COMBUSTION PRINCIPLES AND FUEL STORAGE DESCRIPTION

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1. GENERAL

1.01 This section describes combustion principles and fuel storage and supply for the burner.

1.02 Whenever this section is reissued, the reason(s) for reissue will appear in this paragraph.

1.03 The recommendations contained in this section are minimum requirements. Other codes having jurisdiction will apply if they are more stringent. Engineering judgment, based on a specific job, may dictate more stringent requirements.

2. COMBUSTION

2.01 To establish and maintain combustion, three elements must be present: fuel, air, and temperature greater than the ignition temperature. Removal of any one of these elements causes combustion to cease. (Fuel types and classifications are described in Section 760-530-100.*) Refer to Section 770-210-305 for additional information on the combustion process and combustion efficiency.

A. Air

2.02 Air must be present in the correct proportion to maintain combustion. If there is too little or too much air, the fuel will not burn. The range between these two extremes is called the flammable limits of a fuel. Within this range, combustion is self-supporting. Perfect combustion (stoichiometric burning or theoretical combustion) is burning with exactly the correct proportion of air to fuel so that all the fuel and air are consumed. Table A shows the range of air that will support combustion. It is given in percent of stoichiometric air, eg, if 100 cubic feet of air is required for perfect combustion of 10 cubic feet of natural gas, the gas will burn with as little as 64 cubic feet of air or as much as 247 cubic feet of air. The gas and oil air mixtures must be controlled to assure that they stay within the flammable limits once ignited.

B. Ignition

2.03 Ignition is required to initiate the combustion process. Ignition temperatures of fuel vary. Table B lists some of the ignition temperatures of fuels.

2.04 Any means that will raise the temperature of a combustible mixture (fuel and air) above its

*Check Divisional Index 760 for availability.

TABLE A

PERCENT OF STOICHIOMETRIC AIR

FUEL	MINIMUM (CUBIC FEET)	MAXIMUM (CUBIC FEET)
Natural gas	64	247
Oil	30	173

TABLE B

IGNITION TEMPERATURES

FUEL	TEMPERATURE
Kerosene	500°F
Light fuel oil	600°F
Heavy fuel oil	765°F
Propane	875°F
Natural gas	1000°F

ignition temperature will ignite it. The most common ignition system for light oil burners and gas pilots is a spark ignition system. It consists of a spark bridging the gap between two electrodes. Dependent on the energy supplied to the arc, its temperature is well above the ignition temperature of the fuel air mixture. Arc temperatures in excess of 3000°F are common and will readily light the fuel air mixture.

2.05 Other ignition systems employ a spark lighting a gas pilot which in turn ignites the main oil or gas burner. When gas is unavailable, a spark-ignited light oil burner is used to ignite the main heavy oil burner.

2.06 When the mixture has ignited and a flame has developed, the flame will move through the mixture. This is called flame propagation rate, ignition or burning velocity, or flame speed. The rate at which the flame travels relative to the rate at which the fuel air mixture is introduced into the combustion chamber by the burner nozzle determines where the flame will position itself. As the fuel leaves the nozzle, it expands and loses velocity. If the fuel velocity leaving the nozzle exceeds the ignition velocity, the flame burns a short distance away from the nozzle, which is the point where the ignition velocity and mixture velocity are the same. If the mixture velocity is increased, the flame moves farther away, and if the mixture velocity is increased, a point is reached where the flame is blown out. This is one reason for low fire start on burners with large firing rates.

2.07 If the fuel mixture velocity is low compared to the ignition velocity, the flame moves back into the burner. This is easily corrected by increasing the fuel air mixture velocity.

3. FUEL STORAGE

3.01 Gas used in telephone buildings is either natural gas or liquefied petroleum (LP) gas.

3.02 Natural gas is transported and delivered to the user via an underground pipe network. The gas utility company uses high-pressure distribution which is reduced in pressure in two or three steps. The utility company protects each pressure level network with excess pressure relief valves.

3.03 The final pressure reduction takes place at the entry into the building where it is usually reduced to approximately 8 inches water column, which is slightly over 1/4 pound per square inch gauge (psig). This pressure is further reduced by the pressure regulator at the boiler or furnace. Therefore, with this network distribution system, there is no need for on-site storage.

3.04 Liquefied petroleum gas requires on-site storage. It is normally delivered by tank trucks which transfer the LP fuel to the user's tank. Liquefied petroleum gas storage tanks are mounted above grade, buried, or mounded. It is suggested that above-grade storage be used at telephone building installations. This gas is stored under pressure, 165 psig at 90°F, and distributed to the building at a reduced pressure. The pressure regulator at the boiler/furnace reduces the pressure to the burner manufacturer's recommended level.

