual, pg. 3

- **TYPICAL SPECIFICATIONS 1993 NIPER**
- **No. 2 Fuel Oil**

Gravity-API: 33.5

Flash Point: 165 °F

Viscosity-CS @ 104 °F: 2.85

Pour Point: -10°to +5°F

Sediment & Water: 0.017%

Sulfur, wt.%: 0.231 %

Ultra Low Sulfur Grades: 0.00015%

Heat of Combustion: 139,500 BTUs/gal.

FUEL OIL Combustion Manual, pg. 3

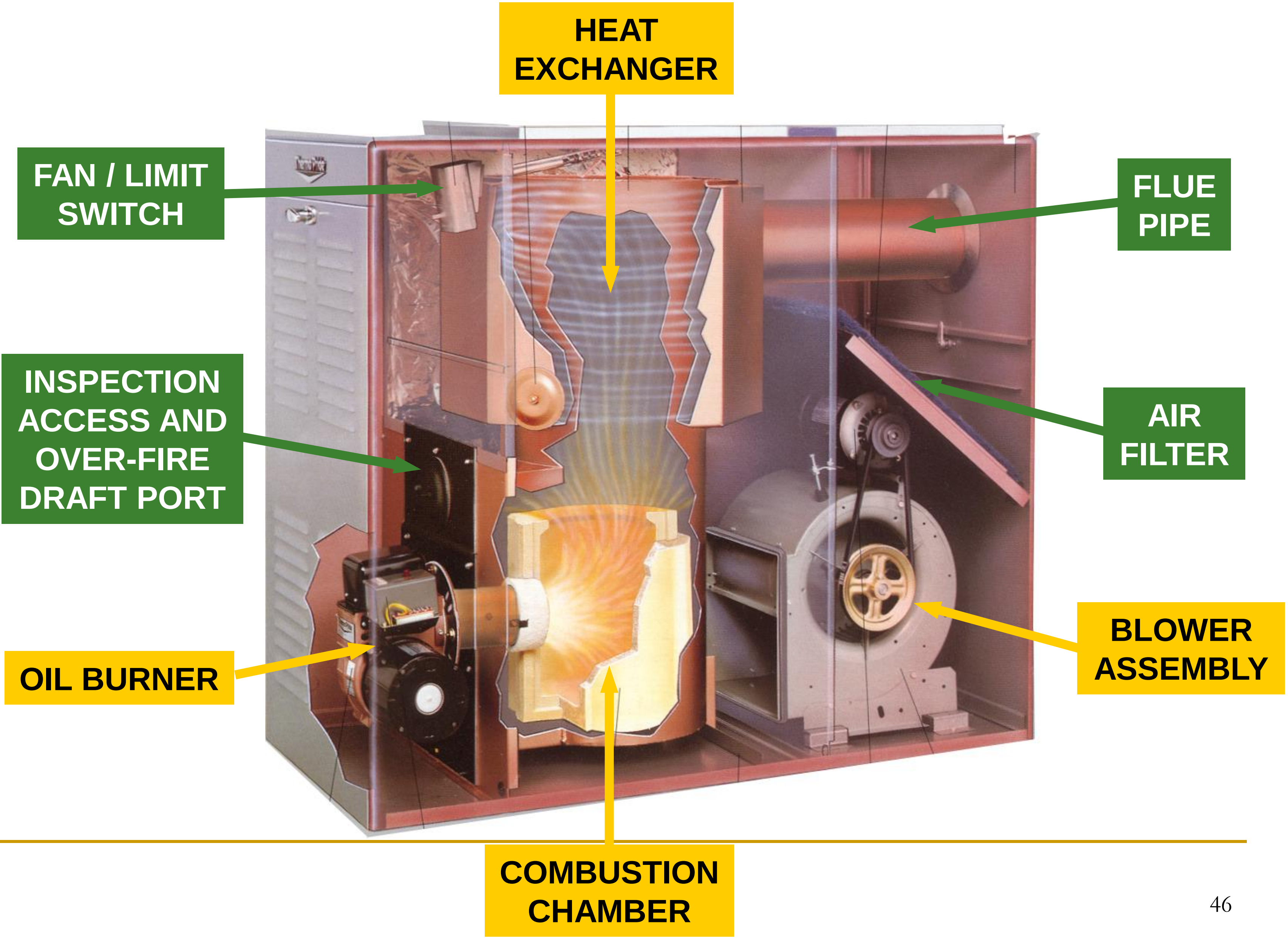
- **HEATING VALUES-BTU CONTENTS of VARIOUS FUELS. The chart in the manual compares the various forms of heating fuels in terms of British Thermal Units (BTU). Each fuel type is compared to the other fuel types in two ways. How many of the fuels measured units does it take to make 1 million BTUs, and how each fuel units does it take to make another fuel type. For example, consider # 2 fuel oil; 1 gallon of #2 fuel oil holds as many BTUs as approximately 1.167 gals of gasoline, 1.04 gallons of # 1 kerosene, 0.900 gals. of # 6 fuel oil, 1.53 gallons of propane, 1.4 therms of natural gas, 41.02 Kilowatts of electricity, and 0.0043 cords of dry oak wood. It would also take 7.14 gallons of # 2 fuel oil to equal 1 million BTUs.**

- **The chart does not take into consideration how efficient the fuel would be burned. For consideration purposes, most fossil fuel furnaces would have a 80% efficiency, electric strip elements at 100%, fireplaces at 0 to 10% efficiency, and heat pumps at the theoretical 200% range.**

FUEL OIL Combustion Manual, pg. 4

- **GRAVITIES, DENSITIES AND HEATS OF COMBUSTION OF FUEL OILS. (Fig.-2)**
- **No 2 Fuel Oil with an API Gravity of 33 would weigh 7.17 lbs/gal. Have approx. 19,520 BTUs/lb., have 140,000 BTUs per gal. and float on water**

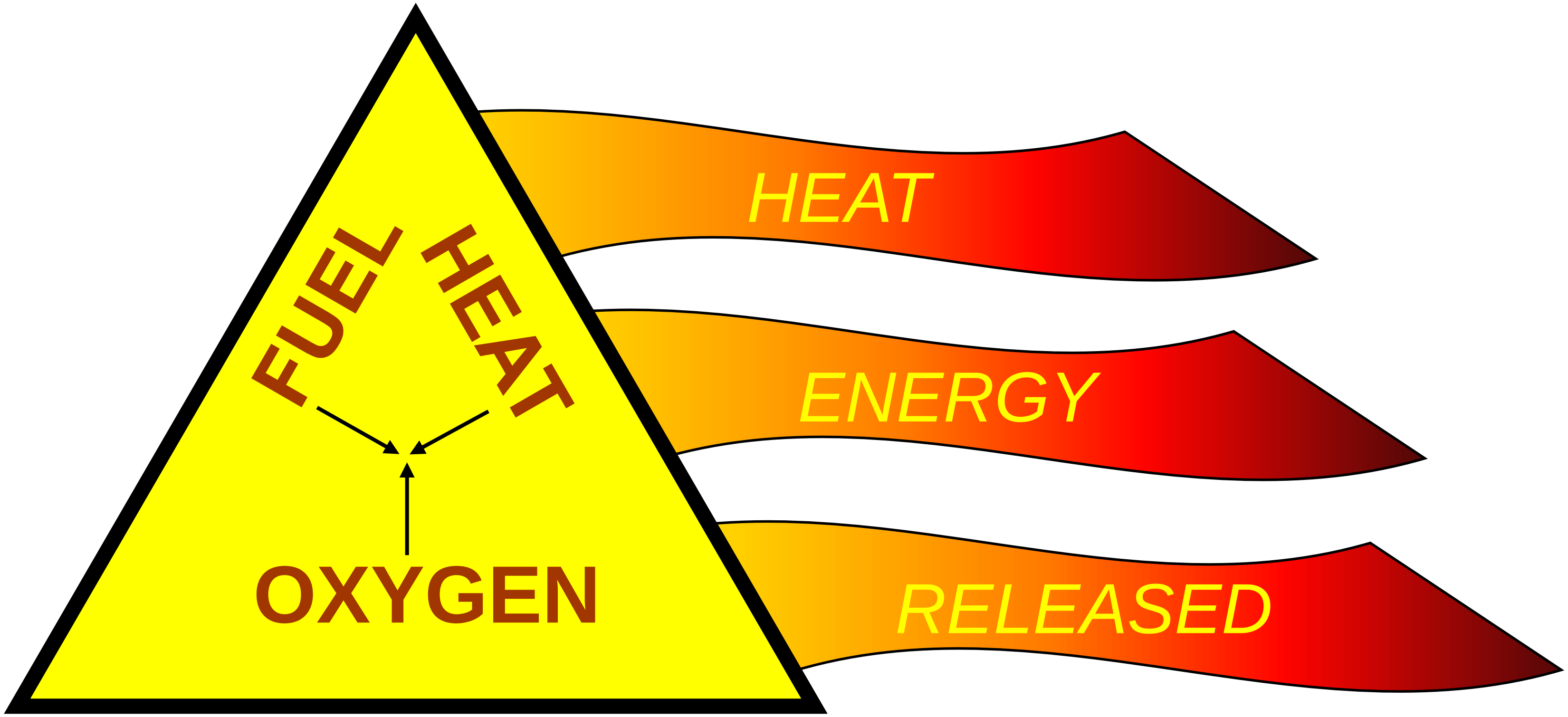
FUEL OIL Combustion Manual, pg. 5



FUEL OIL Combustion Manual, pg. 6

- Oil is a complex mixture of compounds containing carbon (C) and hydrogen (H). These two elements must combine with oxygen (0) to burn. A certain theoretical amount of oxygen must be supplied to combine with (burn) all the carbon and hydrogen. For ordinary equipment, oxygen is supplied mixed with nitrogen (ordinary air).
- Number 2 fuel oil is comprised mainly of 84% carbon and 15% hydrogen along with various other chemicals in small amounts. Air is roughly comprised of 20.9% Oxygen and 79% inert Nitrogen.

What is Combustion?

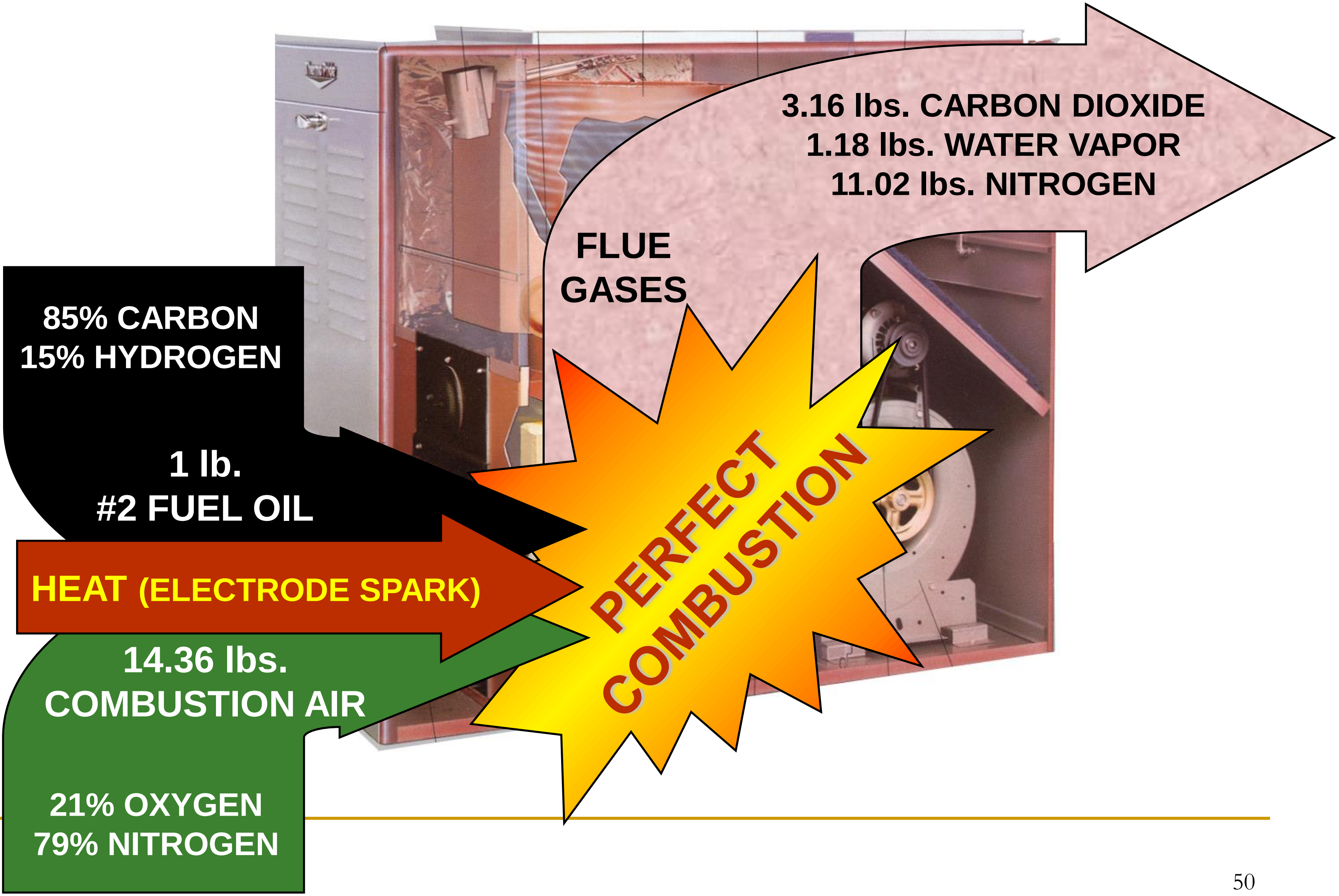


CHEMICAL REACTION

FUEL OIL Combustion Manual, pg. 6

- **To burn 1 gallon of oil that weights 7.17 pounds, it would take 154.44 pounds of air or 2,059.22 cubic feet. The combustion process would produce about 8.64 pounds of water (over a gallon). It would produce approximately 22.66 pounds of Carbon Dioxide. Approximately 130.42 pounds of Air would go through the process essentially unaffected chemically.**
- **It would also produce small amounts of trace gases such as Carbon Monoxide, Nitrogen Oxides and Sulfur Oxides. The combustion process with one gallon of fuel oil would produce approximately 140,000 BTUs of heat energy.**

FUEL OIL Combustion Manual, pg.7



85% CARBON
15% HYDROGEN

1 lb.
#2 FUEL OIL

HEAT (ELECTRODE SPARK)

14.36 lbs.
COMBUSTION AIR

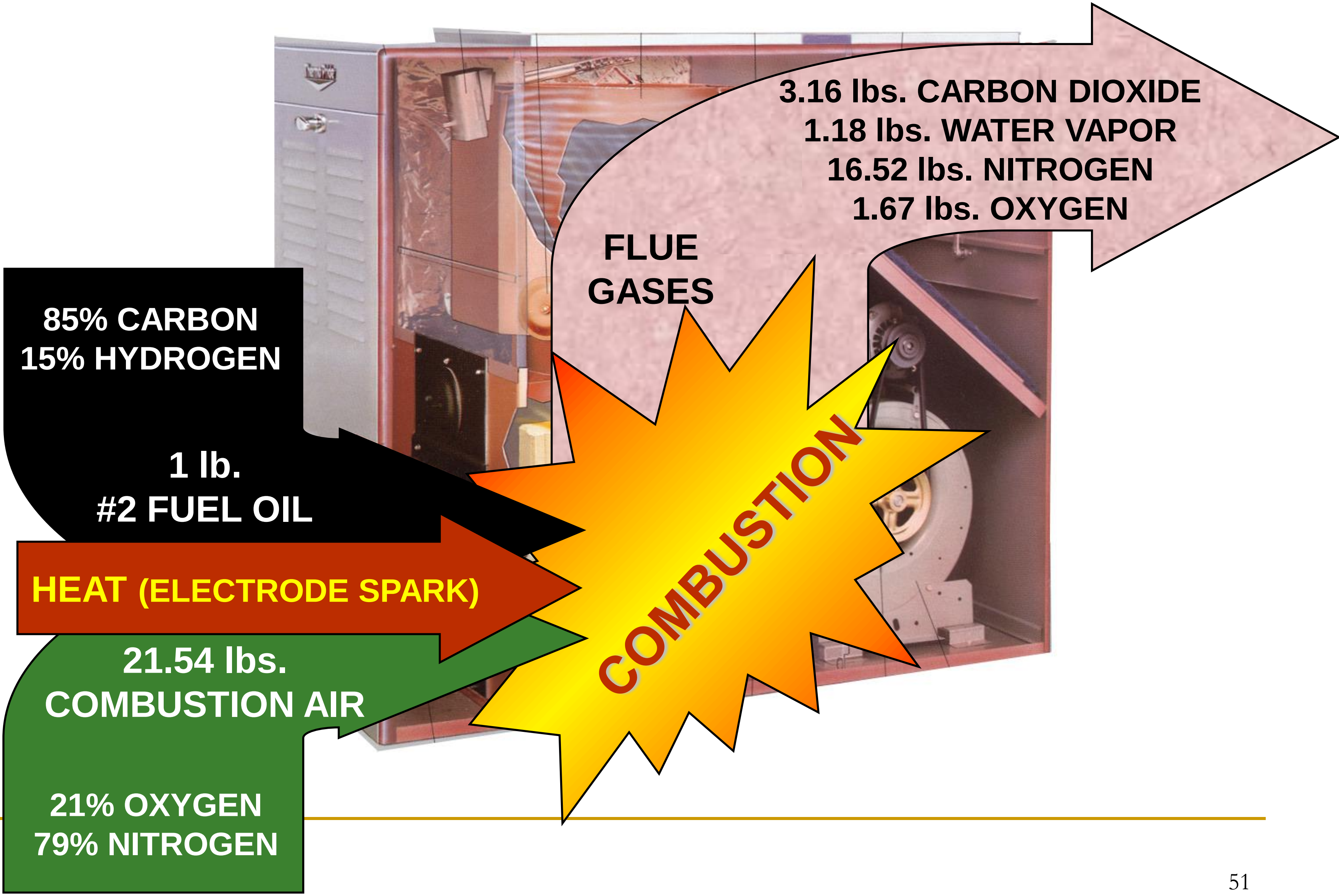
21% OXYGEN
79% NITROGEN

PERFECT COMBUSTION

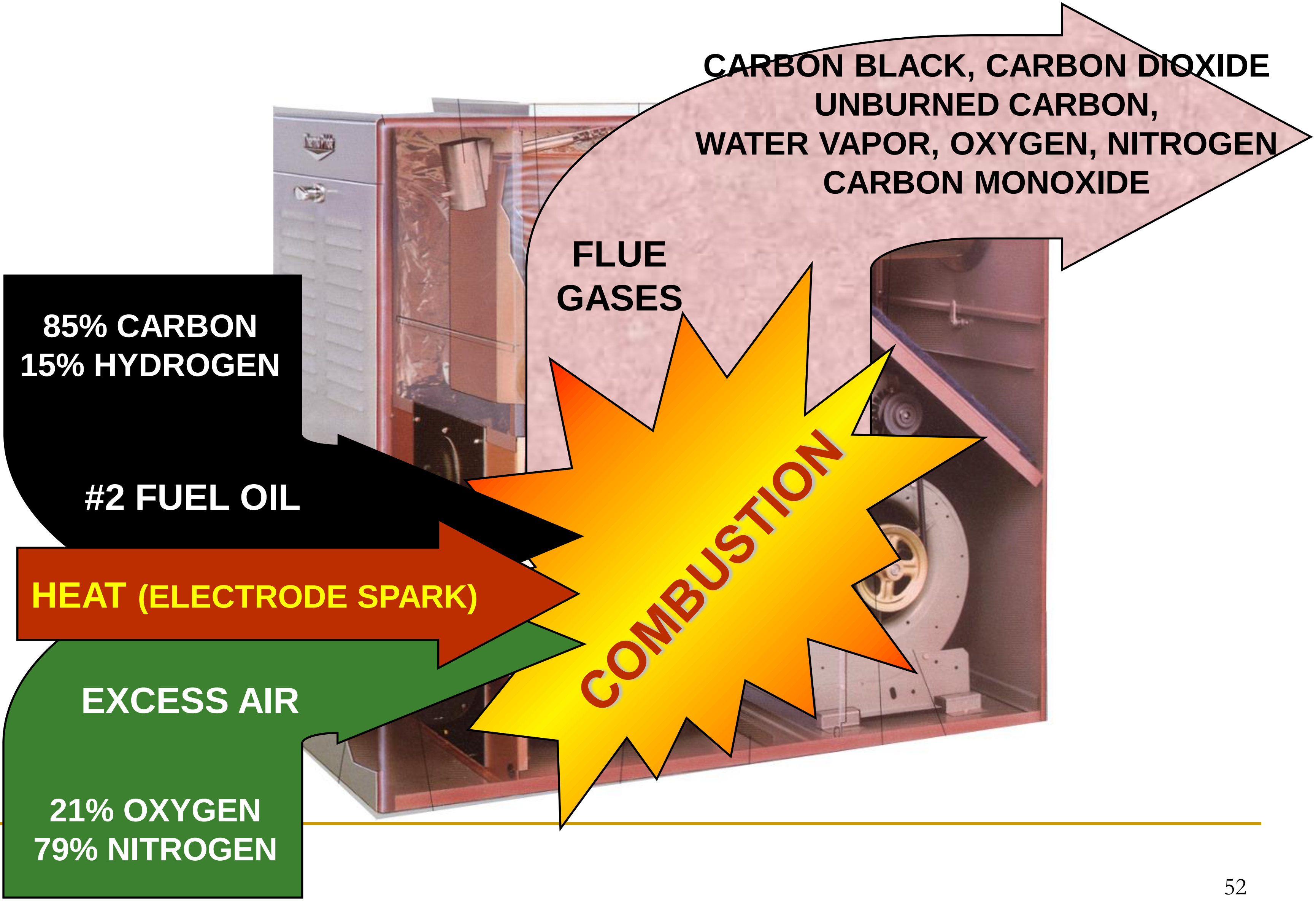
FLUE GASES

3.16 lbs. CARBON DIOXIDE
1.18 lbs. WATER VAPOR
11.02 lbs. NITROGEN

FUEL OIL Combustion Manual, pg.7



FUEL OIL Combustion Manual, pg.7



CARBON BLACK, CARBON DIOXIDE
UNBURNED CARBON,
WATER VAPOR, OXYGEN, NITROGEN
CARBON MONOXIDE

FLUE
GASES

85% CARBON
15% HYDROGEN

#2 FUEL OIL

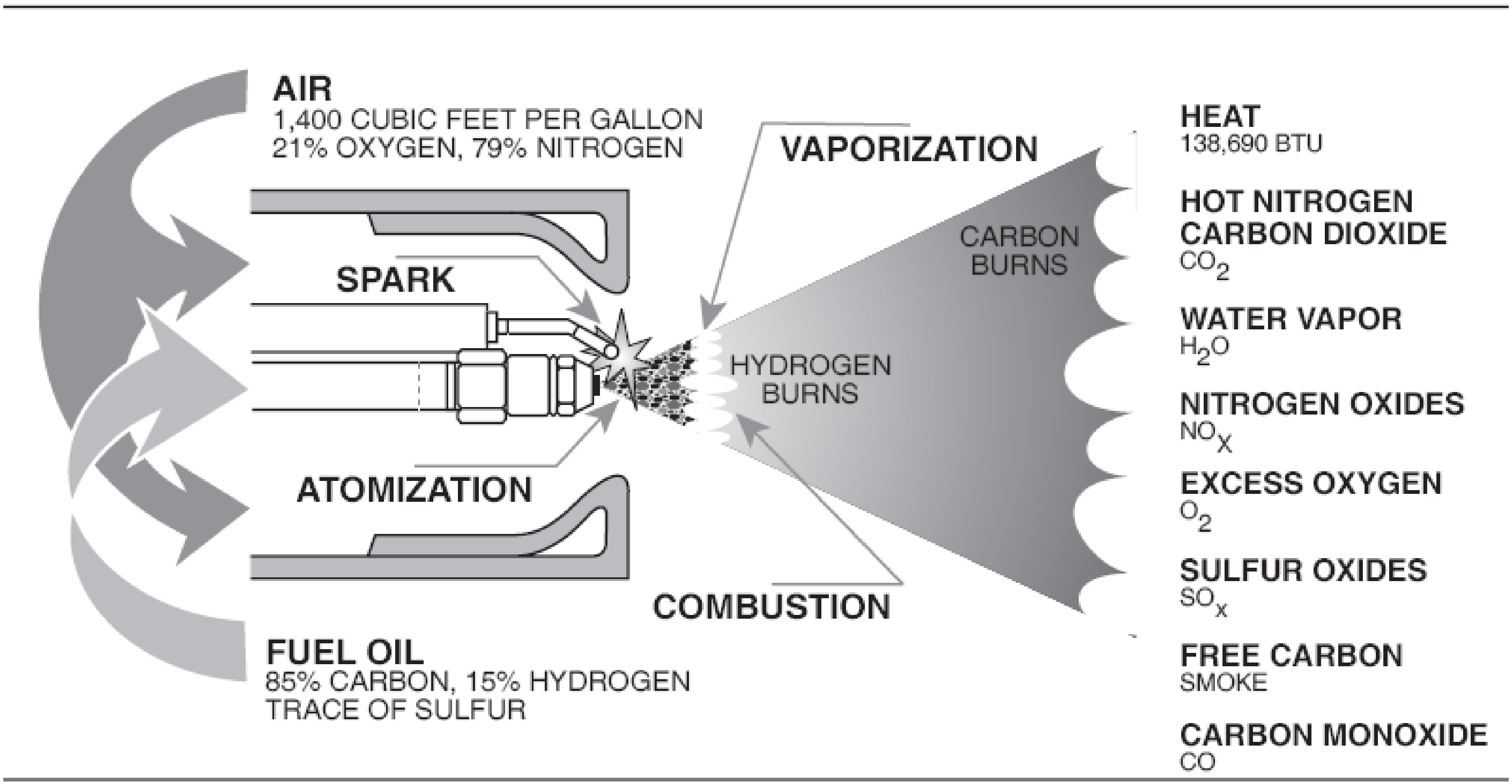
HEAT (ELECTRODE SPARK)

COMBUSTION

EXCESS AIR

21% OXYGEN
79% NITROGEN

FUEL OIL Combustion Manual, pg. 8

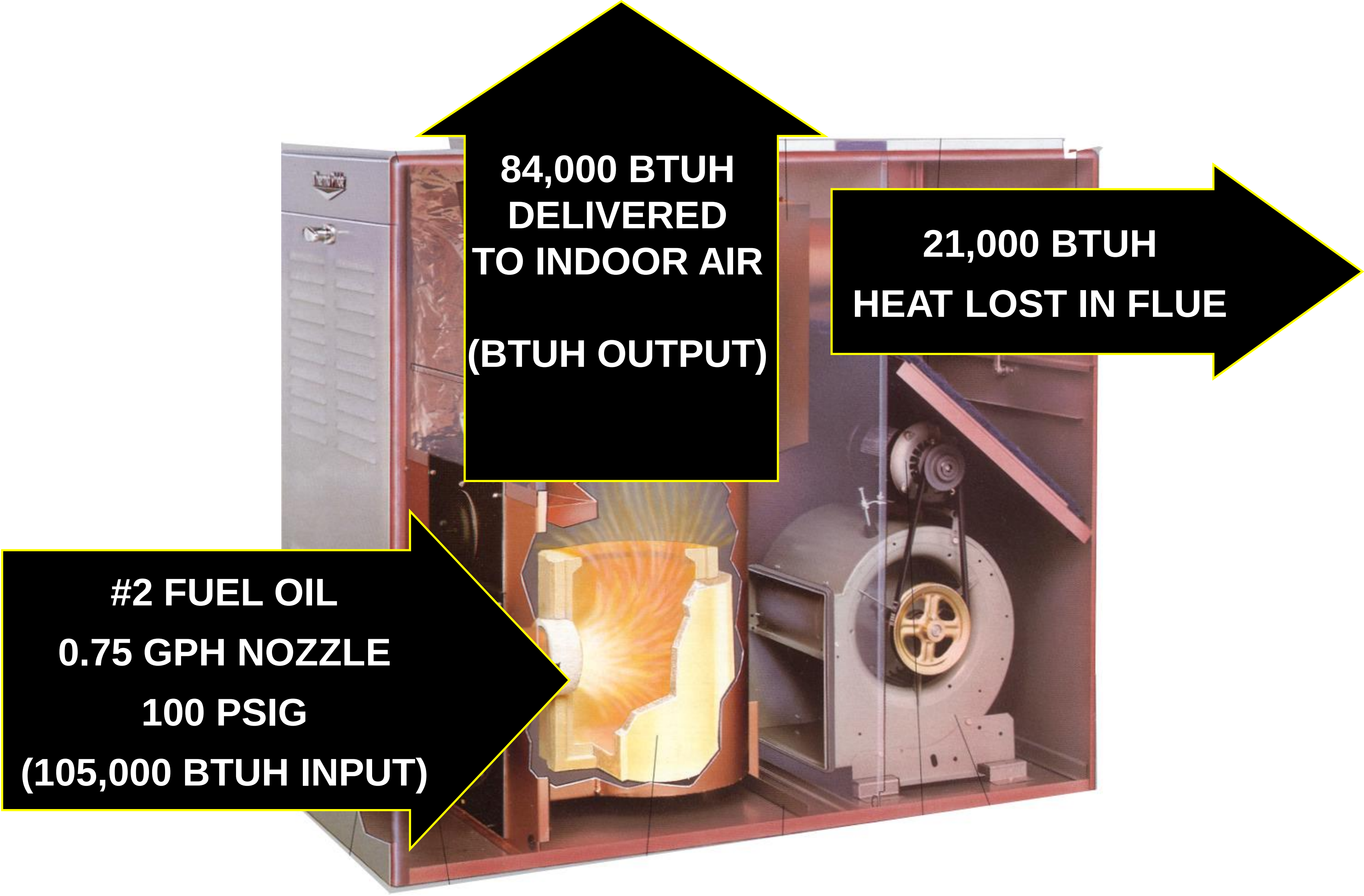


FUEL OIL Combustion Manual, pg 8

No 2 OIL CARBON DIOXIDE & OXYGEN PERCENTAGES IN FLUE GAS VS. EXCESS AIR LEVEL PERCENTAGES

- **12% CO2 gives a reading of 4.8% Oxygen, 27% excess air, and a flame temperature of 2820ºF**

FUEL OIL Combustion Manual, Pg. 9



84,000 BTUH
DELIVERED
TO INDOOR AIR

(BTUH OUTPUT)

21,000 BTUH
HEAT LOST IN FLUE

#2 FUEL OIL
0.75 GPH NOZZLE
100 PSIG
(105,000 BTUH INPUT)

80% STEADY STATE COMBUSTION EFFICIENCY

(Jacket Heat Loss not Included)

FUEL OIL Combustion Manual, pg. 10

TESTING & ADJUSTING OIL BURNING OPERATIONS

- Primary Air Shutter for best yellow flame.
- Operate combustion until stack temperature levels off.
- Measure Over-Fire Draft at -0.01 to -0.02 inches water column.
- Make Smoke test, try for No. 0 smoke.

FUEL OIL Combustion Manual, pg. 10

TESTING & ADJUSTING OIL BURNING OPERATIONS

- Take CO2 or O2 test reading. Try for 10% CO2 or 5% O2 with no smoke reading.
- Low CO2 or high O2 can be caused by: Excessive Primary Air
  Poor Atomization
  Wrong Nozzle or Combustion
  Chamber

FUEL OIL Combustion Manual, pg. 10

TESTING & ADJUSTING OIL BURNING OPERATIONS

- After achieving high CO2 or low O2, measure Flue Gas Temperature.
- Using Thermal Combustion Efficiency Charts, determine combustion efficiency using Net Stack Flue Gas Temp. and CO2 or O2 readings.

FUEL OIL Combustion Manual, pg. 10

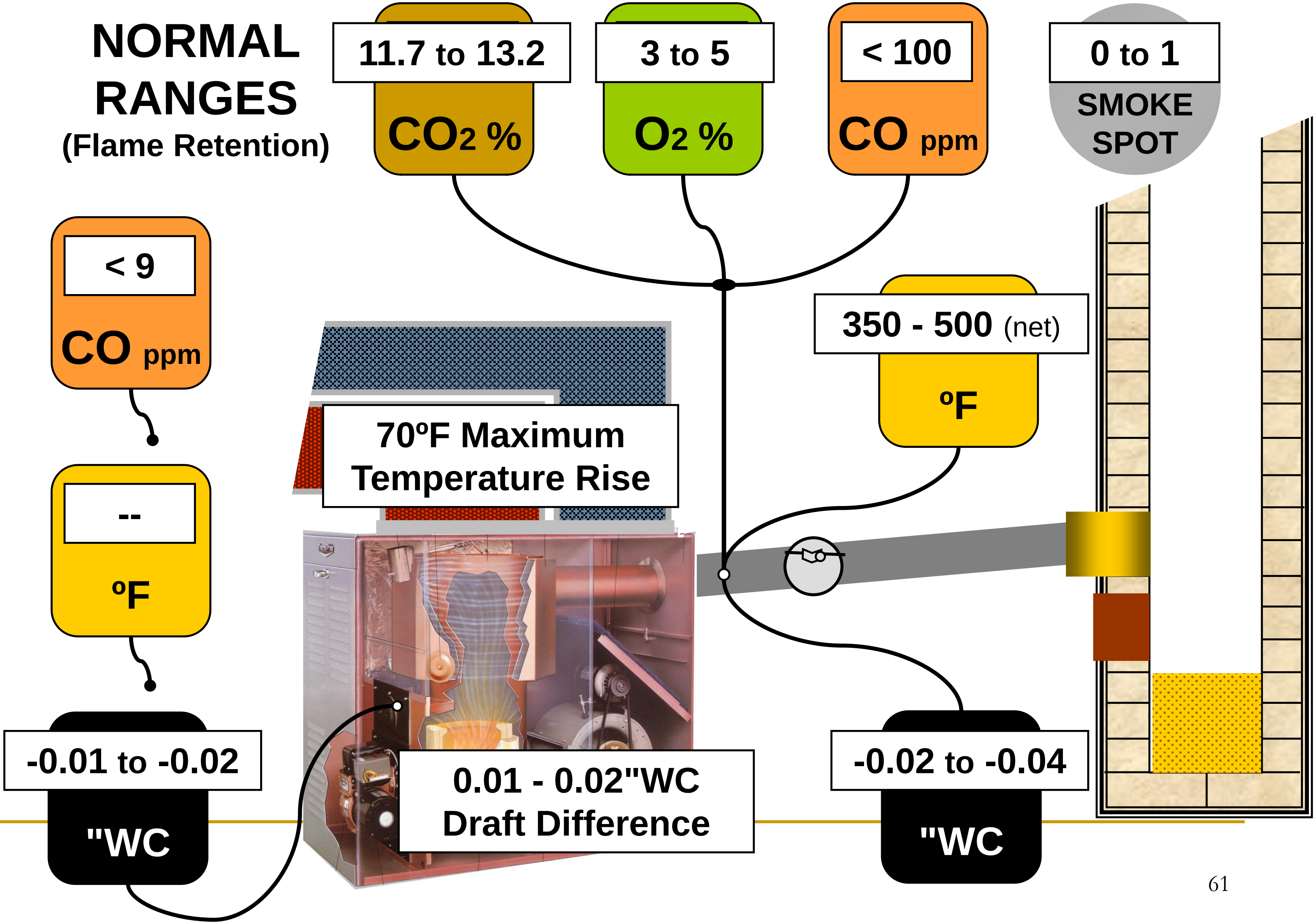
TESTING & ADJUSTING OIL BURNING OPERATIONS

- Excessive Flue Gas temperature indicates too much primary air or the presence of insulating deposits.
- Very low Flue Gas temp. indicates under firing & flue gas condensation.

FUEL OIL Combustion Manual, pg. 11

- Combustion Test Work Sheet for determining increase in combustion efficiency and decrease in fuel cost.
- Fuel saving determined by using chart on page 13.

Combustion Analysis



NORMAL RANGES
(Flame Retention)

11.7 to 13.2
CO_2 %

3 to 5
O_2 %

< 100
CO ppm

0 to 1
SMOKE SPOT

< 9
CO ppm

--
ºF

-0.01 to -0.02
"WC

70ºF Maximum
Temperature Rise

350 - 500 (net)
ºF

0.01 - 0.02"WC
Draft Difference

-0.02 to -0.04
"WC

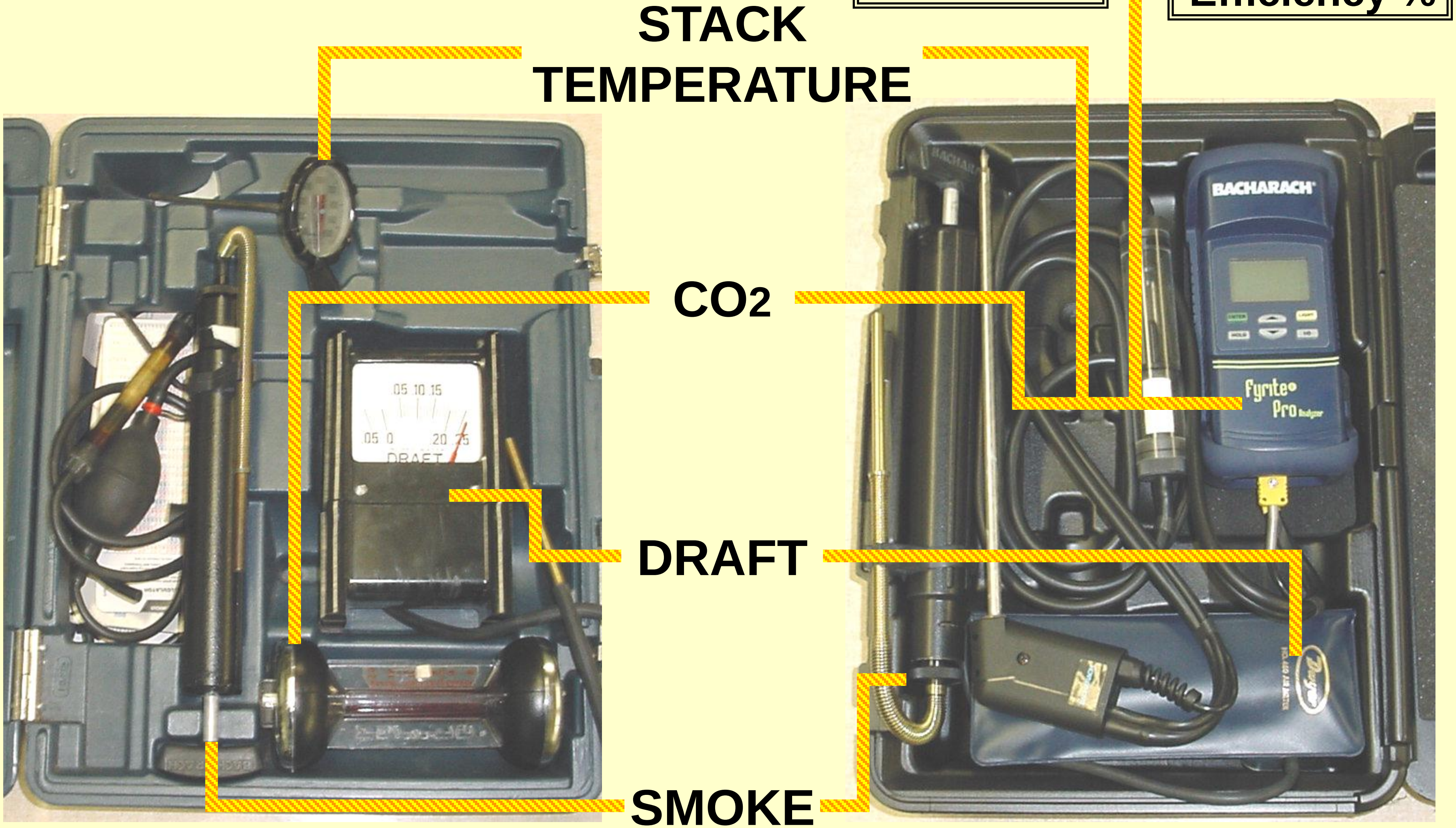
Combustion Test Instruments

- Carbon Dioxide or Oxygen (%)
- Carbon Monoxide (0 - 2000 ppm)
- Flue Stack Thermometer (200ºF - 1000ºF)
- Draft Gauge (0.1"WC to -0.25"WC)
- Smoke Tester (ASTM D2156 approved)

COMBUSTION TEST KITS
(Old and New)

Measures:
O2
Air Temp.
CO
Draft

Calculates:
CO2
Excess Air %
CO (Air Free)
DRAFT
Efficiency %



Combustion Test Printer Reading

BACHARACH, INC.

FYRITE PRO ANALYZER

DATE: 7/30/2002

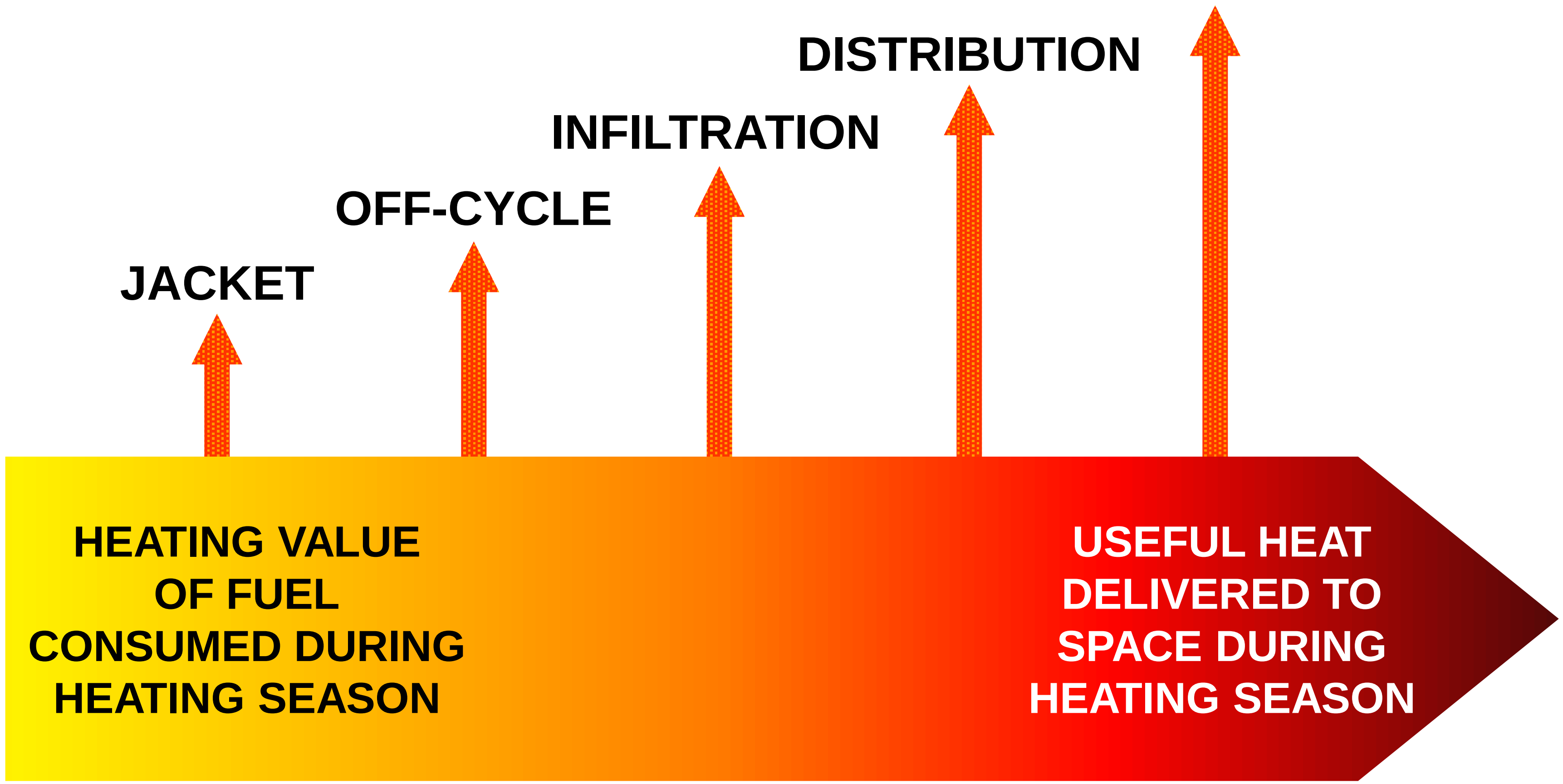
TIME: 12:24 AM

FUEL: (F2) Oil #2

EFFICIENCY	83.1%
EXCESS AIR	45.7%
STACK TEMP	456 ºF
PRIMARY TEMP	62.0 ºF
O2	6.9%
CO2	10.4%
CO	20 ppm
CO AIR FREE	30 ppm

FUEL OIL Combustion Manual

A.F.U.E.



COMBUSTION

DISTRIBUTION

INFILTRATION

OFF-CYCLE

JACKET

HEATING VALUE
OF FUEL
CONSUMED DURING
HEATING SEASON

USEFUL HEAT
DELIVERED TO
SPACE DURING
HEATING SEASON

ANNUAL FUEL UTILIZATION EFFICIENCY

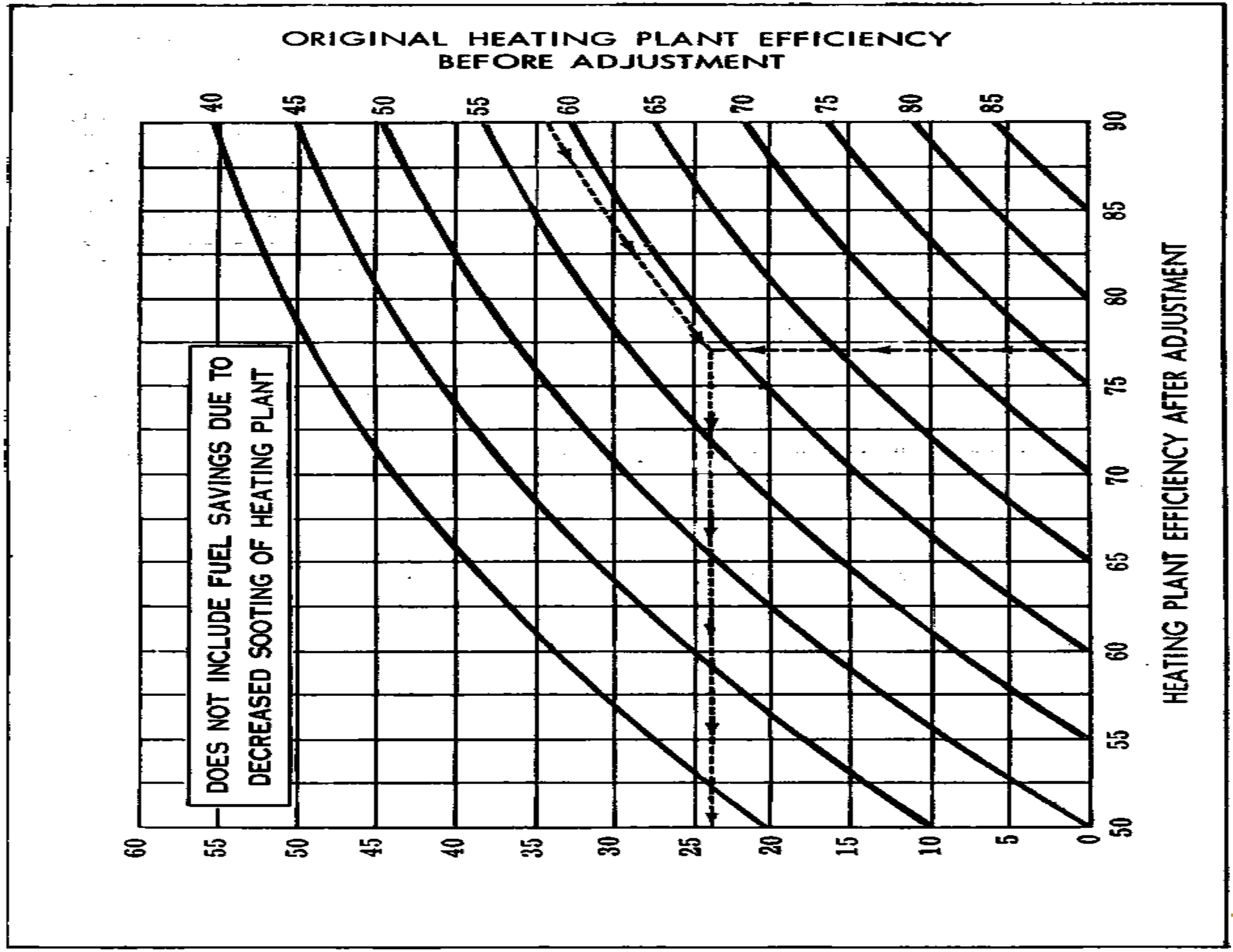
(Includes All Heat Losses Associated With Equipment Operation)

FUEL OIL Combustion Manual, pg. 12

Temperature

O2%	200	250	300	350	400	450	500	550	600	650	700	750	800	CO2 %
1	90	88	87	86	85	84	83	82	81	80	78	77	76	14.7
2	89	88	87	86	85	84	82	81	80	79	78	77	75	14.0
3	89	88	87	86	84	83	82	80	79	78	77	76	75	13.2
4	89	88	86	85	84	83	82	81	80	78	76	75	74	12.5
5	89	87	86	85	83	82	81	80	78	77	75	74	73	11.7
6	88	87	86	84	83	81	80	79	77	76	74	73	71	11.0
7	88	87	85	84	82	81	79	78	76	75	73	72	70	10.3

FUEL OIL Combustion Manual, pg. 13



FUEL OIL Combustion Manual, pg. 14

Heat Exchangers:

- Heat transfer occurs two ways with oil burners.