3.05 The tank must be at a location which is at a lower elevation than any building opening, eg, windows, window wells, fresh air intakes, doors, or vents. This is required because LP gas is heavier than air and will migrate to the point of lowest elevation. If a leak develops at the tank and the tank is higher than a building opening, the LP gas would follow the slope of the land and enter the building. Once in the building where sources of ignition exist (eg, hot water heaters, electric motors and starters, etc), the opportunity for an explosion is great.

3.06 All LP gas fuel installations should conform to the applicable sections of the National Fire Protection Association (NFPA) Standard 58, "Standards for the Storage and Handling of Liquefied Petroleum Gases."

3.07 All American Society of Mechanical Engineers (ASME) LP gas fuel tanks should be equipped with overpressure relief devices. The relieving capacity, in flow rate cubic feet per minute (CFM) air, of the overpressure device for aboveground tanks should be as shown in Table D-1 of NFPA 58 or as determined by the following formula:

Flow rate CFM air = $53.632 \times A^{0.82}$, where A equals total surface area of container in square feet.

3.08 All United States Department of Transportation approved cylinders should be protected against overpressure as described in the Compressed Gas Association Pamphlet S-1.1, Safety Relief Device Standards, Part 1, Cylinders for Compressed Gas. This pamphlet is available from the Compressed Gas Association, 1235 Jefferson Davis Highway, Arlington, Virginia 22202.

3.09 Fuel oil requires on-site storage. Oil is delivered by tank truck which transfers the oil to the user's tank. Oil is stored in aboveground tanks, buried tanks, and unenclosed and enclosed tanks inside buildings. All tank installations must conform to the requirements of NFPA Standard 31, "Standards for the Installation of Oil-Burning Equipment."

A. Aboveground Tanks

3.10 Aboveground tanks are not recommended unless subsoil conditions prevent installation of a buried tank, eg, shelf rock immediately below grade. If an aboveground tank is installed, minimum distances from lot lines, public ways, and other buildings must conform to the requirements of NFPA Standard 31, "Standards for the Installation of Oil-Burning Equipment." Aboveground tanks should be equipped with an emergency venting device(s) or some form of construction that relieves excessive internal pressure caused by exposure fires. Aboveground tanks should be supported on a suitable foundation designed to prevent excessive concentration of loads on the supporting portion of the shell.

B. Buried Tanks

3.11 Buried tanks must conform to the requirements of NFPA Standard 31, "Standards for the Installation of Oil-Burning Equipment." Tanks should have a minimum cover of 2 feet of earth or be covered with 1 foot of earth fill which is protected with a slab of reinforced concrete, a minimum of 4 inches thick. Tanks should not be placed beneath roadways, driveways, or parking areas. However, if it is necessary, a minimum of 3 feet of earth cover or 1 foot 6 inches of well-tamped earth plus 6 inches of reinforced concrete should extend at least 1 foot horizontally beyond the outline of the tank in all directions.