1) Radiation: Luminous Flame to primary heating surfaces within sight of flame

2) Convection: Hot combustion gases in contact with secondary heat exchanger surfaces, mostly out of site of flame

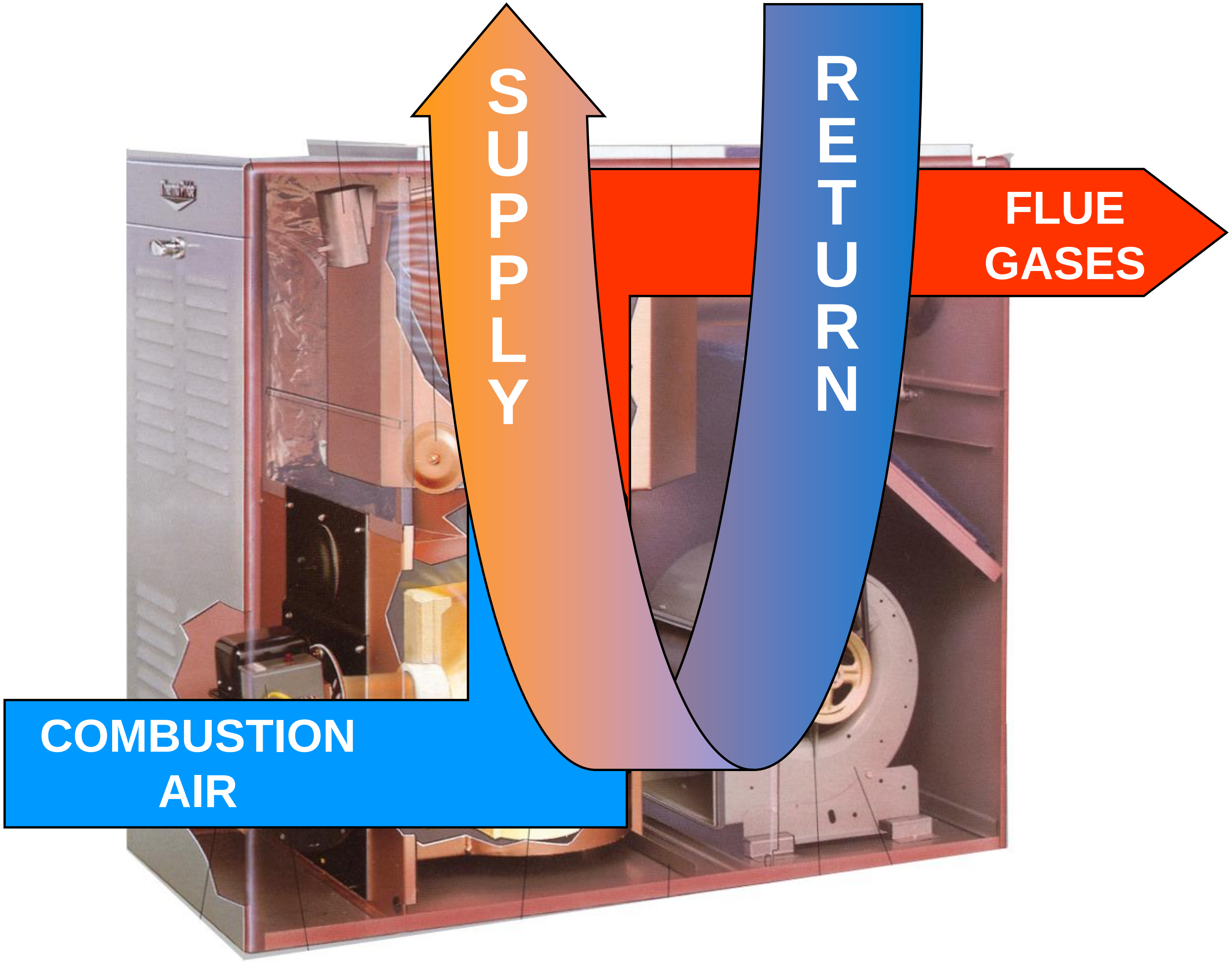
FUEL OIL Combustion Manual, pg. 14

Heat Transfer:

1) **Temperature Difference:** The greater the temperature difference between flue gases and heated medium, the more heat transferred.

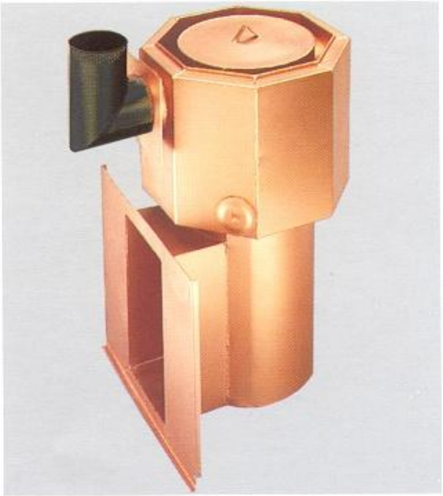
2) **Contact Time**: The longer the hot combustion gases are in contact with the walls of the heat exchanger, the more heat will be transferred. Longer contact time can be achieved by reducing the amount of combustion gases produced per gallon of fuel burned or per period of time.

FUEL OIL Combustion Manual

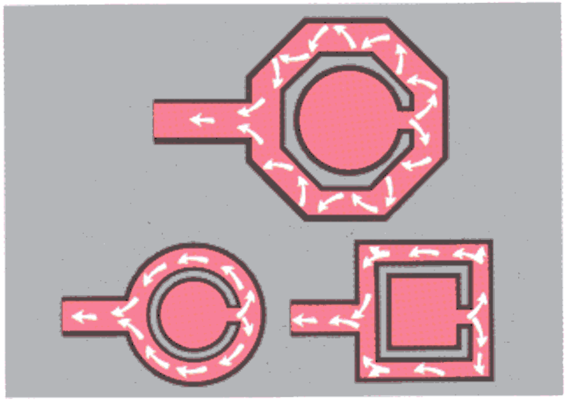


HEAT TRANSFERS TO THE INDOOR AIR AND FLUE GASES

Heat Exchanger



- Provides a barrier between the indoor air and the combustion gases.



- Designed for maximum contact time and efficiency.

FUEL OIL Combustion Manual, pg. 15

EXCESS AIR EFFECTS ON HEAT RANSFER

- Absorption of additional heat into the inert nitrogen and unused oxygen which passes to outdoors.
- Dilutes combustion gases, dropping their temperature and thereby decreasing their rate of heat transfer.
- Increases the volume of flue gas which causes a faster travel over the heat transfer surfaces. Thus less heat is transferred and exit flue gas temperature increases.

FUEL OIL Combustion Manual, pg. 16

Domestic Oil Burners

- Transport oil from remote storage as required.
- Supply the correct oil feed rate.
- Supply the correct air feed rate.
- Prepare oil and air for combustion by initiating mixing process.
- Provide ignition of the oil on initial start-up.

FUEL OIL Combustion Manual, pg. 17


NOTICE
Beckett
WARNING
R7184 B 1032
ThermoPride

FUEL OIL Combustion Manual, pg. 18

ELECTRONIC IGNITORS & TRANSFORMERS

IGNITORS:

- They are smaller (1/4 to 1/2 the size) and weigh less than a transformer (1 lb. compared to 8 lb.). Prolonged life of Electrodes that can last 50% longer without adjustment . Electronic ignitors offer improved performance with cold oil or delayed spark conditions and consume 75 percent less power than transformers.
- Have output currents and peak voltages that can be up to double that of iron core transformers.
- Produce a spark intensity that can be less sensitive to line voltage fluctuations; and
- Are epoxy sealed for moisture resistance and non-rusting plastic enclosures.


DANGER
HAZARDOUS VOLTAGE
WILL CAUSE SHOCK, BURN OR DEATH.
TURN OFF POWER BEFORE SERVICING.
ELECTRONIC IGNITER
PART NO. 7460
PRI. 120 VOLTS 60 Hz 35VA
SEC. 6kV RMS, 20kV PEAK 35mA
SECONDARY MID-POINT GROUNDED
CENTRE DE L'ENROULEMENT
HAUTE TENSION MIS A LA TERRE
0401
Beckett
ELYRIA, OH 44036
61389

FUEL OIL Combustion Manual, pg. 18

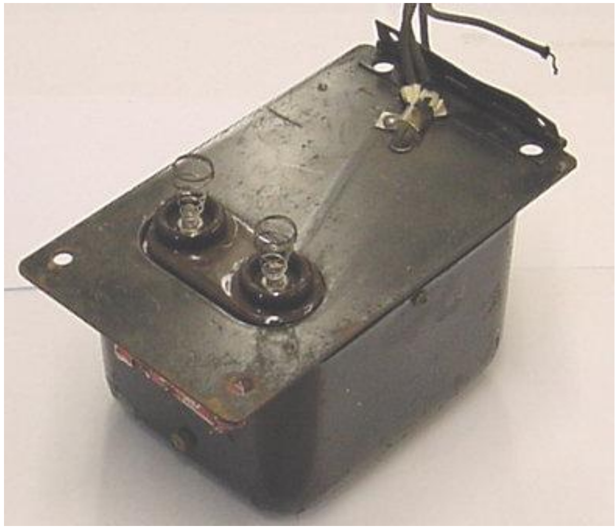
ELECTRONIC IGNITORS & TRANSFORMERS

TRANSFORMERS:

- **The ignition transformer takes 120 volts AC and transforms it into 10,000 volts AC to ignite the oil droplets.**
- **A wide electrode gap beyond the 1/8” – 5/32” could be a problem. As the gap is widened, the high voltage stress on the secondary coil increases and could shorten the life of the transformer.**
- **Excessive moisture can cause problems.**

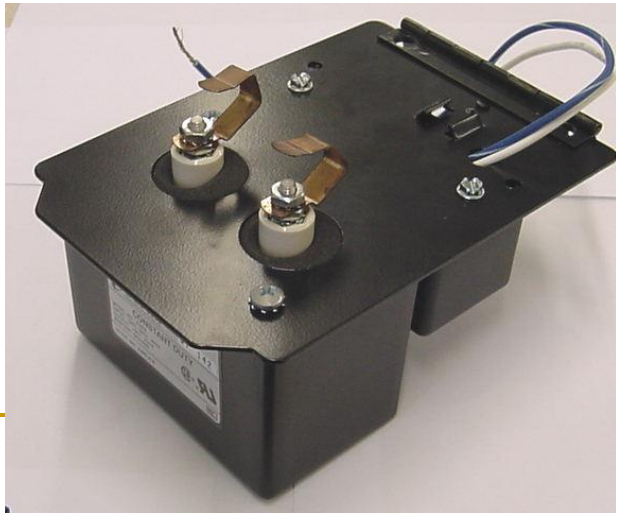
FUEL OIL Combustion Manual

Ignitor / Transformer Testing



CHECK IGNITION TRANSFORMERS
WITH HIGH VOLTAGE PROBE
OR ARC TEST

CHECK NEW ELECTRONIC
IGNITORS BY OHMS
(2000 ohms) OR ARC TEST
(Do not use high voltage
probes or transformer testers!)



FUEL OIL Combustion Manual, pg. 19

PRE-PURGE & POST PURGE

- **PRE-PURGE**
- **The pre-purge controls currently offered by Burner Manufactures and others as a factory-installed option on most of its models. These burners turn the blower on several seconds before the flame is ignited. This establishes the level of airflow required for fast, smooth ignition. This airflow is already fully established when ignition occurs. The burner doesn't have to "struggle" to achieve ignition under inadequate draft conditions. Another significant factor is the stability and capacity of the ignition arc. The arc should be at full strength and well established when the oil is delivered from the nozzle. With pre-purge, the arc is allowed to reach its maximum potential, contributing to easier ignition of the oil droplets and producing a cleaner burning flame from the moment of ignition. In addition, the oil pressure level in the pump is stabilized well before the oil solenoid valve opens.**

FUEL OIL Combustion Manual, pg. 19

PRE-PURGE & POST PURGE

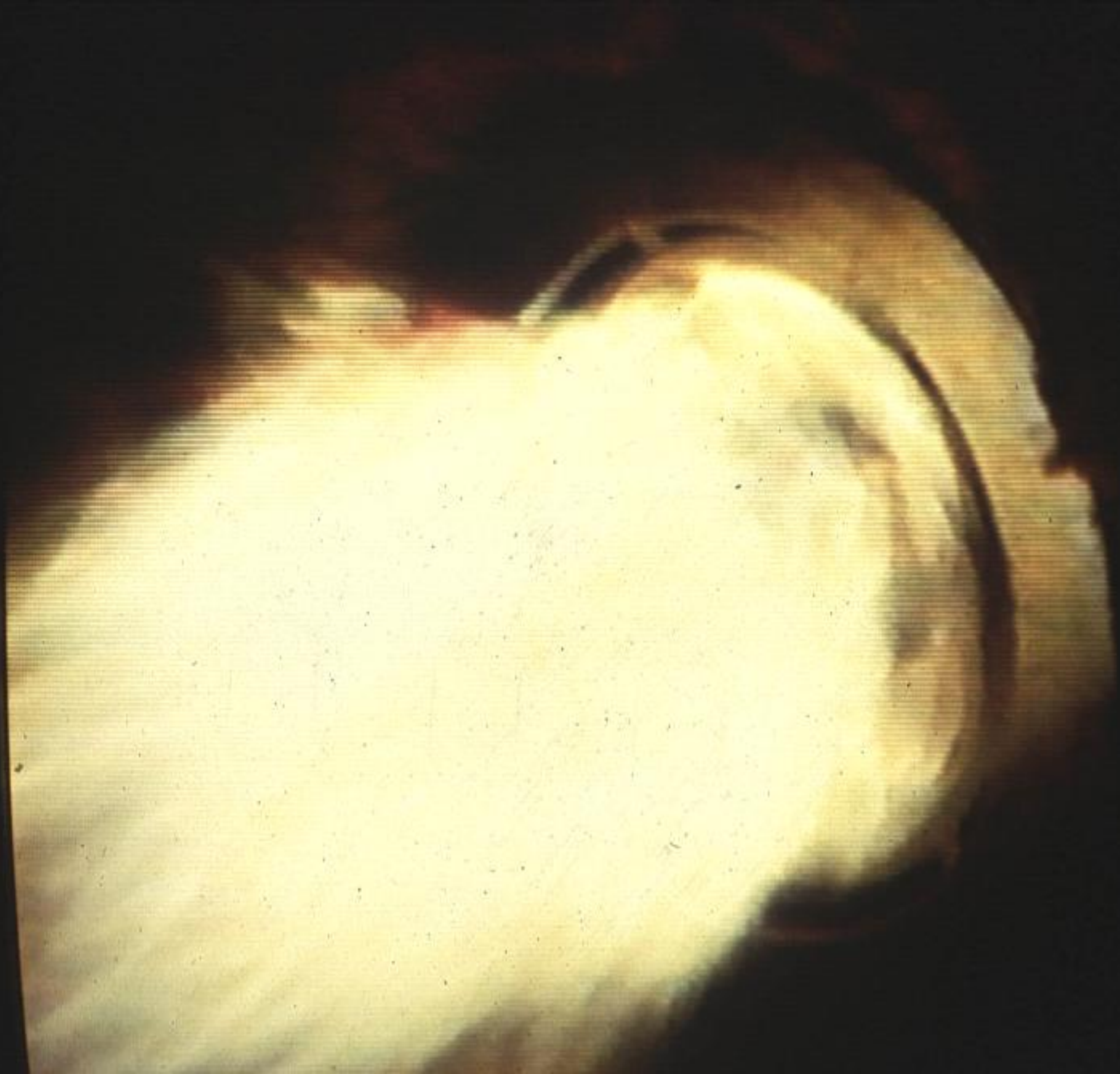
- **POST-PURGE**
- **Post-purge is involved with the other end of the burner Cycle. When the desired heat level in the home or building has been achieved, the thermostat calls for burner shut-off, which occurs immediately without post-purge. As a result, combustion gases may still be present in the flue without sufficient airflow to evacuate them. Draft reversals may also occur, forcing flue gases back into the flue pipe and the combustion chamber. This can cause odor problems and/or leaking combustion gases into the home. The heat from the gases can also affect nozzles and other system components. Post-purge keeps the blower operating for a selected period after burner shut-off. Flue gases are evacuated, draft-reversal is eliminated, and nozzles are protected from overheating.**

FUEL OIL Combustion Manual, pg 20

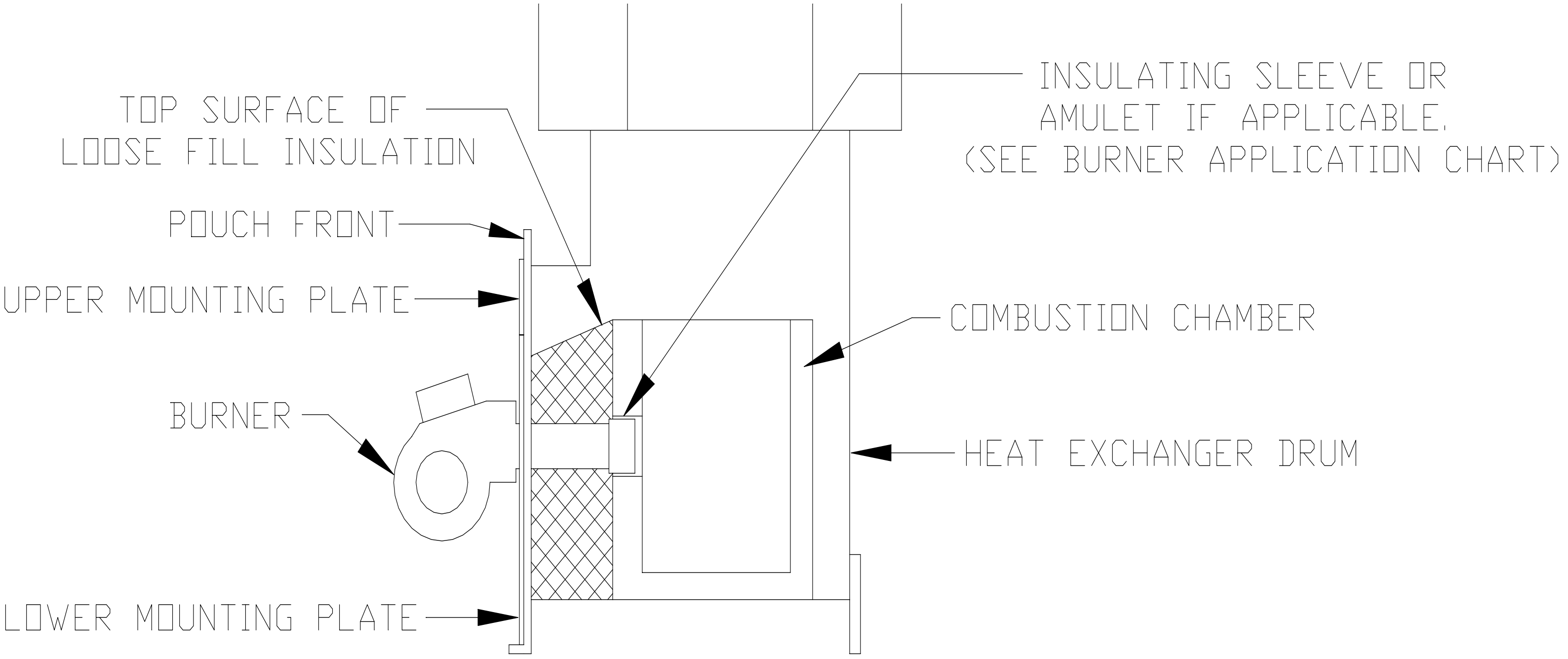
FLAME RETENTION OIL BURNERS

FUEL OIL Combustion Manual, pg 20

FUEL OIL Combustion Manual, pg 20

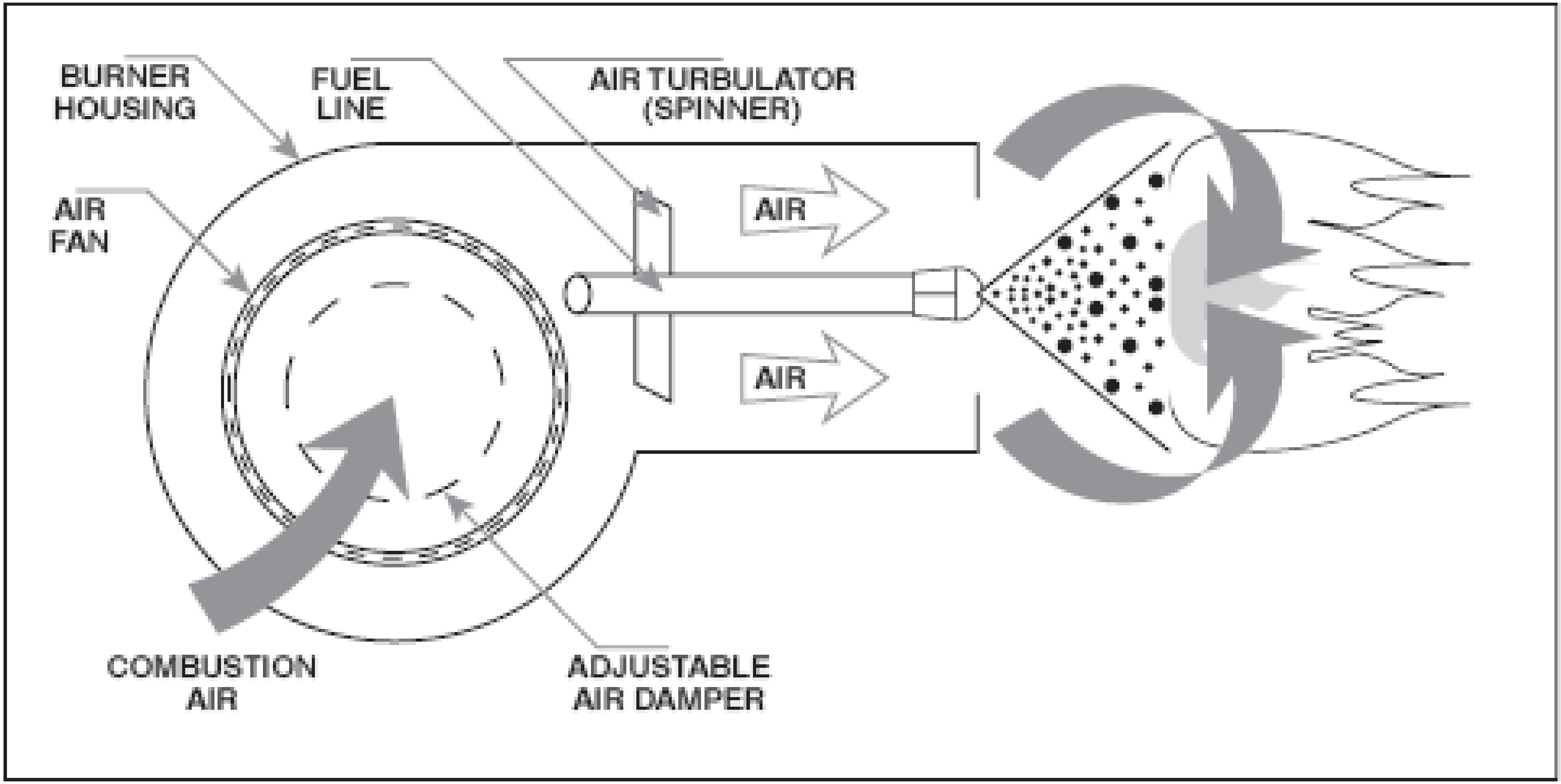


Burner Installation

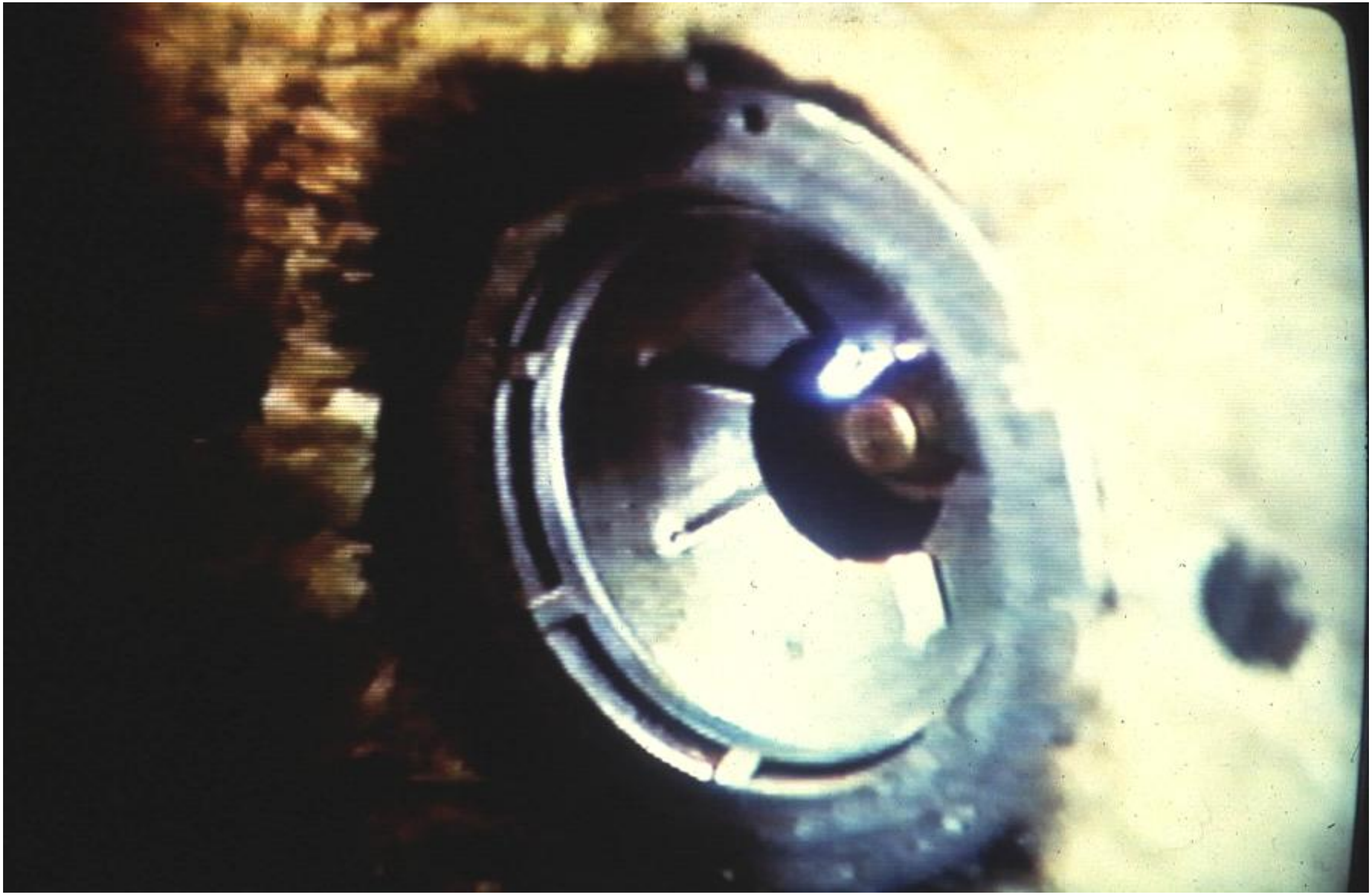


Oil Burners

DRAWING OF OIL BURNER OPERATION



Ignition Spark 10,000 to 14,000 volts



FUEL OIL Combustion Manual, pg. 22

OIL NOZZLES

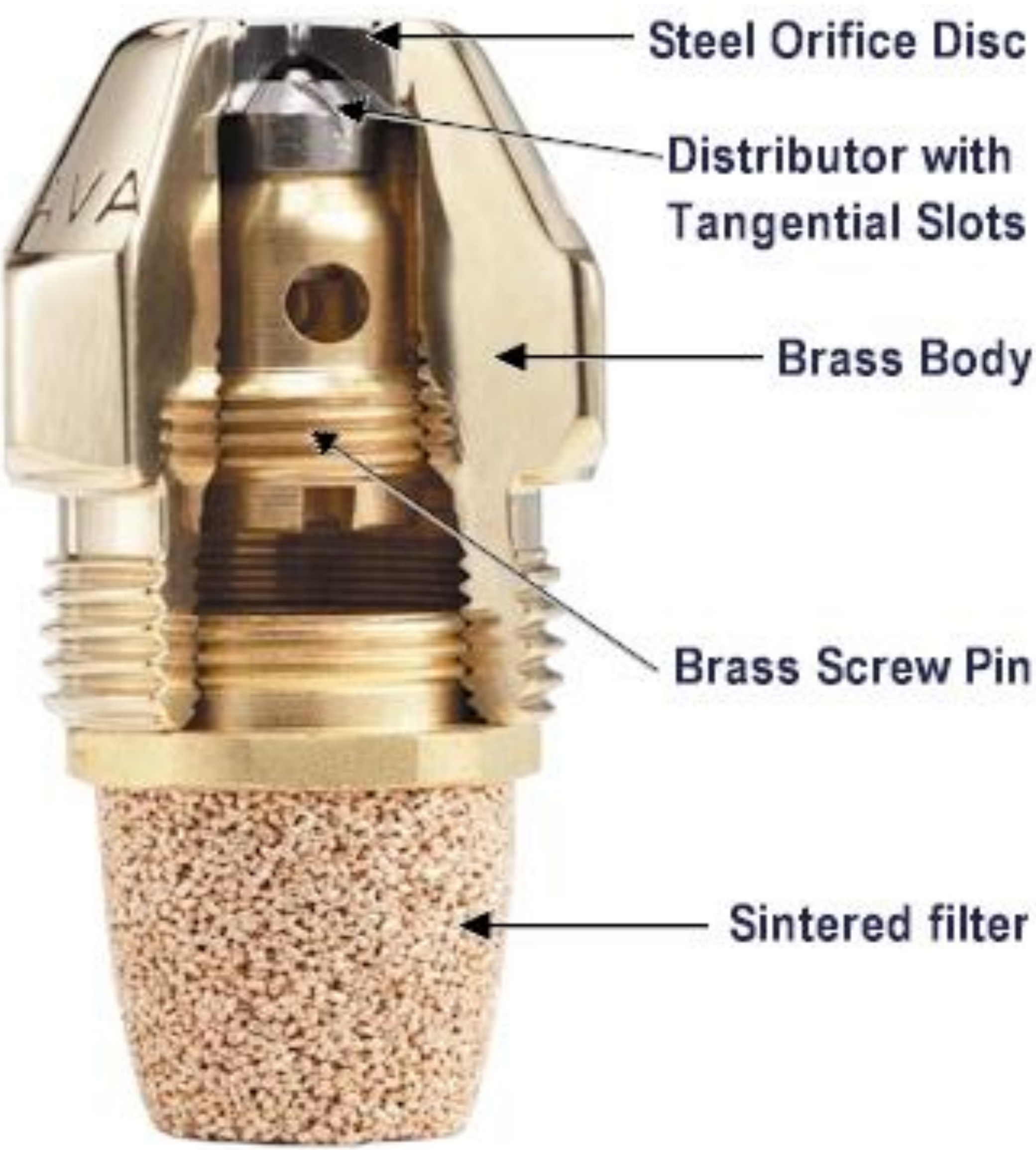
- In the perfect oil flame, each droplet of oil from the nozzle is completely surrounded by air supplied by the burner fan.
- The mechanic who adjusts an oil flame works with four factors: **oil pressure, air volume, burner air pattern, and oil nozzle spray pattern.**
- Two instruments tell him how well he is doing; the **smoke tester** indicates whether all oil is being burned and the **C02-O2 tester** indicates how much excess air over the theoretical requirement is being supplied.

FUEL OIL Combustion Manual, pg. 22

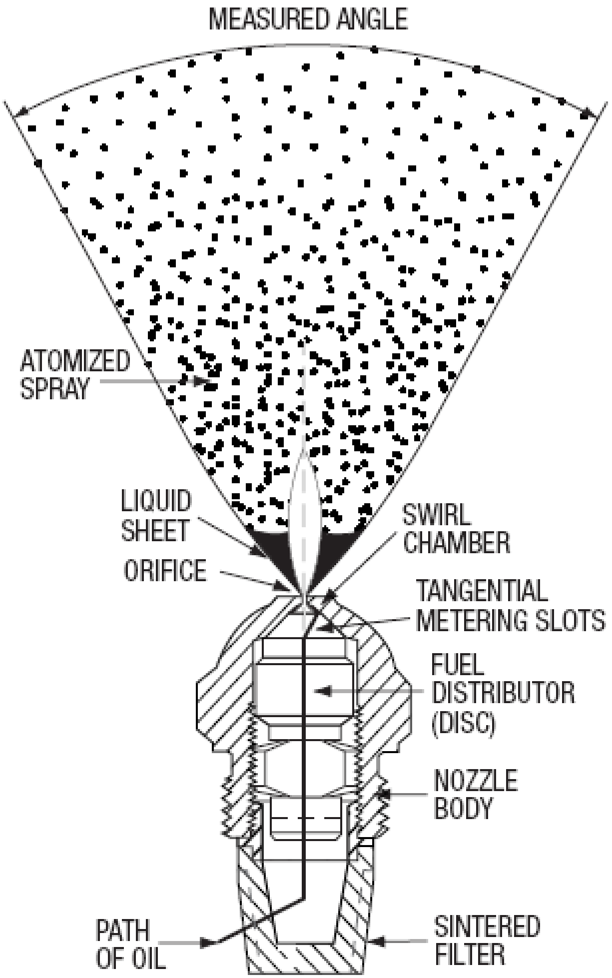
OIL NOZZLES

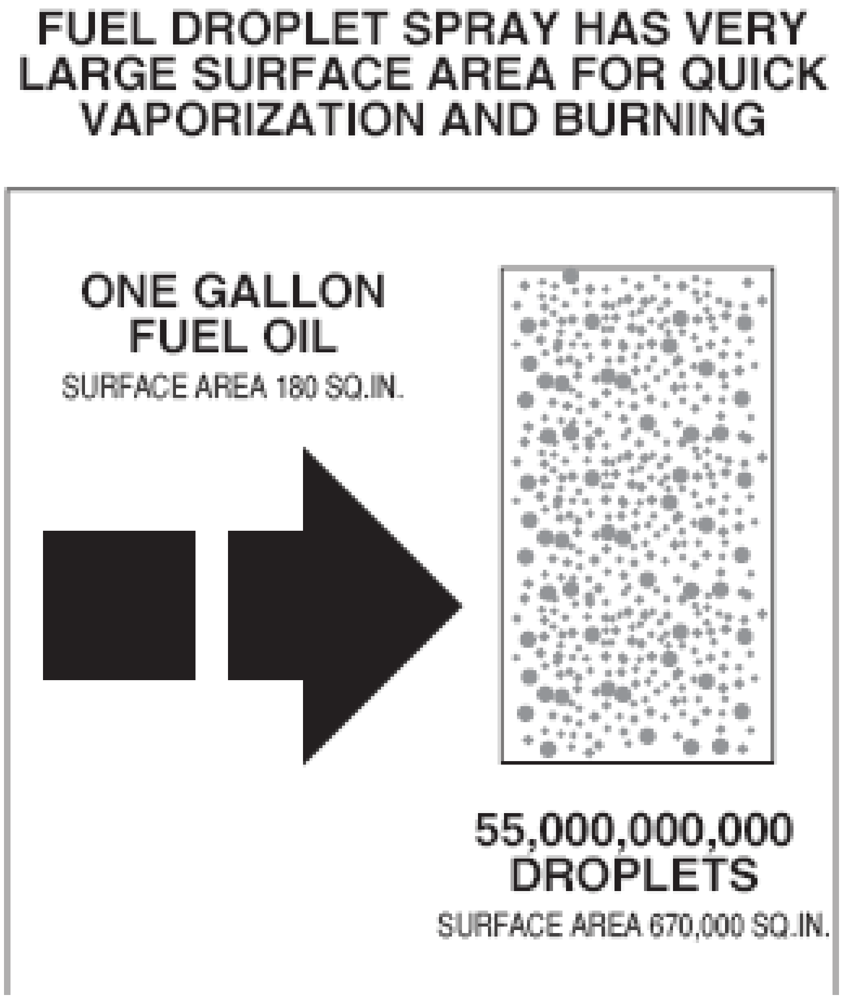
- The nozzle requirements for spray angle and type should be specified by the oil burner manufacturer as a result of laboratory tests.
- Normally, 100 psi is considered satisfactory for the fixed pressure supplied to the nozzle, and all manufactures calibrate their nozzles at that pressure. **Most burner manufactures now recommend that nozzle pressures be set at 140 psi.** As pressure is increased, the spray angle becomes better defined and oil droplets become smaller. **Smaller oil droplets allow for a cleaner flame with colder than normal oil.** An increase in pressure causes a corresponding increase in nozzles flow rate. **Any increase in nozzle pressure must be compensated by the use of a smaller nozzle with the same spray angle.**

FUEL OIL Combustion Manual, pg. 22



FUEL OIL Combustion Manual, pg. 22




FUEL DROPLET SPRAY HAS VERY LARGE SURFACE AREA FOR QUICK VAPORIZATION AND BURNING

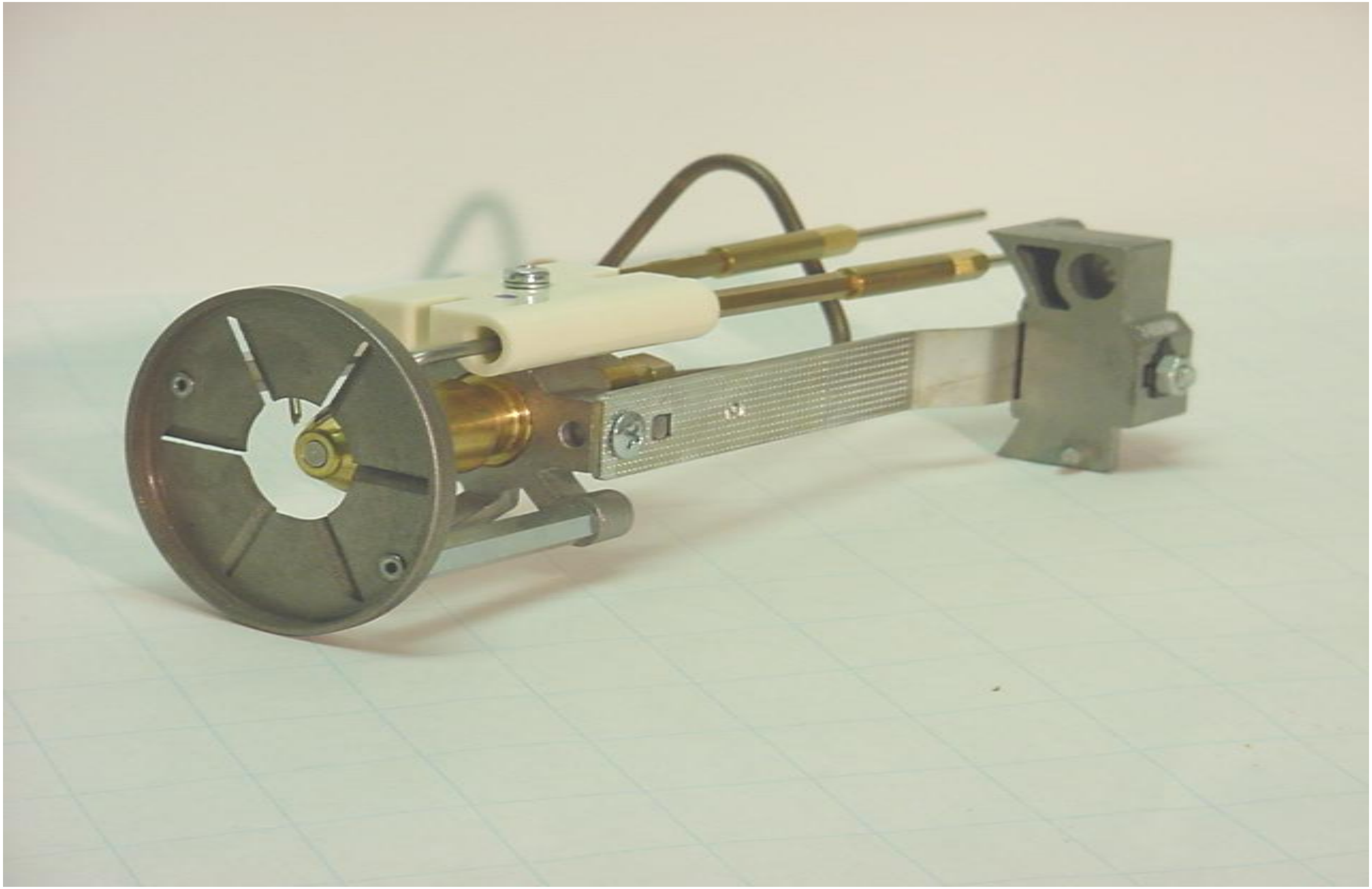
ONE GALLON FUEL OIL

SURFACE AREA 180 SQ.IN.

55,000,000,000 DROPLETS

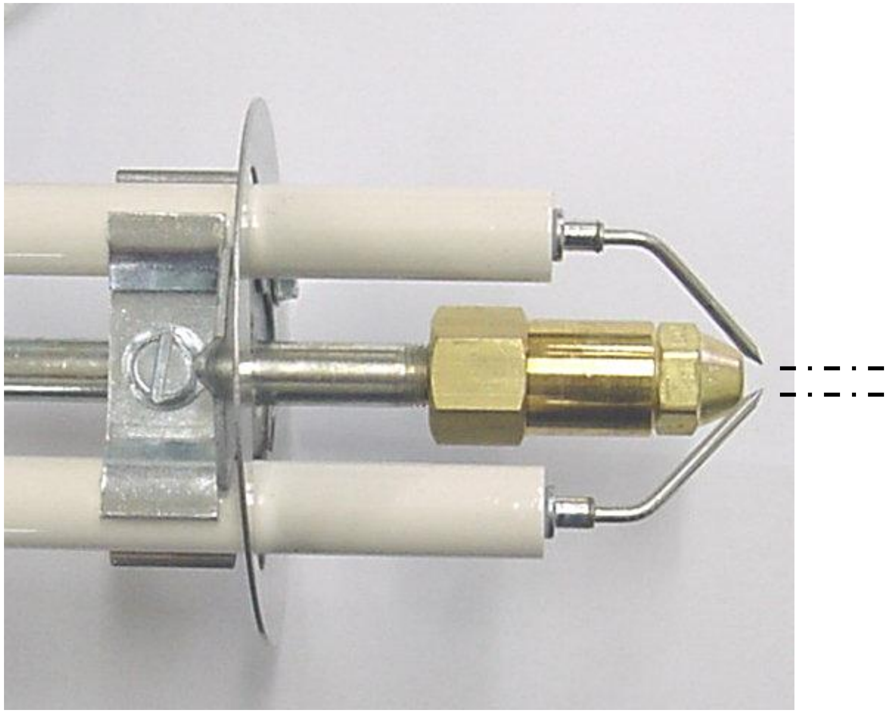
SURFACE AREA 670,000 SQ.IN.

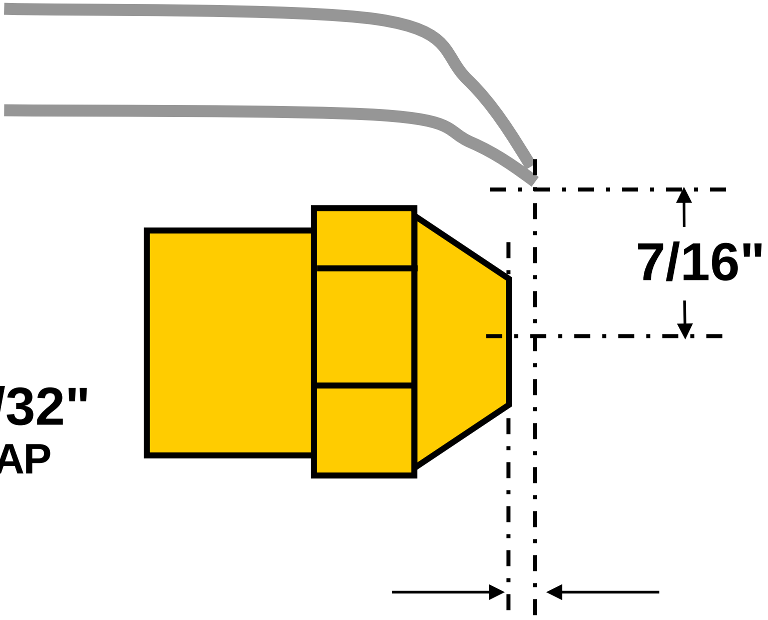
Nozzle Assembly



FUEL OIL Combustion Manual, pg. 23

Electrode Settings BECKETT (F-HEADS)





- 1/16" on F0 - F31
- 1/8" to 5/32" on F30 - F300

FO

FUEL OIL Combustion Manual, pg. 23

Nozzle Pressure vs. G.P.H.

NOZZLE RATING AT 100 PSI	NOZZLE FLOW RATES IN GALLONS PER HOUR (Approx.)		
	120 PSI	80 PSI	140 PSI
.50	0.45	0.55	0.59
.65	0.58	0.71	0.77
.75	0.67	0.82	0.89
.85	0.76	0.93	1.00
.90	0.81	0.99	1.07
1.00	0.89	1.10	1.18
1.10	0.99	1.21	1.30
1.20	1.07	1.31	1.41
1.25	1.12	1.37	1.48

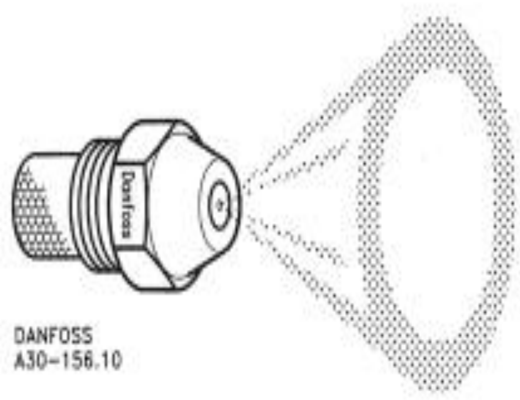
NOZZLE RATING AT 100 PSI	NOZZLE FLOW RATES PER HOUR (A		
	120 PSI		
1.35	1.21	1.48	1.60
1.50	1.34	1.64	1.78
1.65	1.48	1.81	1.95
1.75	1.57	1.92	2.07
2.00	1.79	2.19	2.37
2.25	2.01	2.47	2.66
2.50	2.21	2.74	2.96
2.75	2.46	3.00	3.24
3.00	2.69	3.29	3.55

FUEL OIL Combustion Manual, pg. 24

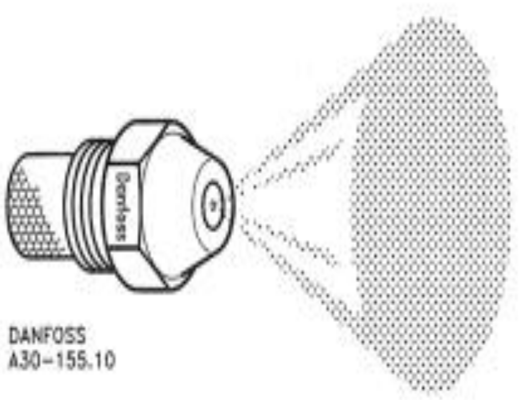
OIL NOZZLES

Type B Solid Cone: for larger burners & where air pattern is heavy in the Center or for long fires

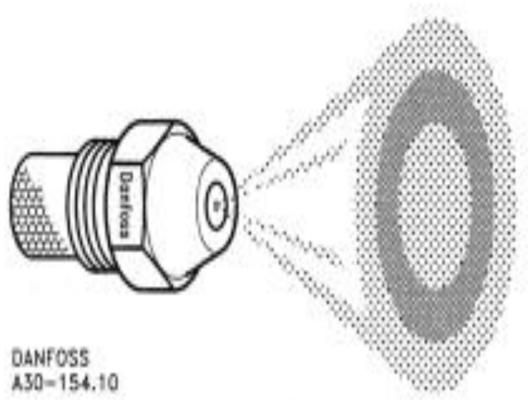
Type A Hollow Cone: Creates Stable flame at low flows



Hollow



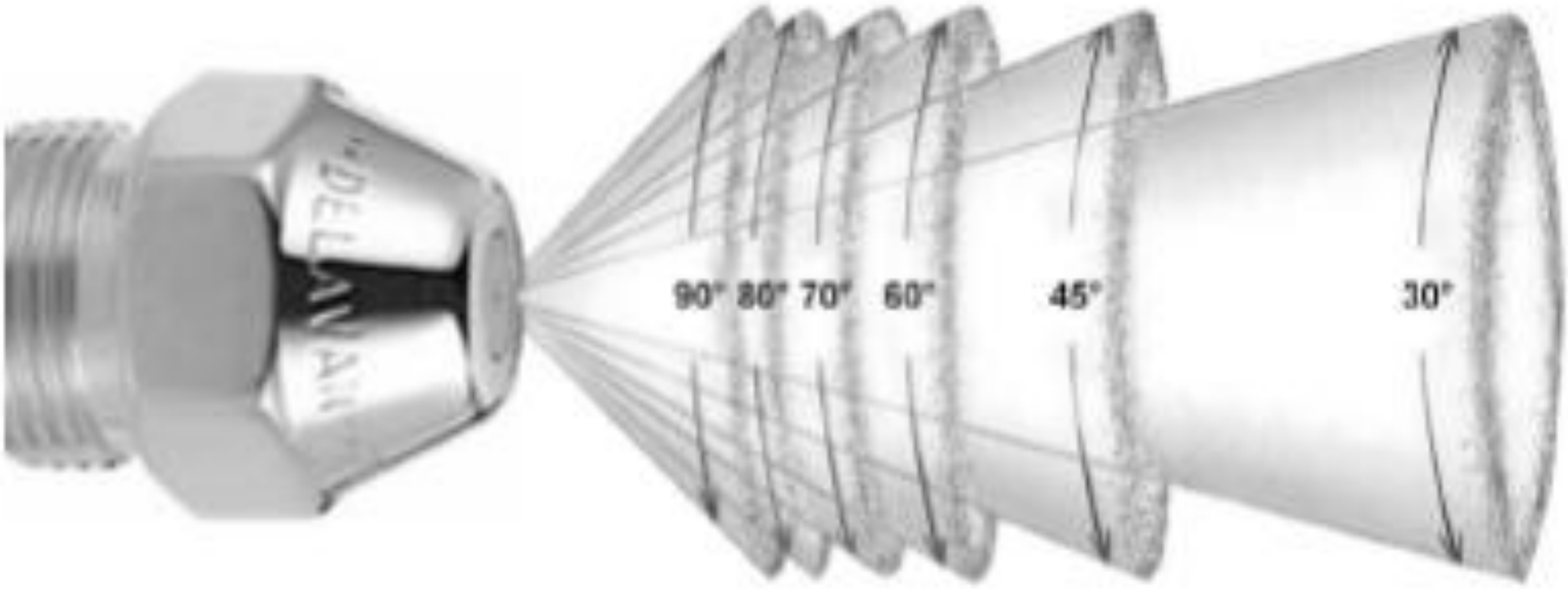
Solid

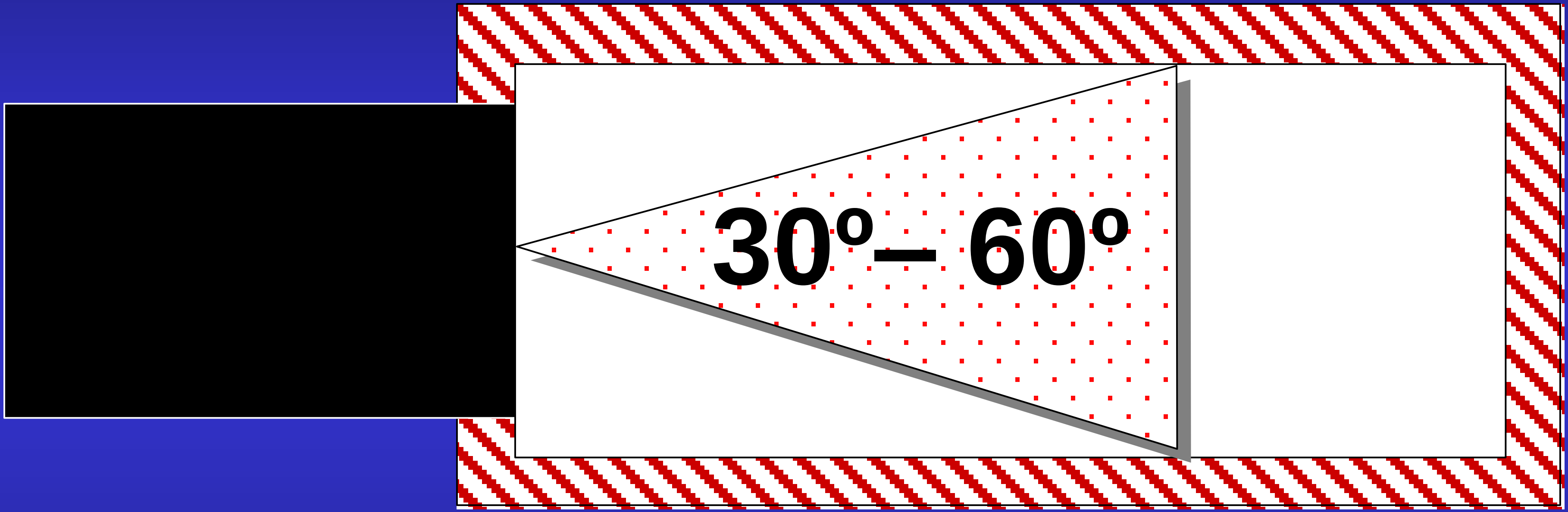


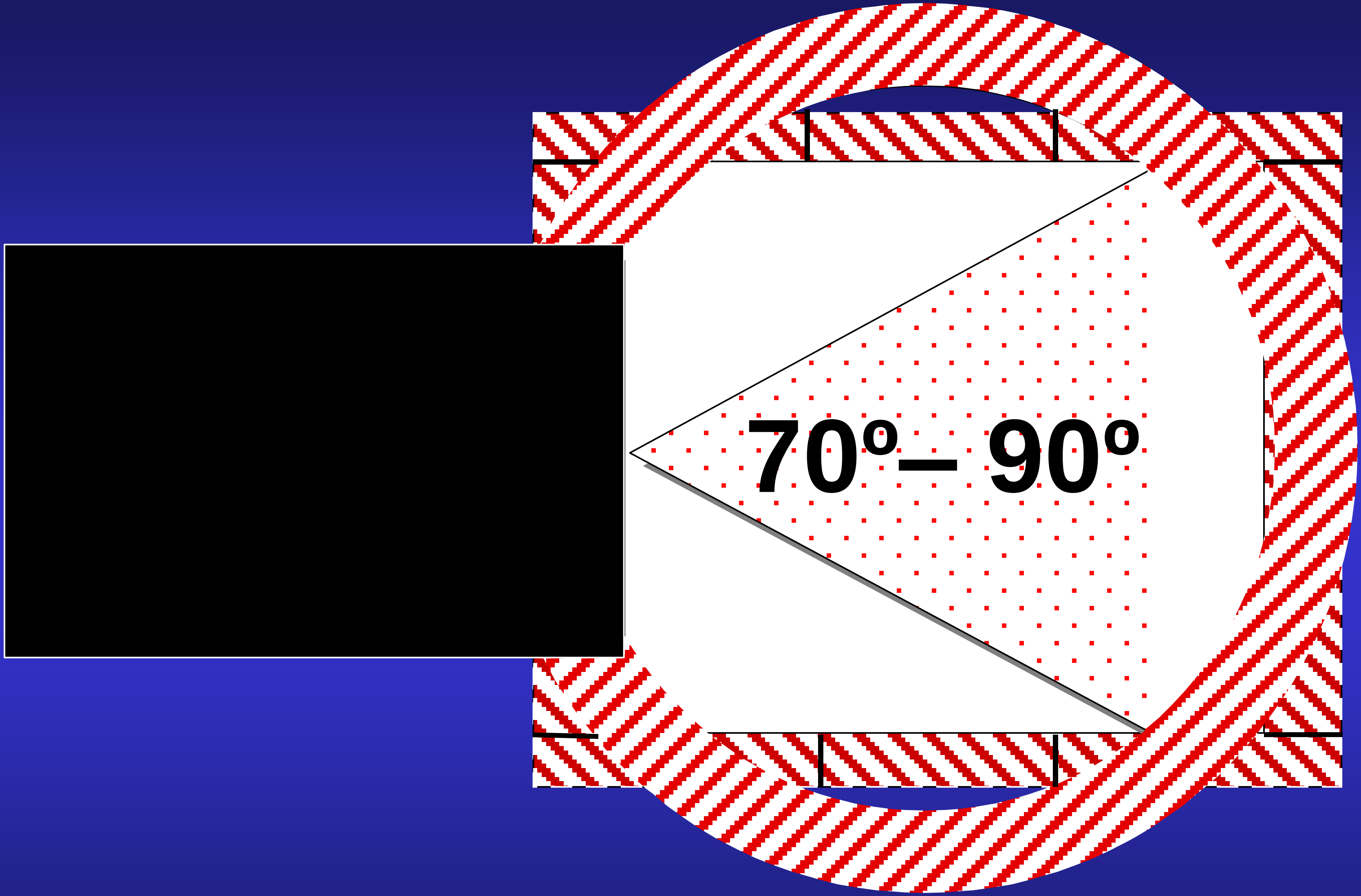
Semi-solid

FUEL OIL Combustion Manual, pg. 24

OIL NOZZLES: **70º to 90º spray angles for round or square Chambers. 30º to 60º spray angles for long, narrow chambers**

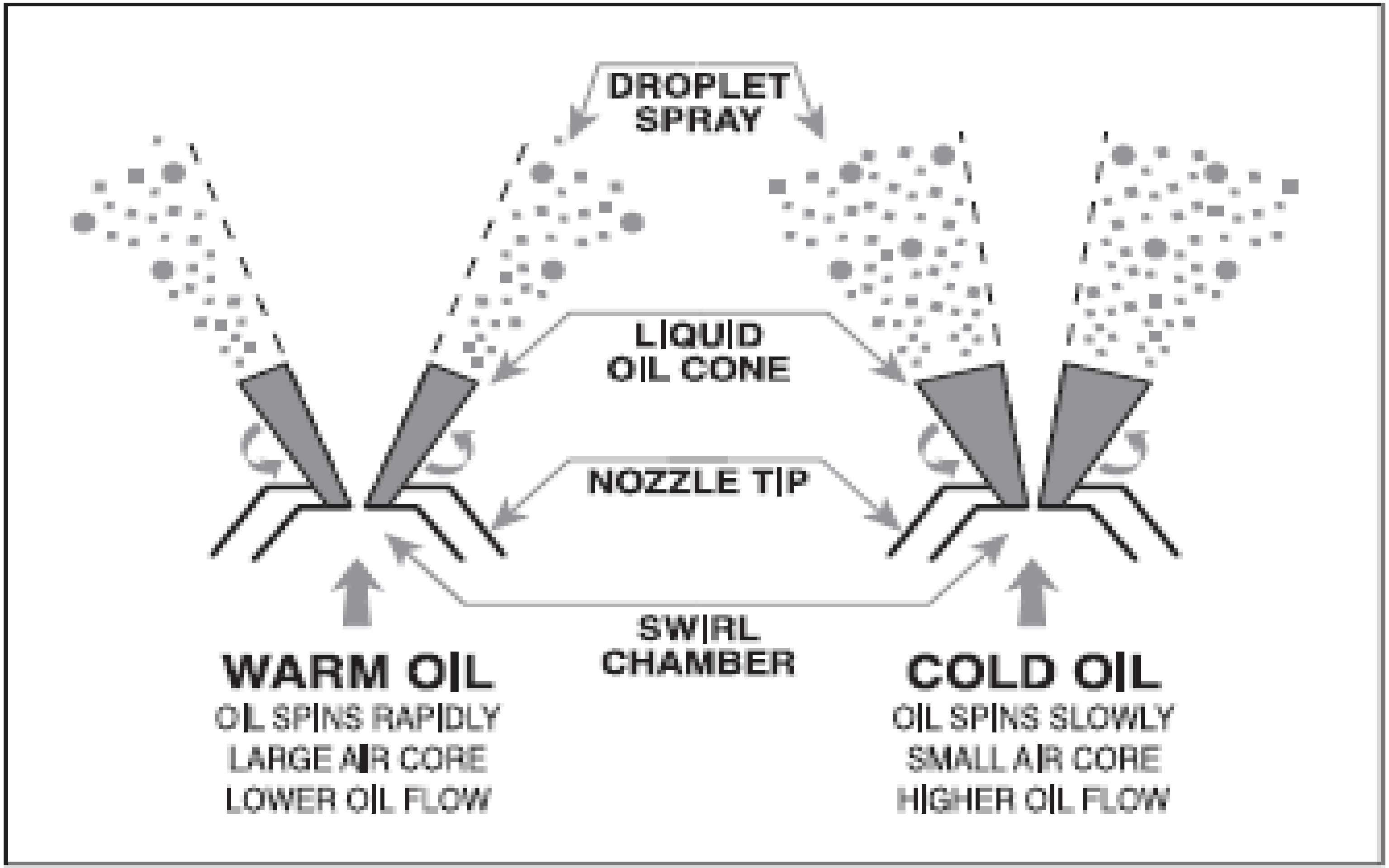



30º– 60º


70º– 90º

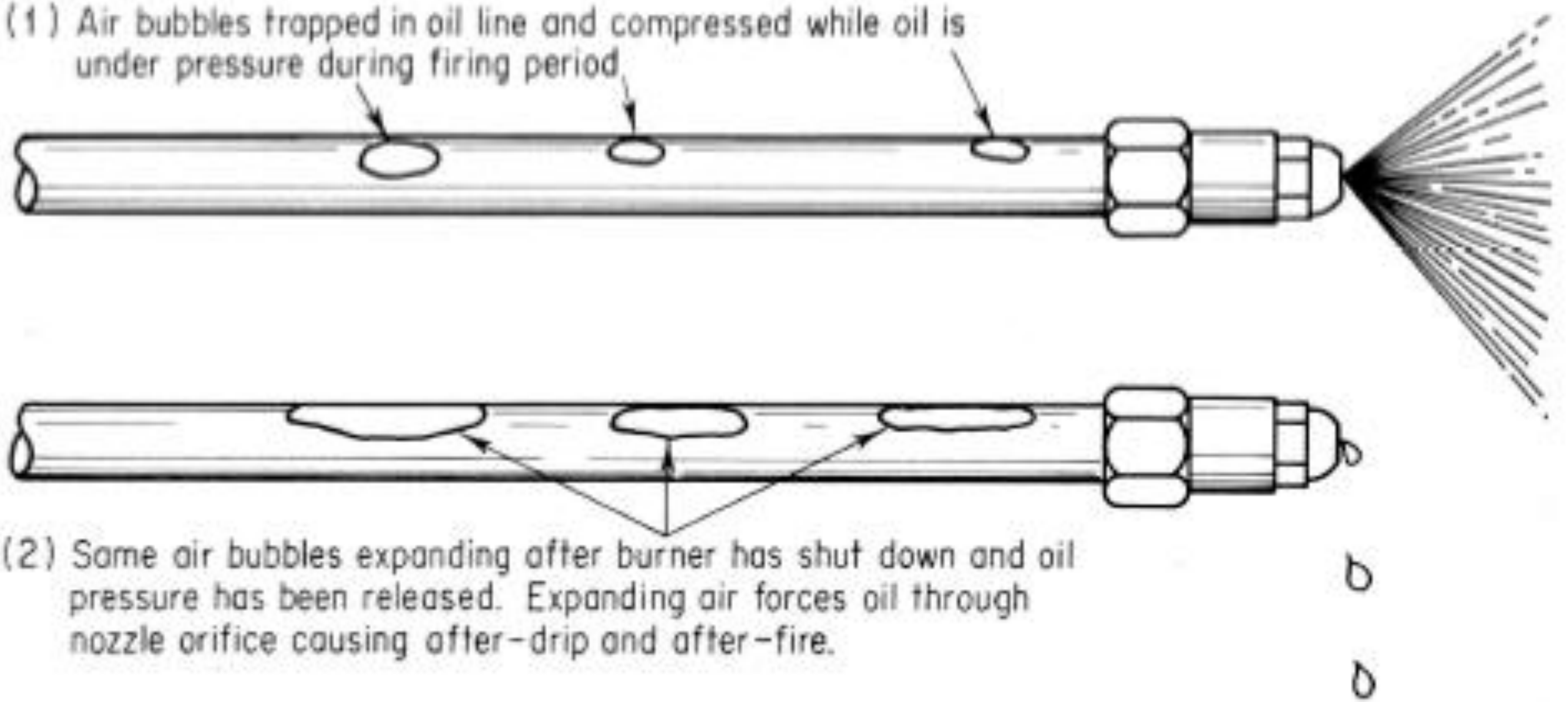
Warm Oil vs. Cold Oil

COLDER OIL CAUSES MORE OIL TO FLOW FROM THE TIP OF THE NOZZLE




DELAVAN OIL BURNER NOZZLES

NOZZLES



(1) Air bubbles trapped in oil line and compressed while oil is under pressure during firing period

(2) Same air bubbles expanding after burner has shut down and oil pressure has been released. Expanding air forces oil through nozzle orifice causing after-drip and after-fire.

Figure 4-21 Air trapped in nozzle line

FUEL OIL Combustion Manual, pg. 25

OIL INPUT FIRING RATE

- **Oil Heat Content X Steady-State Efficiency = Net Output BTU/Hour**

  Equipment Oil Input Rate = <u>Gross Output BTU/Hour</u>

  #2 oil: 140,000 BTUs/gal.; typical AFUE efficiency: 82%
- **By lengthening burner "on periods," the average steady-state efficiency is increased.**
- **Capacity need of the house, and the burner should operate almost continuously on the coldest days of the year.**

FUEL OIL Combustion Manual, pg. 26

STANDARD OIL NOZZLES AND BTU GROSS OUTPUTS at VARIOUS COMBUSTION EFFICIENCIES

GPH @ 100 psi	75%	78%	80%	82.5%	85%
.50	52,000	54,600	60,000	61,875	63,750
.60	63,000	65,520	67,200	69,300	71,400
.65	68,250	70,980	72,800	75,100	77,350
.70	73,500	76,440	78,400	80,850	83,300
.75	78,750	81,900	84,000	86,600	89,250
1.00	105,000	109,200	112,000	115,500	119,000

FUEL OIL Combustion Manual, pg. 28

Heating Degree Day Normal's (Base 65ºF)

Raleigh	**3397**
Banner Elk	**5827**
N. Wilksboro	**4422**
Asheville	**4308**
Wilmington	**2470**
Charlotte	**3341**
Greensboro	**3865**
Edenton	**2918**

FUEL OIL Combustion Manual, pg. 29

Heading Degree Days

<u>Degree Days</u> for a 24-hour time period is the difference between 65 F and the average 24-hour temperature.

Formula: $$DD = 65 - \frac{(TH + TL)}{2}$$

Example: High reading 50 F, Low reading 20 F

Degree days $= 65 - \frac{(50 + 20)}{2} = 65 - 35$

Degree days equal 30

FUEL OIL Combustion Manual, pg. 30

Combustion Chambers:

- **The purposes of a combustion chamber are to:**

(a) “Insulate” the fire, thereby reducing its radiation losses and keeping its temperature high.

(b) Contain the flame, produce recirculation, and assist in the air-oil mixing process.

(c) Protect certain surfaces that do not transfer heat from heat damage.

FUEL OIL Combustion Manual, pg. 30

Combustion Chambers

Correct chamber size will approximately follow these specifications:

- **Inside Floor Area of:**
- **80 Square Inches per GPH up to 3.00 GPH**
- **90 Square Inches per GPH for 3.00 to 5.00 GPH**
- **100 square Inches per GPH over 5.00 GPH**

A chamber too small will cause flame impingement.

Combustion Chambers

- May be made of soft (fiber) or hard (brick) refractory materials.
- Reflects heat back into flame aiding complete combustion, without flame impingement.

FUEL OIL Combustion Manual, pg. 31

Various size Combustion Chambers charts and recommended Combustion Chamber dimensions

FUEL OIL Combustion Manual, pg. 32

Drafts, Flues & Combustion Air

- **To overcome the friction pressure loss offered by flue passages and venting systems, sufficient pressure difference, commonly called “draft”, must exist.**
- **STANDARD OVERFIRE DRAFT = (NEGATIVE) -0.01" to - 0.02" WATER COLUMN (w.c.).**

FUEL OIL Combustion Manual, pg. 32

- **Excessive over-fire draft** causing too rapid removal of flue gases; high stack temperature, and, fuel waste.
- **Insufficient over fire draft** causing combustion troubles—mostly pulsation and smoke generation.
- **Variation in draft from cold start to hot operating conditions.** The input of primary air from the oil burner blower varies somewhat with the pressure in the firebox. Lower pressure (greater draft) permits more primary air feed by the oil burner blower.
- Normal draft for #2 oil units will vary from negative -.03" w.c. to -.06" w.c. in the flue outlet, this draft is to produce over-fire draft (-.0l" w.c. to -.02" w.c.).

FUEL OIL Combustion Manual, pg. 32

Drafts, Flues & Combustion Air

Natural draft will vary greatly depending upon:

- **-temperature of gases and flue components.**
- **-temperature of outdoor air, (the colder the air, the greater the available draft).**

The required draft at the gas exit of the equipment must be constant. Therefore, as the available draft increases, a DRAFT REGULATOR by-pass will begin to open when the draft exceeds its adjusted setting, which is the draft required at the exit. When air enters the regulator and mixes with the hot flue gases, they are cooled and less draft will be produced. Failure to curtail the rising available draft will result in faster moving flue gases, higher exit temperatures, and waste.

FUEL OIL Combustion Manual, pg. 32

Draft Regulator

- Locate the control as close as possible to the furnace (ideally 3 flue pipe diameters).
  - Follow OEM guidelines.

FUEL OIL Combustion Manual, pg. 33

Drafts, Flues & Combustion Air

- **Draft can be measured by using a draft gauge. The draft should be checked at two different locations in the heating plant: 1) over the fire, which indicates firebox draft condition, and 2) draft in the breech connection**

FUEL OIL Combustion Manual, pg. 33

Drafts, Flues & Combustion Air

- **If the over-fire draft is higher than -.02 inch, the draft regulator weight should be adjusted to allow the regulator door to open more.** ***Open to Decrease***
- **If the draft is below -.01 inch, the draft regulator weight should be adjusted to just close the regulator door.**

  Close to Increase

FUEL OIL Combustion Manual, pg. 33

Drafts, Flues & Combustion Air

- The over fire draft is also affected by soot buildup on heat exchange surfaces. As the soot builds up, the heat exchange passages are reduced and a greater resistance to the flow of gases is created. This causes the over fire draft to drop. As over fire draft drops, the burner air delivery is reduced and the flame becomes even more smoky.

FUEL OIL Combustion Manual, pg. 34

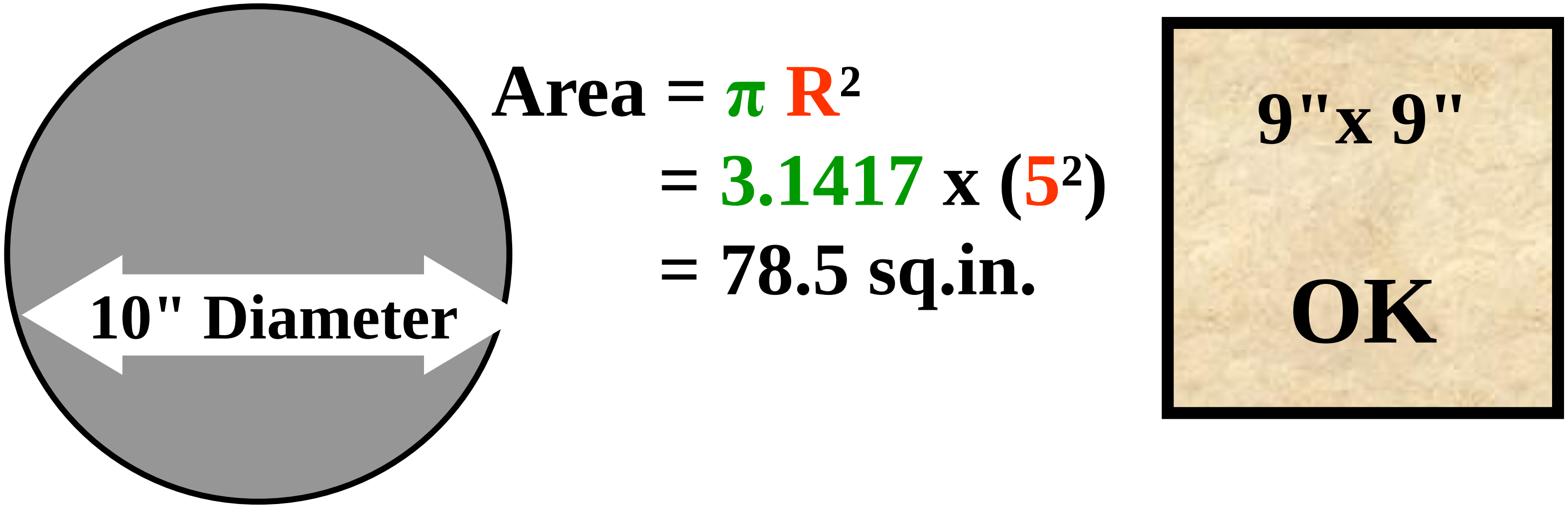
Chimneys & Flue Sizing

Chimneys should extend 3 feet above the highest point of the roof or otherwise capped for protection against down-drafts. Chimneys should always have a tiled vitrified or stainless steel liner. The State Building Code is specific for these requirements.

FUEL OIL Combustion Manual, pg. 34

Chimney Size

- The minimum inside area of the chimney MUST equal the area of the vent pipe exiting the furnace:



$$\text{Area} = \pi R^2$$
$$= 3.1417 \times (5^2)$$
$$= 78.5 \text{ sq.in.}$$

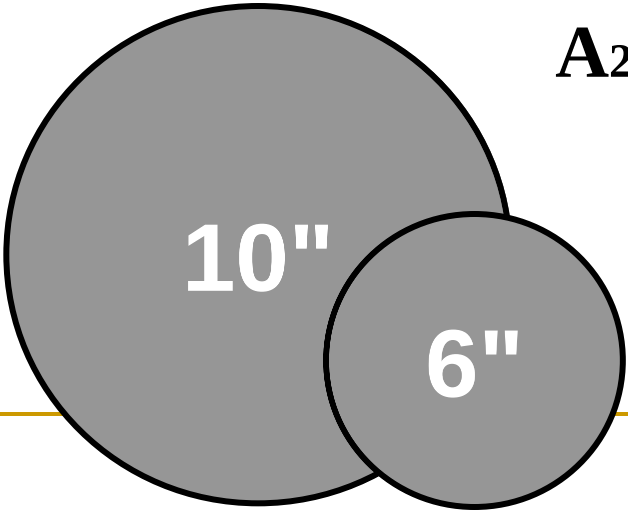
FUEL OIL Combustion Manual, pg. 34

Chimney Size (MULTIPLE APPLIANCES)

- The minimum inside area of the chimney MUST equal the area of the largest vent pipe PLUS one-half the area of additional pipe(s).

A_1 = 78.5 sq.in.

A_2 = 28.3 sq.in.



78.5 + (28.3 / 2)
= 92.7 sq.in.

10 x 10 OK

FUEL OIL Combustion Manual, pg. 34

Multiple Appliance Venting

- Separate vent connectors preferable.
  - Largest BTUHIN enters chimney at lowest point.
- Tapered manifold better than single size.
  - Each section must equal the total combined area of flue pipes connected to it.
- Minimize length of common manifolds.
- Avoid 90 degrees turns, maintain upward rise.
- One draft regulator per appliance preferable.
  - Installed in flue pipe directly above appliance.

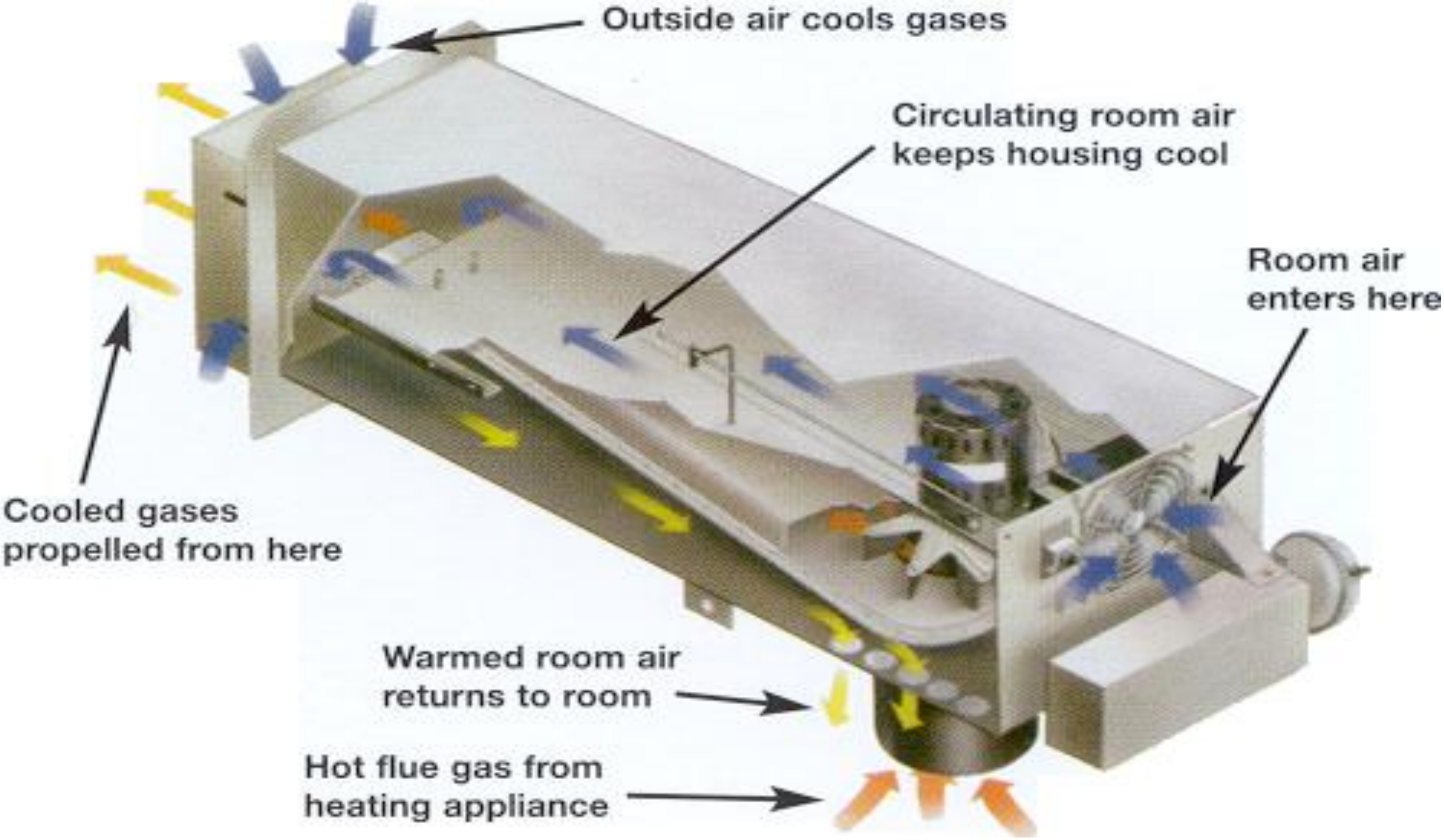
FUEL OIL Combustion Manual, pg. 34

Mechanical Draft

- **Forced draft** for small equipment usually is a function of the oil burner’s primary air combustion air blower.
- **Induced draft** requires the installation of a centrifugal blower at the chimney connection
- Combustion air must be supply in accordance with state building codes.

FUEL OIL Combustion Manual, pg. 35

Power Sidewall Venting



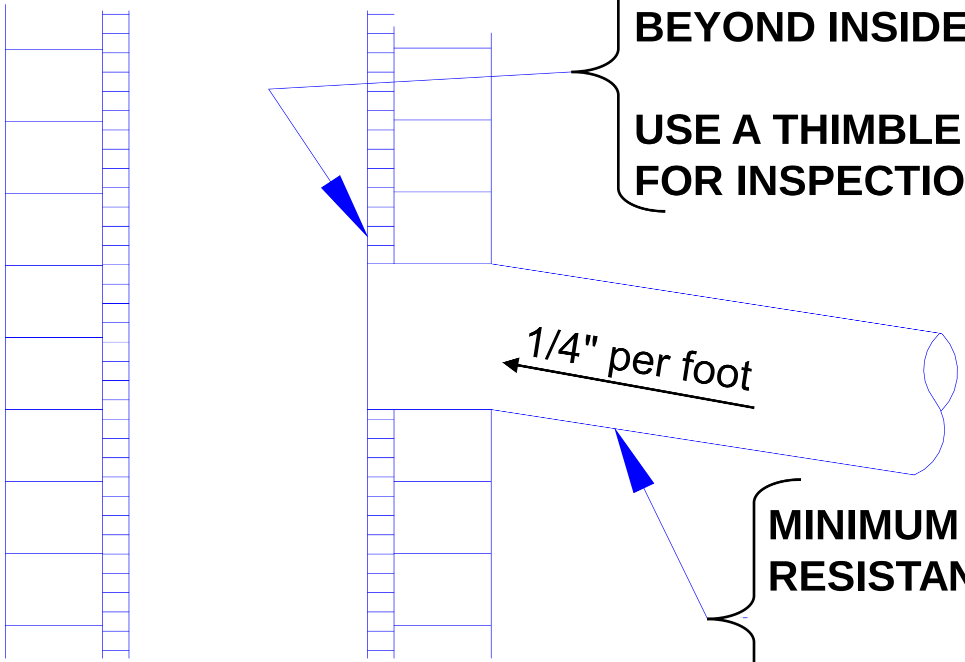
FUEL OIL Combustion Manual, pg. 35

Condensation of Flue Gases

- Combustion byproducts can condense in the chimney if cooled below dew point:
  - Condensation of Acids at flue gas temperatures at approximately 200ºF and below.
  - Condensation of water vapor at approximately 120ºF to 200ºF.
- This situation may be caused by:
  - Oversized Chimney or Vent Connector
  - Under-fired Appliances
  - Ambient Conditions and Vent Location

FUEL OIL Combustion Manual, pg. 36

Vent Connectors-Troubles



DO NOT EXTEND VENT CONNECTOR BEYOND INSIDE WALL OF CHIMNEY

USE A THIMBLE TO FACILITATE REMOVAL FOR INSPECTION AND CLEANING

MINIMUM 24 GA. CORROSION-RESISTANT STEEL

THE CONNECTOR LENGTH SHOULD NEVER EXCEED 75% OF THE VENT HEIGHT

FUEL OIL Combustion Manual, pg. 37

Oil Pumps & Piping

The two main types are the single-stage and two-stage fuel units. The difference is that the two-stage fuel unit has two sets of pump gears. The first stage is used to purge the pump of air and supply an uninterrupted flow of oil to the second stage. The second stage of gears provides the pressure for the oil taken from the strainer chamber, with the surplus oil being bypassed back to the strainer chamber.

FUEL OIL Combustion Manual, pg. 37

Oil Pumps & Piping

Two-stage fuel units have two primary advantages:

- **Higher intake vacuums are permissible with this unit. (Longer Pipe Runs)**
- **Permits any air (leaks) to be delivered back to the tank without effecting pump operation. Pump will not have to be bled during start-up (two pipe only).**

FUEL OIL Combustion Manual, pg. 37

Oil Pumps & Piping

Although some technicians will not use two pipe systems with aboveground tanks because of the input of cold oil, single-stage one pipe fuel units pump five to ten times the oil needed by the nozzle and bypass this excess oil back to the strainer chamber, thus warmer fuel oil. It is important to remember that both types of pumps might be found in a one pipe or two-pipe system.

FUEL OIL Combustion Manual, pg. 37

Fuel Piping Guidelines

- Minimum 3/8" Steel or Type L Copper
- Flare Fittings or Pipe Thread Connections
- Oil Resistant Thread Seal
- Shut-off Valves
- Fuel Filter
- 3 PSI Maximum Code Inlet
  - 8' Head on Gravity Feed Systems (NFPA)

FUEL OIL Combustion Manual, pg. 37

One-Pipe Systems

- Most fuel units come set up for one-pipe installations (**Bypass plug removed**).
- All gravity-feed installations may use a single-pipe system with a single-stage fuel unit.
- Sloping the line approx. 1/2" per foot toward the burner will avoid formation of air pockets.
- See OEM data on lift capabilities.

FUEL OIL Combustion Manual, pg. 37

Two-Pipe Systems

- Fuel units can be set up for two-pipe installations (**Bypass plug installed**).
- Recommended by manufactures for all installations where oil must be lifted to burner.
- Self-purging system.
- See OEM data on lift capabilities for single and two-stage fuel units.

FUEL OIL Combustion Manual, pg. 37

Fuel Storage Options

MAIN ISSUES TANK LOCATION	LOW UPFRONT COST	LOW AMBIENT EXPOSURE	LOW ENVIRONMENTAL CONCERNS	IMPROVED AESTHETICS & SPACE
ABOVE GROUND	✓		✓	
BELOW GROUND		✓		✓
SHED BASEMENT CRL.SPACE	✓	✓	✓	✓

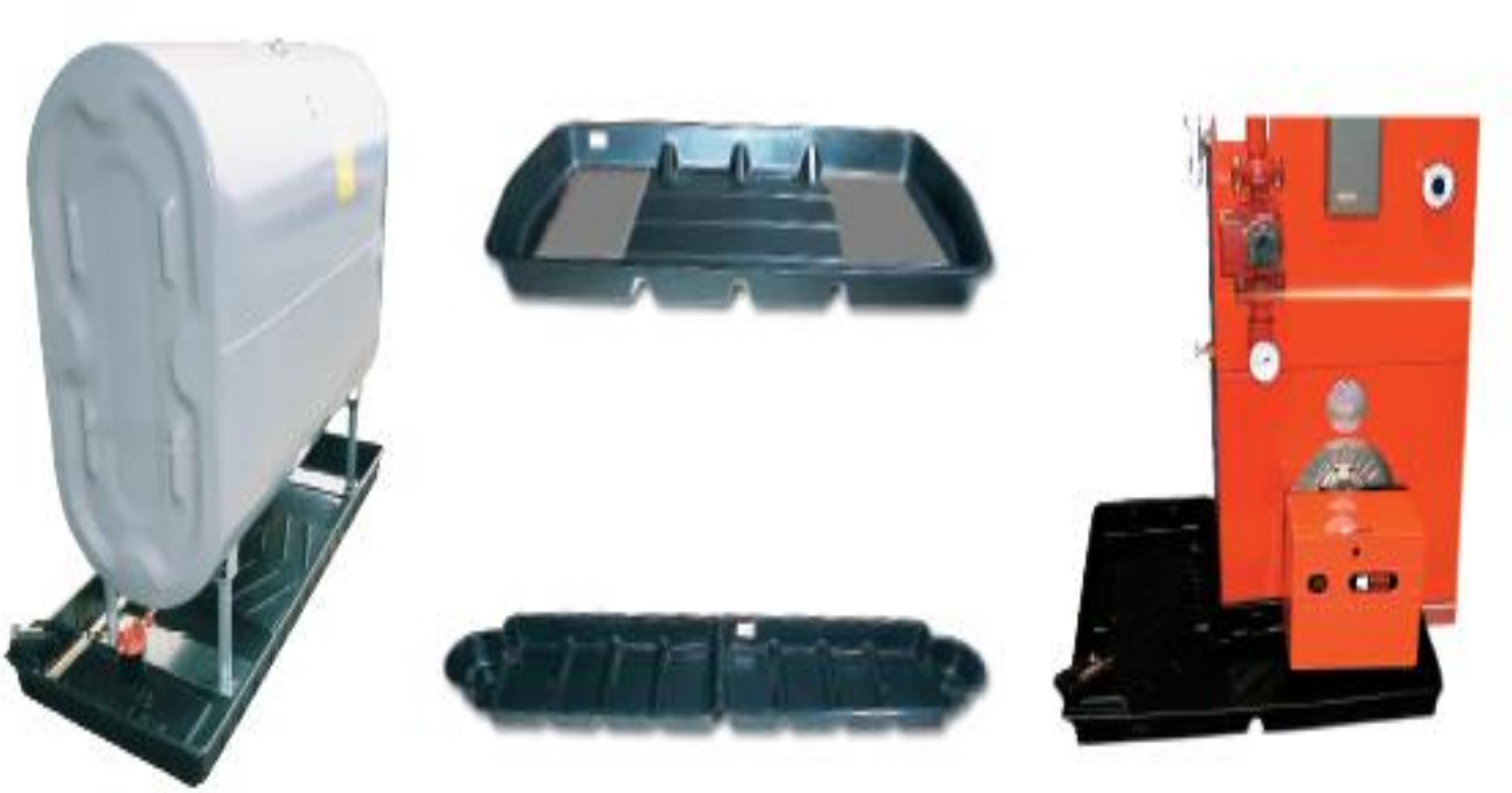
TANKS

TANKS

TANKS


Vent fitting
1- 1.5" NPT fitting
2- 2" NPT fittings
Corrosion resistant,
fire retardant resin
and fiberglass
Liquid tight,
weather proof
fuel oil storage
Fiberglass handles
Easy & safe to
install indoors
or outdoors
Monitoring sight glass
(Double wall tanks)
Burner feed
Stable Fiberglass
'saddle' style legs
25
Year
Warranty

Tank & Burner Spill Protection



Tank & Burner Spill Protection

Oil Piping and Storage Tank

- Replace Line Filter
  - Use Correct Type (Microns)
  - Observe Canisters for Sludge, Rust or Particles
- Tank Location, Vent and Fill Pipes
- Pipe Size, Routing, Support and Valves
- Fuel Appearance
- Supply Line Vacuum Test

FUEL OIL Combustion Manual, pg. 38

Pipe Sizing Suntec Book

- Always Follow OEM Guidelines and Charts
  - Include losses for filters, valves and fittings.
- Suntec Single-Pipe Formulas:
  - Maximum 3/8" Line Length = (6 - 0.75H) / (0.0086Q)
  - Maximum 1/2" Line Length = (6 - 0.75H) / (0.00218Q)
  - "H" = Head in Feet
  - "Q" = Firing Rate in GPH
  - Change (-) to (+) if tank is above pump.

FUEL OIL Combustion Manual, pg. 38

Piping Size Chart & Heating Fuel Treatment

- **Inches of Vacuum Required to Lift Oil for Combined Horizontal Run & Vertical Lift Based on Suntec Single Stage Pump.**
- **Most of us are familiar with variables that impact fuel quality such as bacteria, fungus, water, cold flow concerns such as waxing and gelling, rust from storage tanks, and the natural oxidation of the fuel.**

FUEL OIL Combustion Manual, pg. 39

Finding Oil Supply Leaks

- Pressure Testing
- Vacuum Testing
- Visual Testing
- Electronic Detection

Supply Line Vacuum Test

SUNTEC

MAXIMUM READINGS

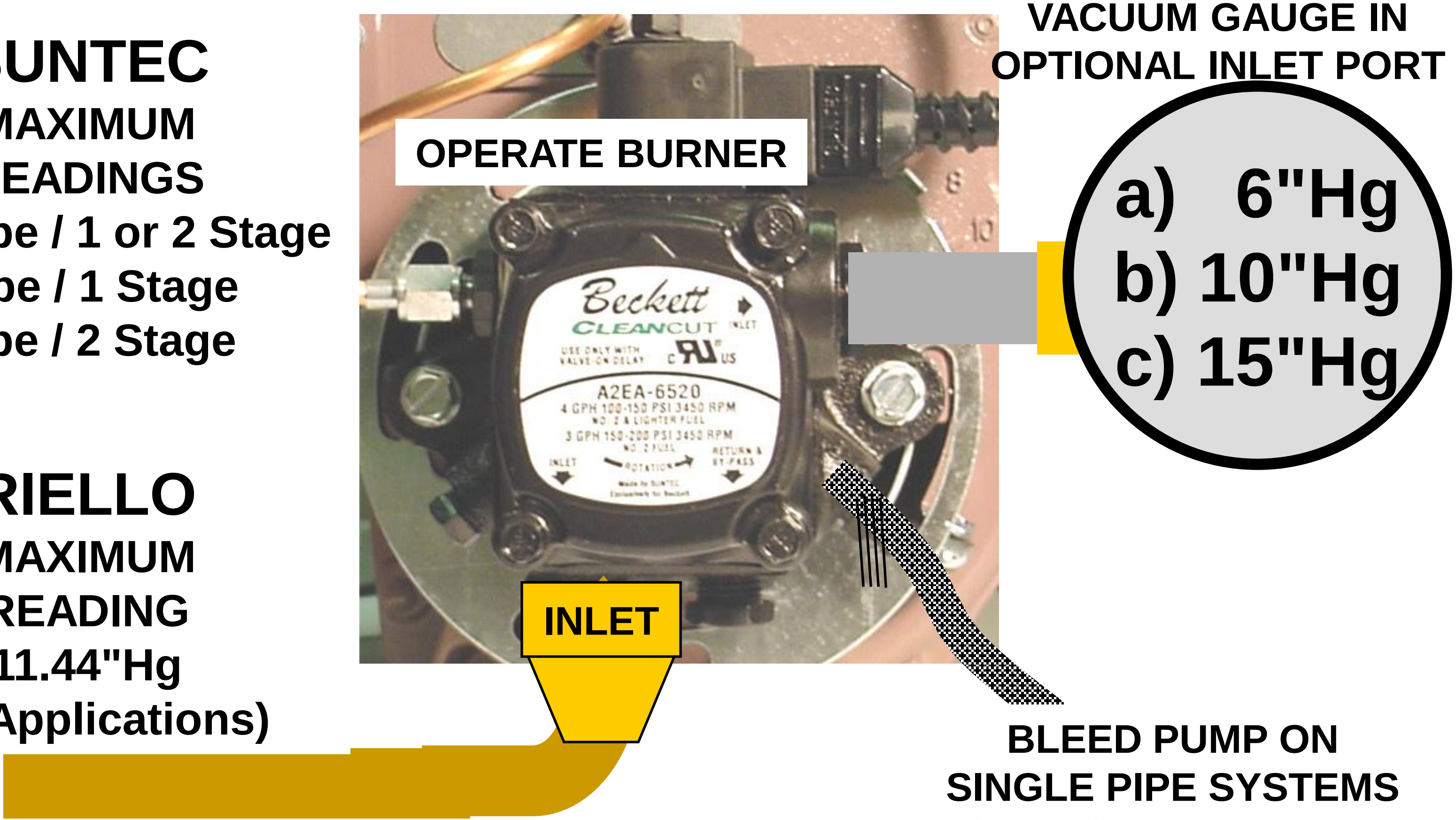
- a) 1 Pipe / 1 or 2 Stage
- b) 2 Pipe / 1 Stage
- c) 2 Pipe / 2 Stage

RIELLO

MAXIMUM READING

11.44"Hg

(All Applications)



VACUUM GAUGE IN OPTIONAL INLET PORT

- a) 6"Hg
- b) 10"Hg
- c) 15"Hg

BLEED PUMP ON SINGLE PIPE SYSTEMS (close before reading)

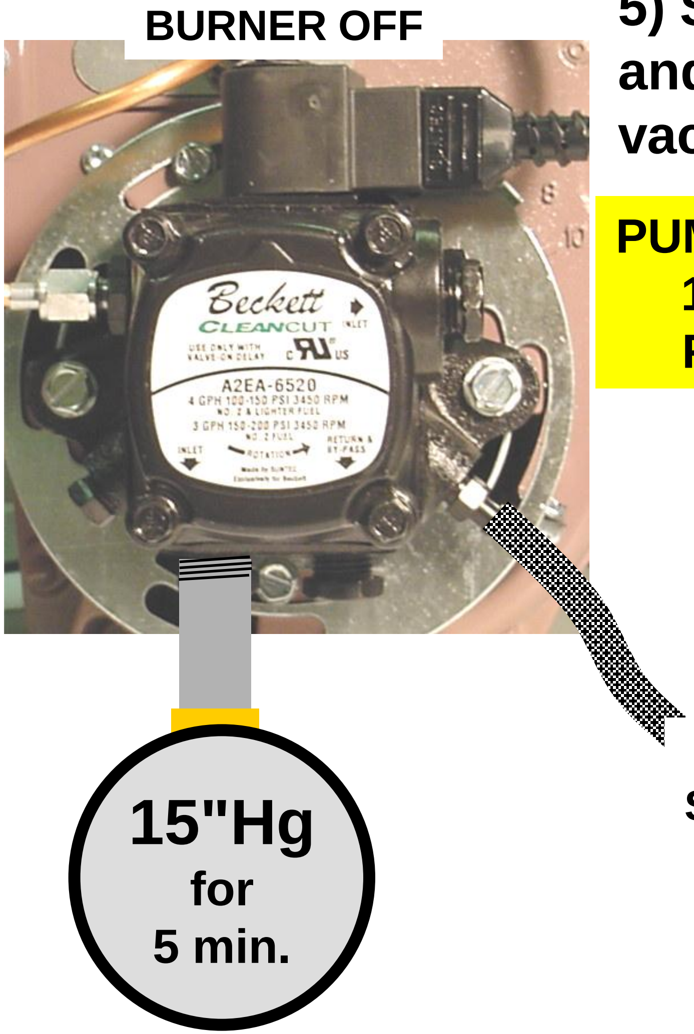
Pump Vacuum Test

1) Remove inlet and return lines.

2) Connect vacuum gauge directly to inlet.

3) Fill pump with oil (if dry).

4) Operate until vacuum reaches 15"Hg, then shut bleed or plug return.



5) Shut off burner and monitor vacuum level.

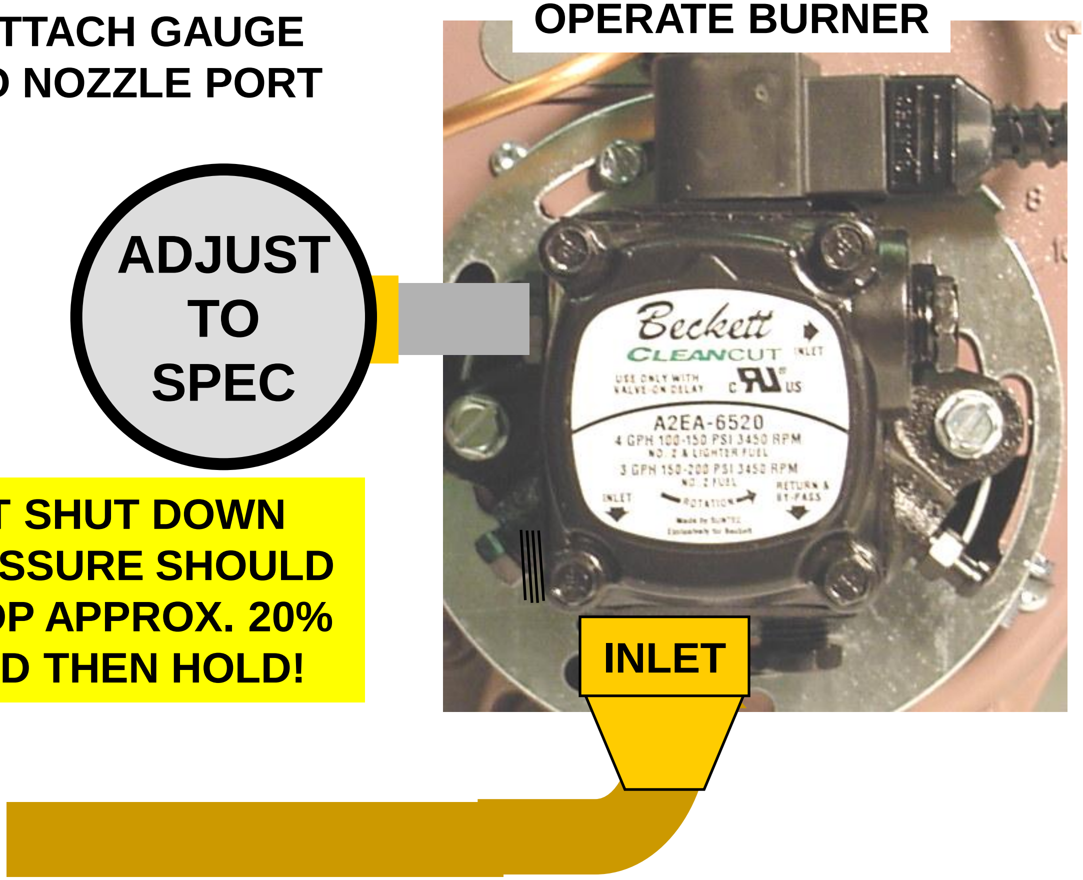
PUMP SHOULD HOLD 15"Hg. VACUUM FOR 5 MINUTES

BLEED PUMP ON SINGLE PIPE SYSTEMS (close at 15"Hg vac.)

Nozzle Pressure/Cutoff Test

ATTACH GAUGE
TO NOZZLE PORT

OPERATE BURNER



ADJUST
TO
SPEC

INLET

**AT SHUT DOWN
PRESSURE SHOULD
DROP APPROX. 20%
AND THEN HOLD!**

**OPERATING
NOZZLE
PRESSURE**

SUNTEC
(SEE SPECS)
100 - 140 PSIG

RIELLO
(SEE SPECS)
145 - 170 PSIG

FUEL OIL Combustion Manual, pg. 40

Useful Formulas

ESTIMATE HEATING ENERGY CONSUMPTION

Degree Day Method-Annual

$$F= \frac{HL \times 24 \times DD}{E \times P \times T.D.}$$

(Not to be used for Heat Pumps)

HL is the design heating load (BTU/Hour).

DD is the degree days for the location.

E is the seasonal efficiency.

P is the heating value of the fuel (BTUs).

T.D. is the design temperature difference (F).

F is the annual fuel consumption.

$$\text{Heat Pumps KWH/YR.} = \frac{0.77 \times HLH \times HL}{1{,}000 \times HSPF}$$

HLH = (Heating Degree Days x 24) (65-Winter Design Temp.)

FUEL OIL Combustion Manual, pg. 41

Water Heaters

$$\frac{(47743\ \text{BTUs})}{(\text{EF})}\ \text{X}\ \frac{(\text{Unit Fuel Costs})}{(\text{Fuel BTUs})}\ \text{X}\ 365$$

47743 BTUs is the amount of energy needed to heat 64.3 gallons of water at a 90º rise

(64.3 gallons is the DOE daily average usage of hot water for the home.)

EF is the DOE energy factor of the equipment:

EF oil = .68; EF gas = .53; EF electric = .79

FUEL OIL Combustion Manual, pg. 42

Thermostats

Digital All electronic.

Bimetallic element two different metals fused together, moves with change in temperature.

Snap acting t-stat eliminates arcing and

pitting of the contacts and possible

“chattering” noise.

Mercury-filled tube switch to tilt from the “off” position to the “on” position on change in temperature.

FUEL OIL Combustion Manual, pg. 43

Limits

Limit controls are generally divided into two groups, the first being "high limit or safety controls," and the second "low limit or operating controls."

Both the high limit control and the fan control may be operated by a bimetallic element, a liquid expanding or contracting, moving a diaphragm, or an expanding and contracting quartz rod as heat sensing elements.

FUEL OIL Combustion Manual, pg. 43

Limits

Average Furnace & System

Limit Set Point: 200ºF

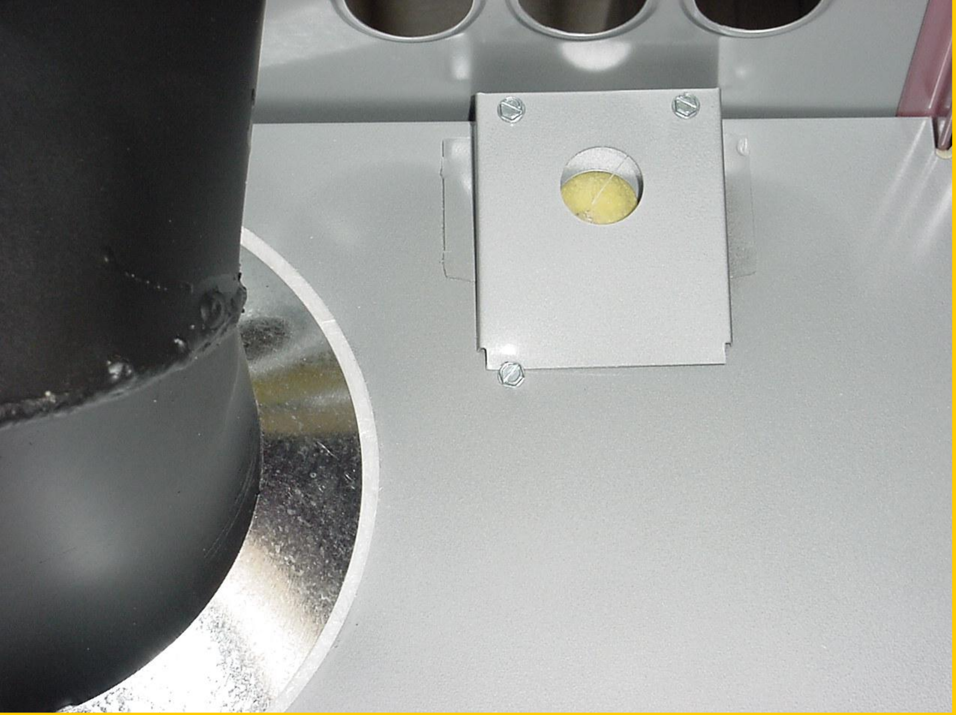
Fan-Off: 120ºF

Fan-On: 100ºF

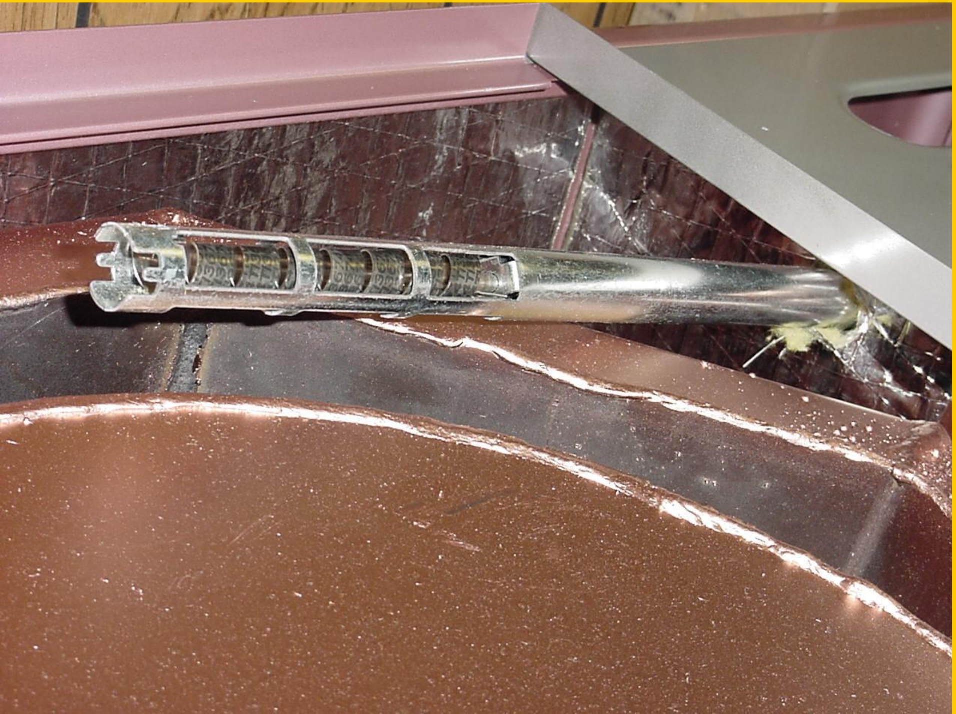
FUEL OIL Combustion Manual, pg. 43

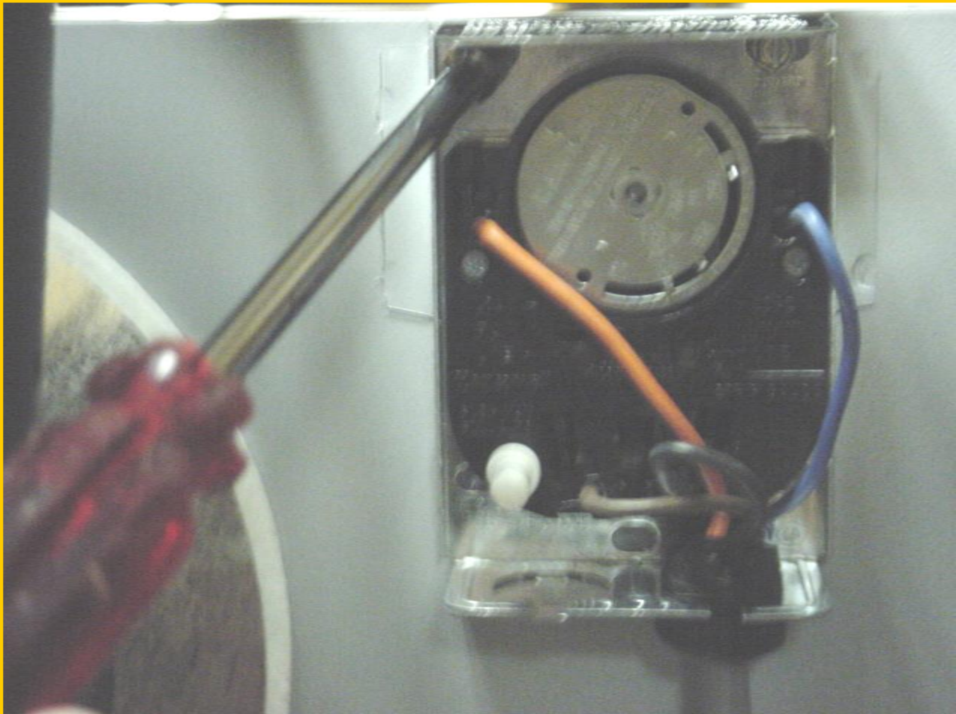
Limits

In the event the fan failed to operate, or the air filters are clogged, the temperature in the furnace bonnet would continue to rise going beyond the "fan on" position and ultimately reaching the high limit indicator setting of 200º. Upon reaching this point, the limit control would "open" its electrical contacts in its switch thus preventing line voltage from reaching the No. 1 terminal of the primary control. This would cause the oil burner to go "off."




CAUTION




CAUTION

FUEL OIL Combustion Manual, pg. 44

Primary Controls

The primary control must:

1) **Control the ignition transformer and, in turn, the burner motor.**
2) **Prove the presence or absence of flame.**
3) **Shut down the system on malfunction such as failure to establish flame on start, flame failure during run, and power failure.**

FUEL OIL Combustion Manual, pg. 44

Primary Controls

The primary control uses the information transmitted to it from the detector to shut down the burner (or allow it to operate) through the use of a safety switch. The safety switch consists of a small bimetal element and a separate safety switch heater. When current is allowed to pass through the safety switch heater, the bimetal heats and starts to warp. When it warps sufficiently, the safety switch breaks and the system shuts down. The safety switch must be manually reset anytime it opens.

FUEL OIL Combustion Manual, pg. 44

Primary Controls

There are two methods of detecting the flame. Thermal detectors respond to an increase or decrease in stack temperatures through a bimetal element inserted into the stack or the old type stack mounted primary controls. Visual detectors respond to the light emitted by the oil flame (cad cells). Cad cells respond by letting electricity pass through them upon the presence of a flame (light) after a few seconds.

TM

Advanced Burner Control

#7505 A, B, or P
Compatible with boiler controls (aquastats) and mechanical and many power stealing 24 V thermostats.

For oil burners
< 20 gph

GeniSys™ Display Module Basic Features

- 32 Character backlit alphanumeric display
  - Continuous real-time cycle monitoring
  - Cad cell resistance readings
  - Line voltage read-out
  - Real-time error notification
  - 15 Cycle history monitoring
  - Customizable lockout service message

Installation - Mounting

Remove communications port cover

Slides on from top

Honeywell R7184 Control

Priming Delay

60 Sec. Recycle Delay

3 Retries Before Lockout

Limited Lockout Reset

Diagnostic Led

CAD Cell Ohms Check

Carlin Combustion Technology

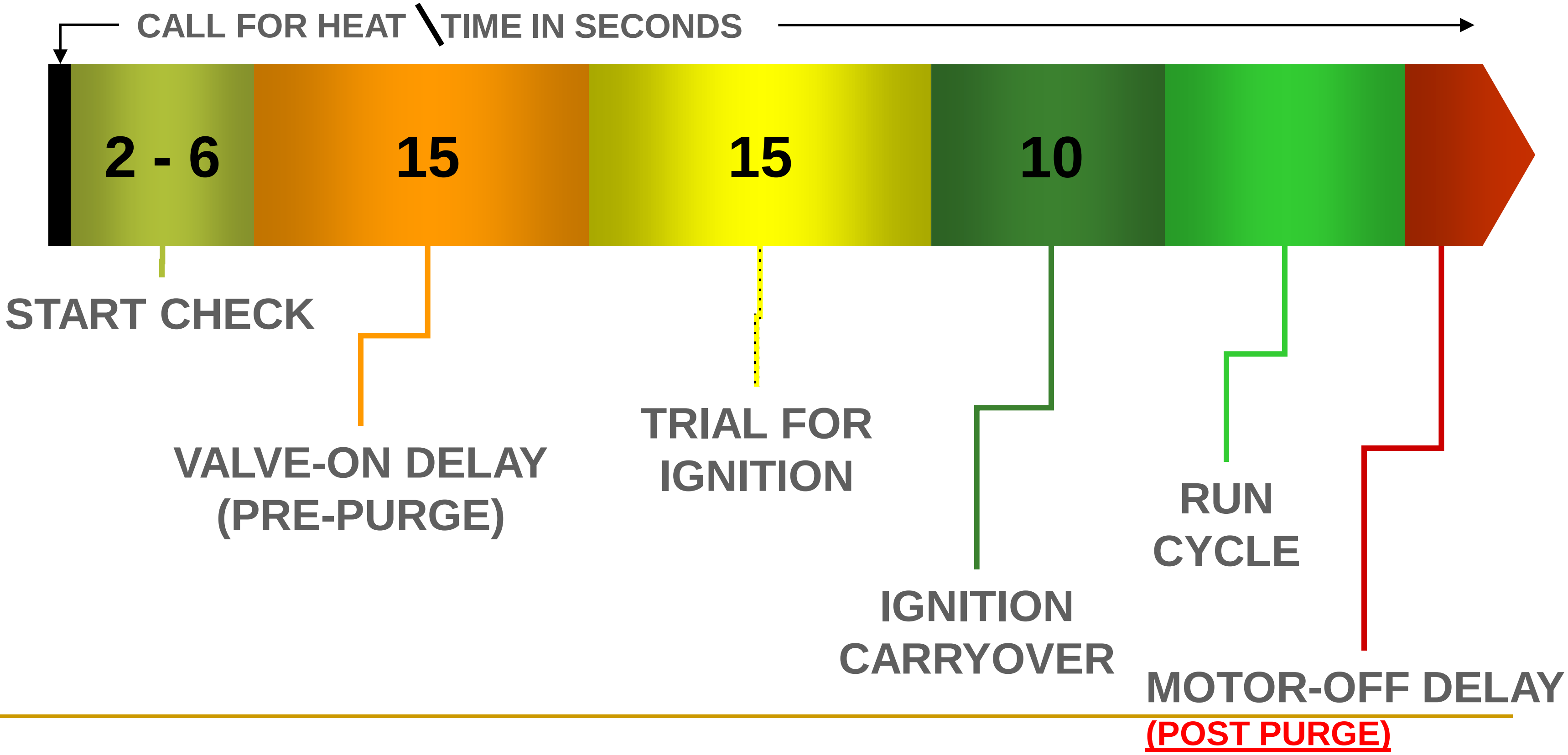
MODEL **80200**

the Sentinel

Flame Quality Indicator
Autodialing Oil Primary

Sequence of Operation

Modern Primary Control



CALL FOR HEAT \ TIME IN SECONDS

2 - 6

15

15

10

START CHECK

VALVE-ON DELAY
(PRE-PURGE)

TRIAL FOR
IGNITION

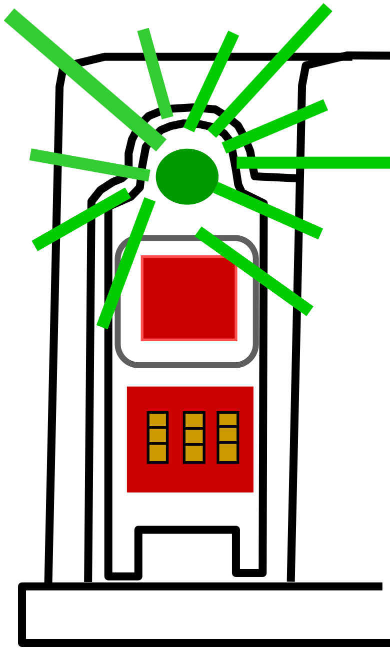
IGNITION
CARRYOVER

RUN
CYCLE

MOTOR-OFF DELAY
(POST PURGE)

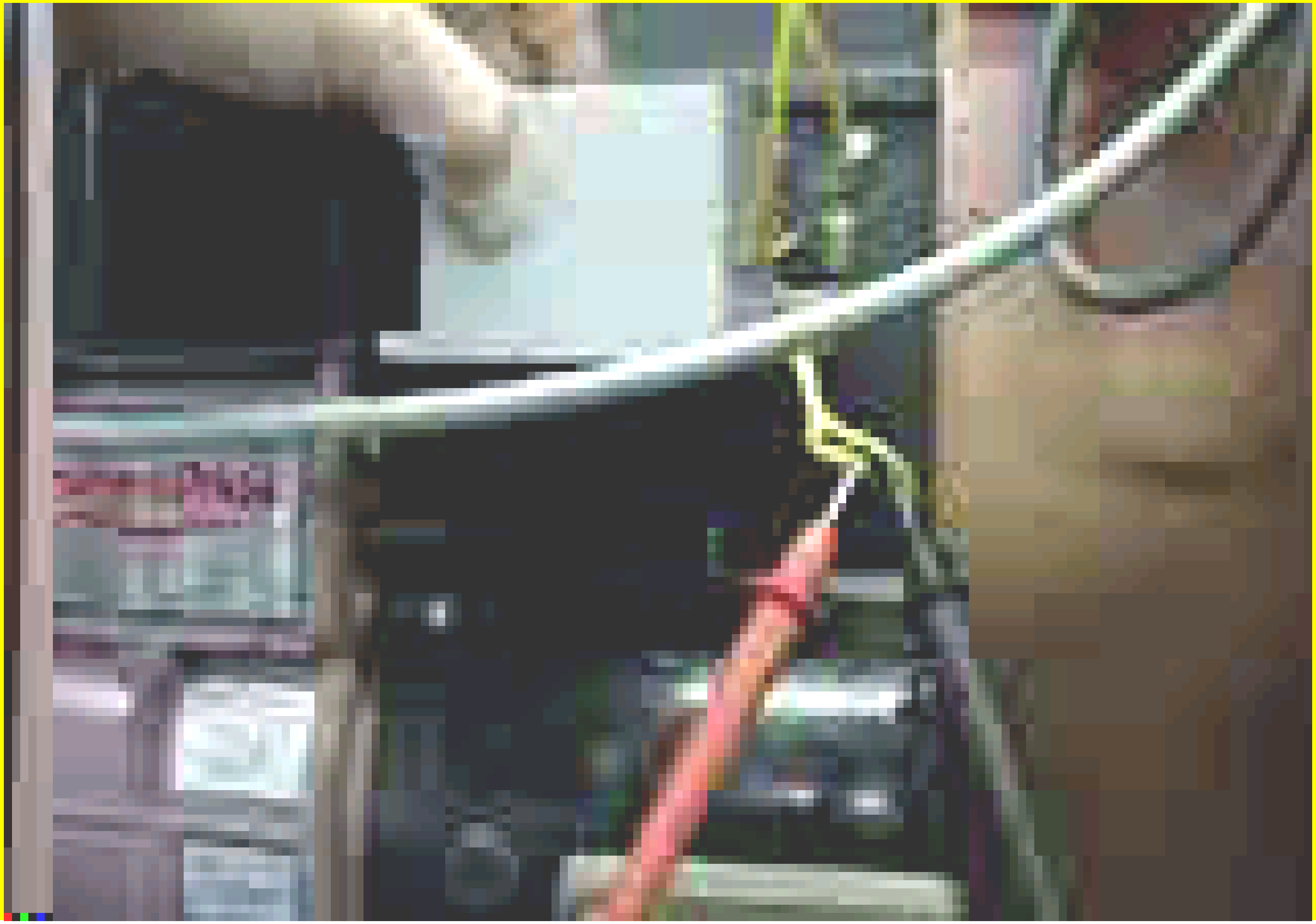
Typical CAD Cell Self-Check

Press reset button once when burner on and ignition off.	
LED FLASHES	CAD CELL RESISTANCE
1	0 - 400Ω
2	400 - 800Ω
3	800 - 1600Ω
4	Equal to or Greater than 1600Ω
Must be under 1600 when flame on.	



CAD Cell Checkout

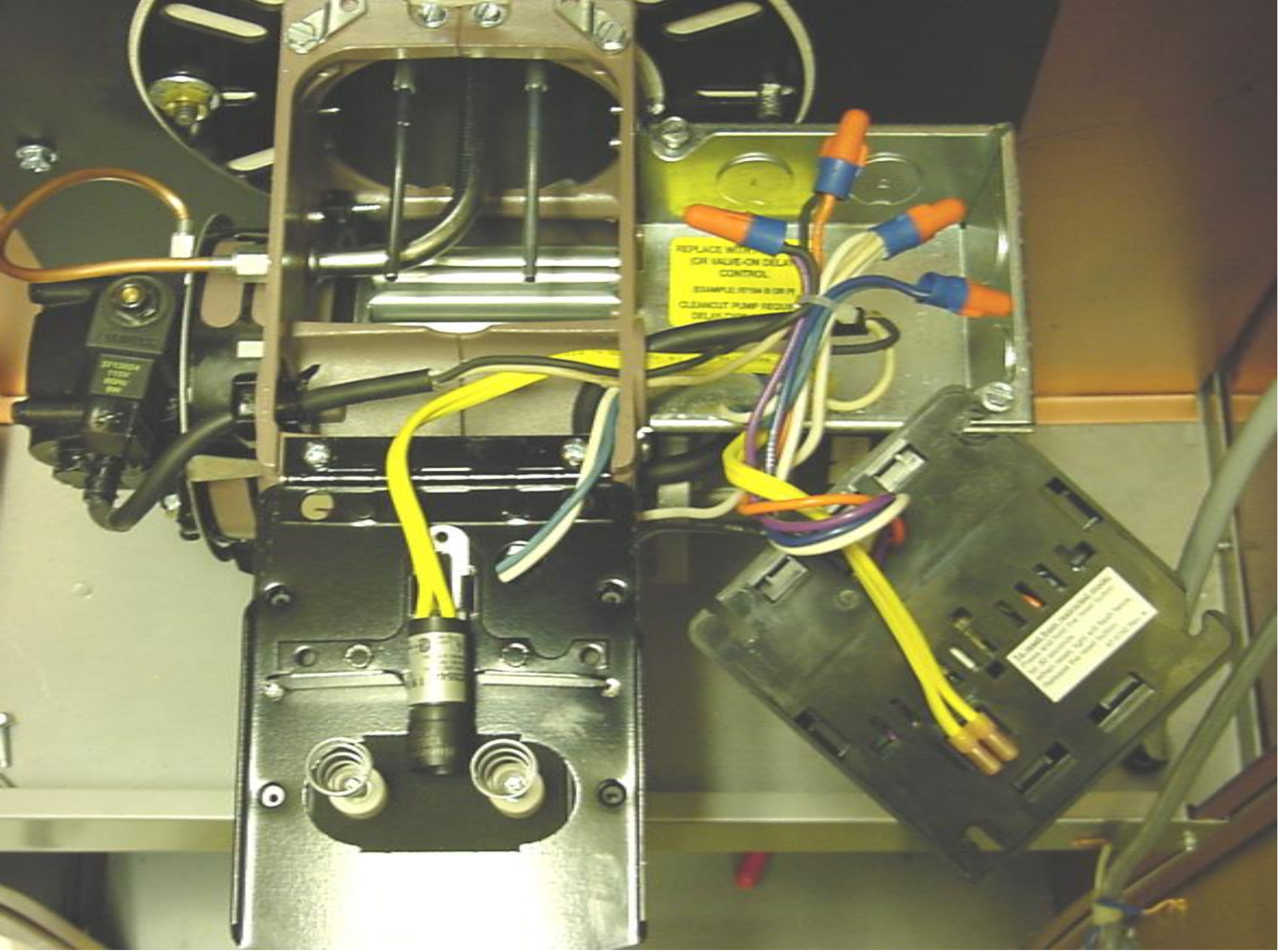
OHM THE CAD CELL IN LIGHT AND DARKNESS OR CHECK DURING OPERATION



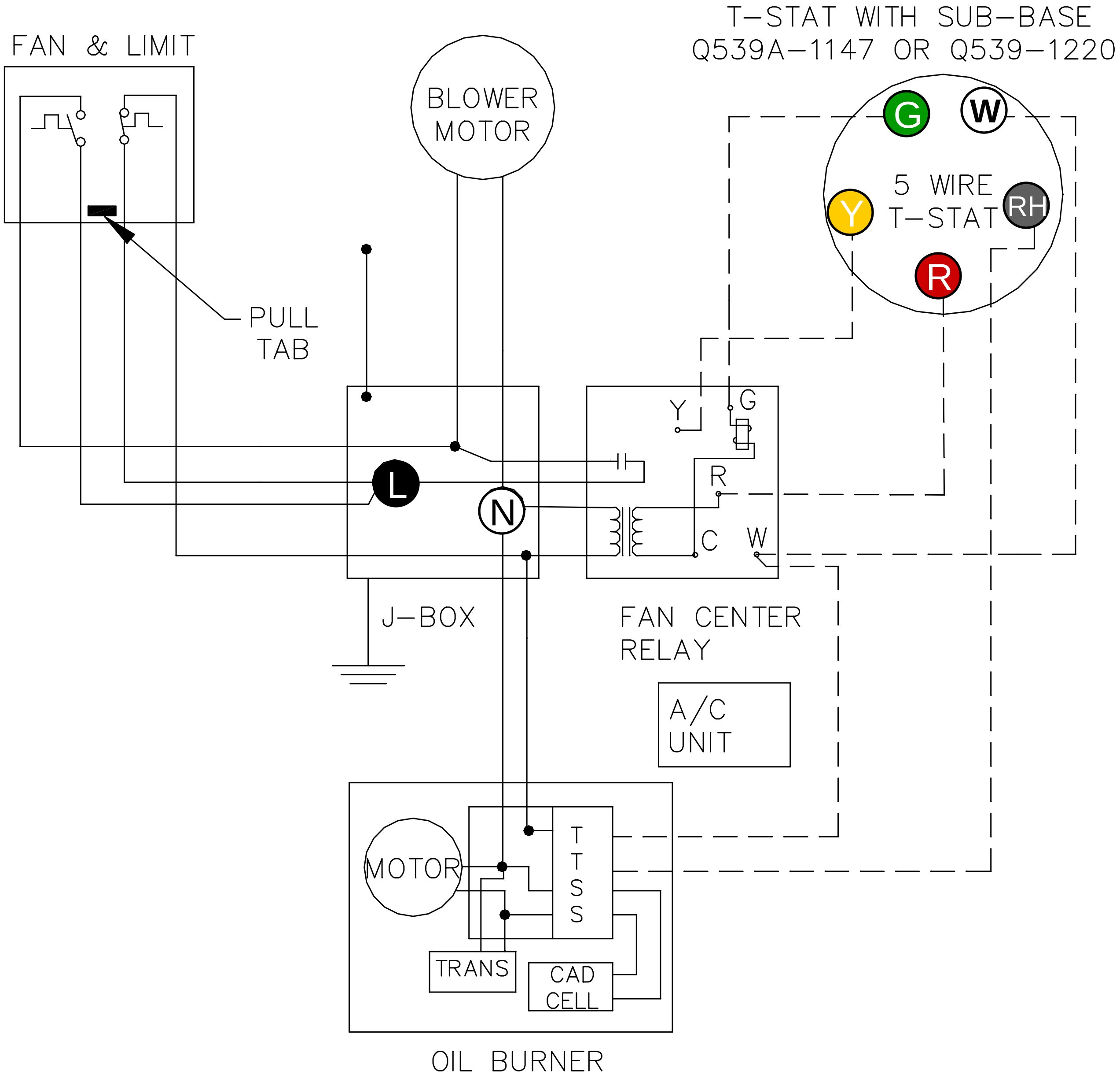
FUEL OIL Combustion Manual, pg. 45

Wiring Color Code

1) Cad Cell	Yellow
2) Power Wiring L1	Black
3) Carlin Power Wiring L1	Red w/ White Stripe
4) Ground L2	White
5) Limit	Red or Red w/ White Stripe
6) Carlin Limit	Black
7) Ignitor	Blue
8) Valve Delay Off/On	Violet
9) Burner Motor	Orange
10) Thermostat (24 volt W)	White
11) Thermostat (24 volt R)	Red



A/C WITH FAN CENTER & OIL OR POWER GAS BELT DRIVE FURNACE USING THERMOSTAT WITH ISOLATED TERMINALS TO BURNER CIRCUIT.



Power and Control Wiring

- Follow all State and Local Codes or NEC
- Wire Sizing (Minimum Circuit Ampacity)
- Circuit Protection (Maximum Fuse Size)
- Protection and Support
- Service Disconnect
- Grounding
- 18AWG Minimum Control Wiring Size
- Nameplate Information

GENERAL FUEL OIL INFORMATION
&
TROUBLE SHOOTING

FUEL OIL Troubleshooting Manual

Rules of Thumb

- ON STANDARD EFFICIENCY EQUIPMENT, FURNACES, BOILER & WATER HEATERS, THE FLUE TEMPERATURE WILL USUALLY BE 320°F-340°F HIGHER THAN THE AIR, WATER, OR STEAM TEMPERATURE BEING SUPPLIED ON OIL EQUIPMENT. (MINUS 50°-70° FOR GAS)

FUEL OIL Troubleshooting Manual

Rules of Thumb

- **HIGHER PUMP PRESSURES COMPENSATES FOR COLDER OIL ESPECIALLY ON OUTSIDE ABOVEGROUND TANKS. BE SURE AND CHANGE NOZZLES (SMALLER) WHEN INCREASING PUMP PRESSURE. HIGHER PUMP PRESSURE ALSO PROVIDES HIGHER CARBON DIOXIDE READING.**

FUEL OIL Troubleshooting Manual

Rules of Thumb

- **ESTIMATE HOME HEATING LOSS AT 20 BTUs/SQUARE FOOT, HOME HEAT GAIN AT 10 to 15 BTUs/SQUARE FOOT. THIS WILL VARY IN DIFFERENT AREAS OF NORTH CAROLINA.**

FUEL OIL Troubleshooting Manual

Rules of Thumb

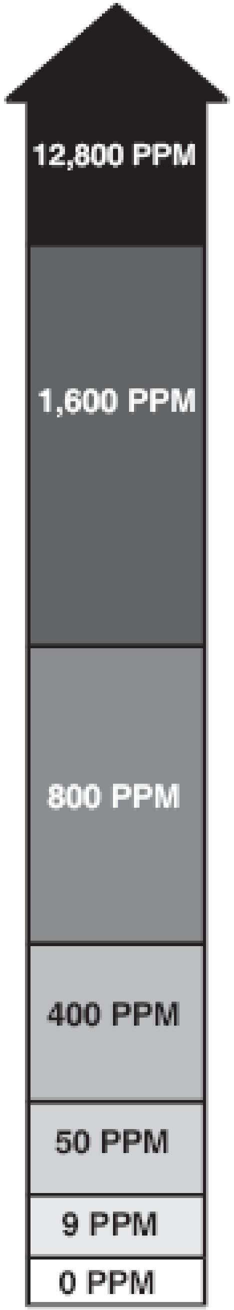
- **OXYGEN - 3% to 5% (FLAME RETENTION - NEW)**
- **CARBON DIOXIDE - 13.4% to 11.8%(FLAME RETENTION -NEW)**
- **FLUE TEMP. - 400° to 575°- 60% to 79% EFF.**
- **FLUE TEMP. - 275° to 425° - +80% EFF.**
- **OIL PUMP PRESSURE - 100 psi to 140 psi**
- **DRAFT - (-.01 to -.02 inches/W.C.) OVERFIRE DIFFERENCE**
- **SMOKE - #0 to #1**
- **CARBON MONOXIDE - 100PPM - MAXIMUM (START-RUN-SHUTDOWN)**

FUEL OIL Troubleshooting Manual

Carbon Monoxide

According to the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE Ventilation Standard 62-89), a concentration of no more than 9 parts per million (ppm) (0.0009%) of CO is permissible in residential living spaces. OSHA has also set an 8 hour work place standard of 35 ppm. The US EPA and the American Gas Association (AGA) has set flue gas CO concentrations at 400 ppm (see Table). Modern Fuel Oil Burners produce about 32 ppm of CO on average.

CO LEVELS



12,800 PPM	Death within 1 to 3 minutes
1,600 PPM	Nausea within 20 miutes, death within 1 hour
800 PPM	Nausea and convulsions, death within 2 hours
400 PPM	Frontal headaches 1 to hours, life threatening after 3 hours
50 PPM	Maximum concentration for continuous exposure in any 8 hour period
9 PPM	Maximum indoor air quality level
0 PPM	Desirabe level

FUEL OIL Troubleshooting Manual

Carbon Monoxide

- **Fuel Oil burners usually produce smoke and a foul odor called aldehydes to warn people of the production of dangerous levels of CO.**
- **Furnace CO can enter the home through Vent Blockage, Flue Pipe Damage, Heat Exchanger Damage, and Air Supply to House (Back Drafts).**

FUEL OIL Troubleshooting Manual

OIL FLAMES

- **Dark red ------------------------------- 975ºF**
- **Dull red-------------------------------- 1290ºF**
- **Dull cherry red------------------------ 1470ºF**
- **Full cherry red-------------------------1650ºF**
- **Clear cherry red---------------------- 1830ºF**
- **Deep orange--------------------------- 2010ºF**
- **White------------------------------------ 2370ºF**
- **Bright White--------------------------- 2550ºF**
- **Dazzling White------------------------ 2730ºF**

FUEL OIL Troubleshooting Manual

The longer the period of continuous firing, the greater will be the efficiency of combustion. The maximum amount of heat is freed when the flame is at its highest temperature. The flue gases however, will leave at a corresponding higher temperature, therefore the heat loss is greater. Consequently it may be necessary to operate a flame which does not reach its maximum intensity due to on/off periods. The prolonged life of the furnace and the reduction in standby losses will ordinarily offset any advantages to be gained by operating at the maximum temperature possible. Actual test indicates that the longer the burning on period and the smaller the ratio of times off to time on, the greater the furnace efficiency.

FUEL OIL Troubleshooting Manual

WHY CAN'T I CLEAN UP THE FIRE

- <u>FUEL SYSTEM</u>
- <u>NOZZLES AND CHAMBERS</u>
- <u>IGNITION SYSTEM AND ELECTRODES</u>
- <u>AIR TUBES, AIR DELIVERY, AND BURNER SETTINGS</u>
- <u>DAMPERS AND CHIMNEYS</u>
- <u>SYSTEM, DRAFT AND DRAFT LOSS</u>

Maintenance Recommendations

- Electrical Wiring
- Venting System
- Heat Exchanger
- Air Filters and Indoor Blower
- Oil Piping and Tank
- Oil Burner
- Combustion Analysis
- Temperature Rise

Venting System Inspection

- Vent Connector and Chimney Base (Interior)
- Size, Support and Grade
- Clearances and Termination
- Physical Condition
- Draft Regulator Operation
- Verify Correct Size and Installation of Common Vent Manifolds

Blower Assembly

- Lubricate Motor or Shaft Bearings if Necessary
- Check Mounting Hardware and Supports
- Clean Blower Wheel
  - Check Hub Tightness
  - Wheel Should be Centered
  - Do not Disturb Weights

Routine Burner Maintenance

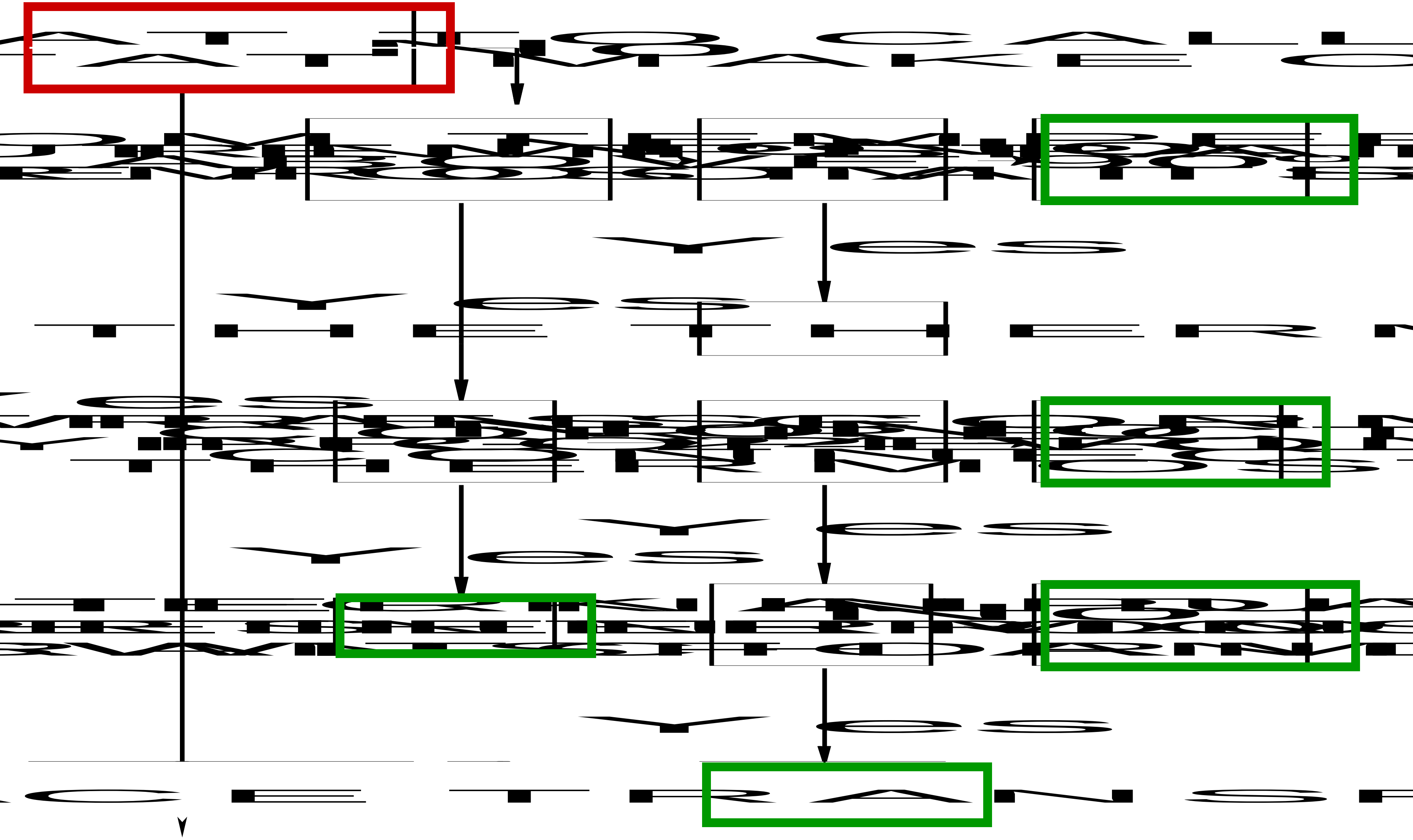
- Check Pump Strainer
- Replace Nozzle
- Check Electrodes
- Check Motor, Blower and Coupling
- Pump Vacuum Test
- Nozzle Pressure / Cutoff Test

Burner Operation

- Observe Flame During Ignition
  - Delay Valve Operation (if applicable)
  - Smooth Ignition and Shut-off
  - Flame Color and Appearance
  - Little or No Visible Smoke

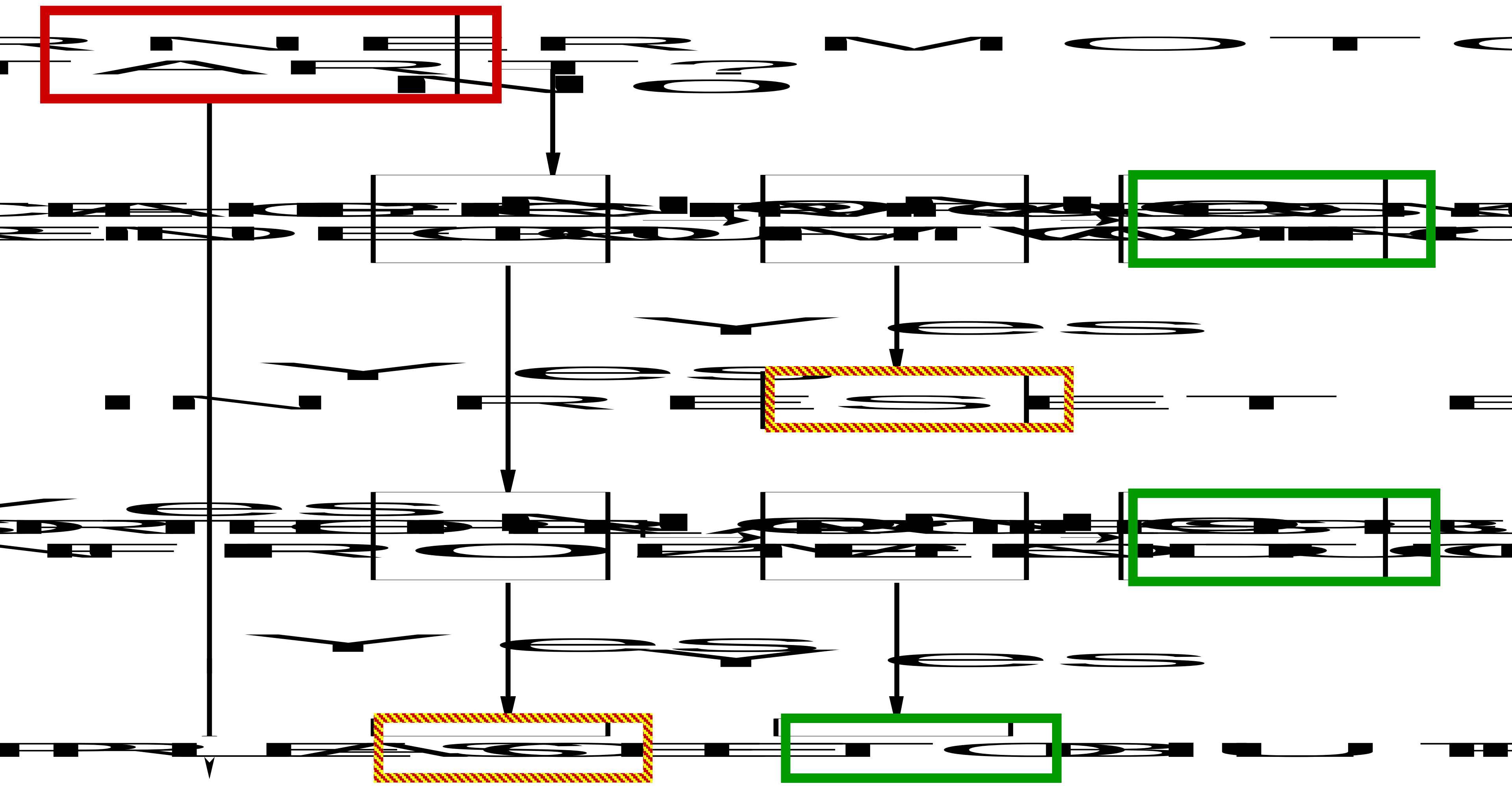
- Combustion Analysis
  - Use Instruments to Prove Safe / Reliable Operation

DIAGNOSTIC CHART | **NO CALL FOR HEAT**



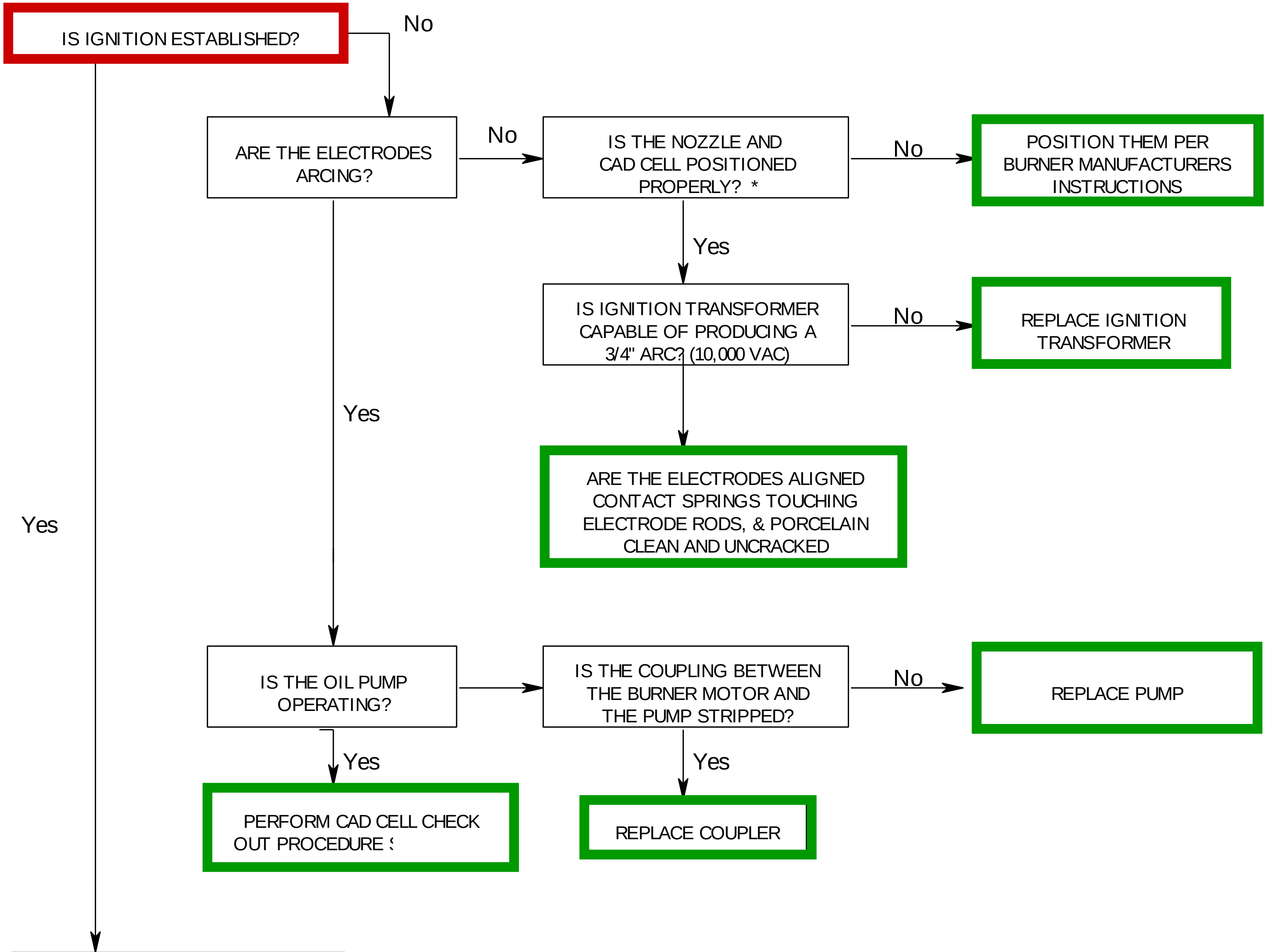
DIAGNOSTIC CHART

BURNER WILL NOT START



DIAGNOSTIC CHART

NO IGNITION / FLAME LOCKOUT



IS IGNITION ESTABLISHED?

No

Yes

ARE THE ELECTRODES ARCING?

No

IS THE NOZZLE AND CAD CELL POSITIONED PROPERLY? *

No

POSITION THEM PER BURNER MANUFACTURERS INSTRUCTIONS

Yes

IS IGNITION TRANSFORMER CAPABLE OF PRODUCING A 3/4" ARC? (10,000 VAC)

No

REPLACE IGNITION TRANSFORMER

ARE THE ELECTRODES ALIGNED CONTACT SPRINGS TOUCHING ELECTRODE RODS, & PORCELAIN CLEAN AND UNCRACKED

Yes

IS THE OIL PUMP OPERATING?

IS THE COUPLING BETWEEN THE BURNER MOTOR AND THE PUMP STRIPPED?

No

REPLACE PUMP

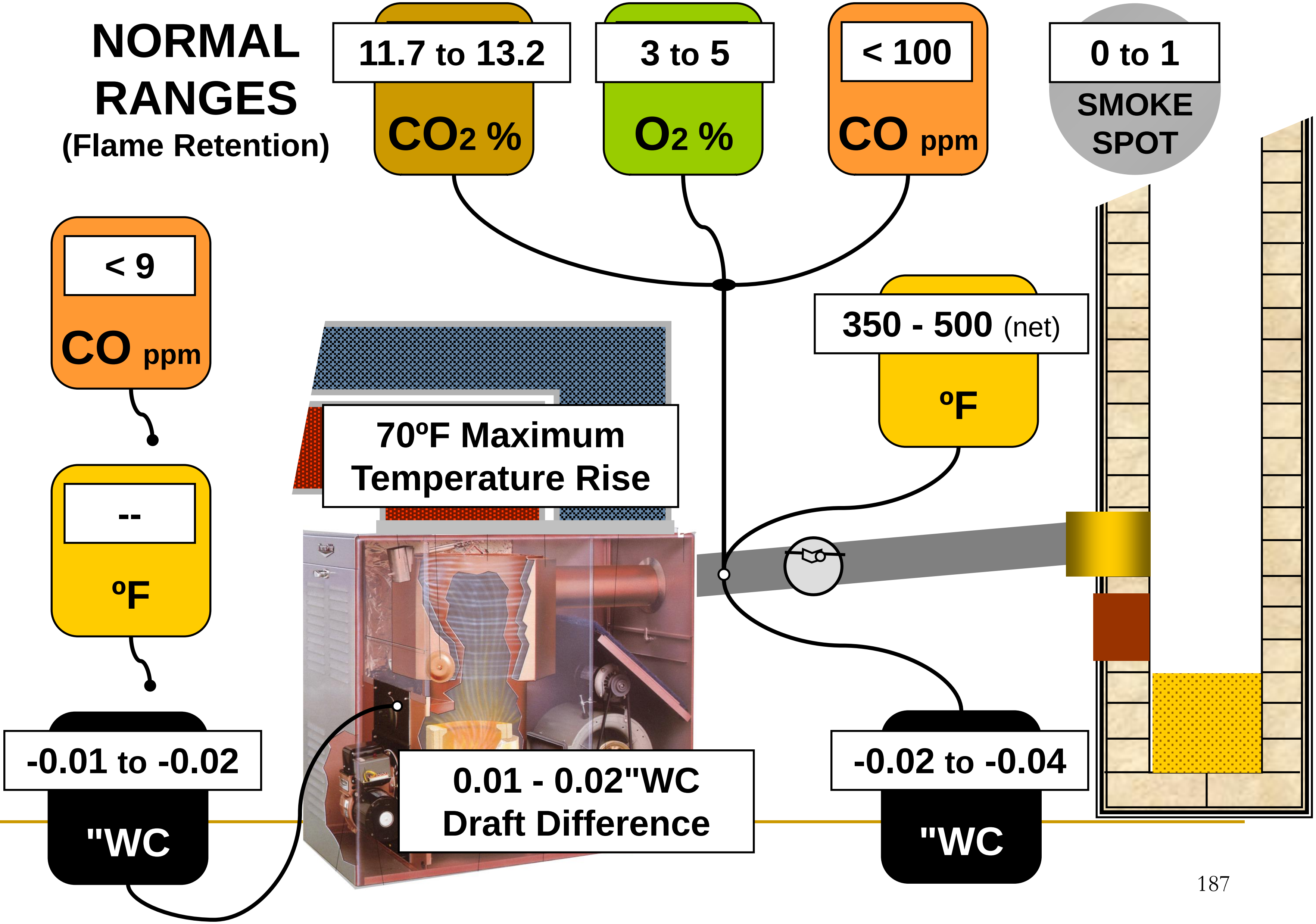
Yes

PERFORM CAD CELL CHECK OUT PROCEDURE

Yes

REPLACE COUPLER

Combustion Analysis



NORMAL RANGES

(Flame Retention)

Combustion Analysis