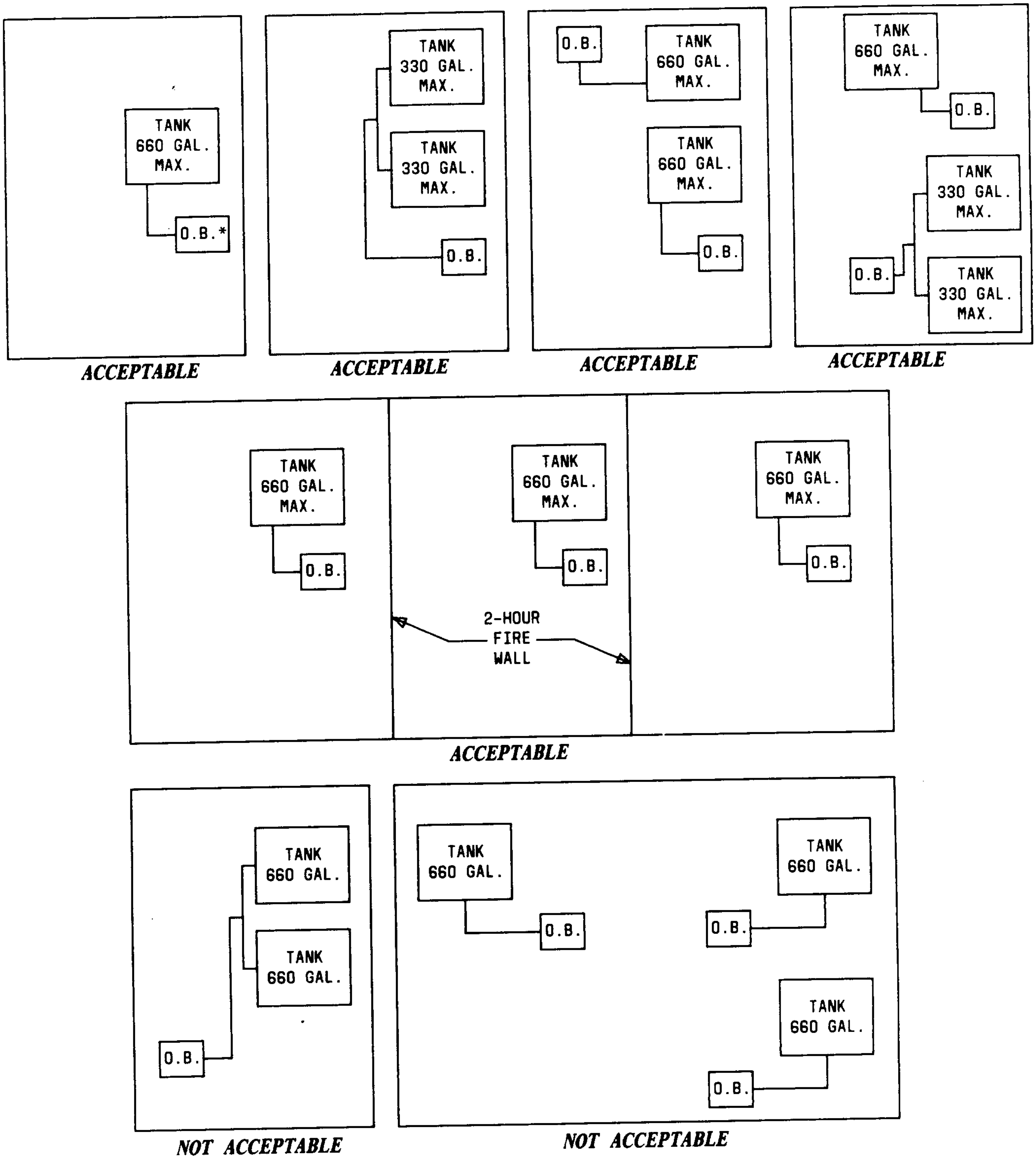
3.12 If ground water is present or if the soil conditions indicate impervious soil, eg, clay, an antiflotation mat should be provided. As an aid in distributing the load on the tank shell, a sand fill is suggested on top of the antiflotation mat below the tank.

C. Unenclosed Tank Inside Building

3.13 An unenclosed tank inside building must conform to the requirements of NFPA Standard 31, "Standards for the Installation of Oil-Burning Equipment." The largest unenclosed supply oil tank is 660 gallons. Not more than one 660-gallon tank or two tanks of aggregate capacity of 660 gallons or less should be connected to oil-burning appliances. The aggregate capacity of such tanks installed in the lowest story or basement of a building and unenclosed should not exceed 1320 gallons unless separation is provided for each 660 gallons of tank capacity. This separation should consist of an unpierced masonry wall or partition extending from the lowest floor to the ceiling above the tank or tanks and should have a fire resistive rating of not less than 2 hours. (See Fig. 1 for examples.)

D. Enclosed Tank Inside Building

3.14 An enclosed tank inside building must conform to the requirements of NFPA Standard 31, "Standards for the Installation of Oil-Burning Equipment." A supply tank with a supply capacity greater than 660 gallons should be enclosed when installed inside a building. In buildings of fire resistive



* O.B. MEANS ONE OR MORE OIL BURNERS.

Fig. 1—Examples of Unenclosed Tank Inside Building

construction, the gross capacity of the tank(s) should not be more than 15,000 gallons. In buildings other than fire resistive construction, the gross capacity of the tank(s) should not be more than 10,000 gallons.

3.15 These enclosures or tank rooms should be constructed of floor, walls, and underside of floor acting as a ceiling and all should have a fire resistive rating of 3 hours. The walls must be bonded to the floor and ceiling. The construction should be in accordance with Section 760-630-400, Compartmentation.

E. Fuel Oil Supply Tanks

3.16 Oil supply tanks must be designed for the head that they will be subjected to. With a closed coupler fill connection on the tank, the tank could be filled and the oil could rise in the vent line until it overflowed. The height of the vent line above the bottom of the tank determines what head the tank should be designed for. Proper vent sizing also protects the tank against overpressure or vacuum damage. Table C gives recommended vent pipe sizes based on tank capacity.

TABLE C

RECOMMENDED VENT PIPE SIZES

TANK SIZE (IN GALLONS)	INTERNAL DIAMETER OF VENT PIPE (IN INCHES) (NOTE)
500 or less	1-1/4
501 to 3,000	1-1/2
3,001 to 10,000	2
10,001 to 20,000	2-1/2
20,001 to 35,000	3

Note: When tanks are filled using a pump on the delivery truck through a closed coupler fill (tight) connection, a vent pipe should be provided on the tank no smaller than the discharge of the pump.

3.17 Vent lines should pitch toward the tank without sags or dips where liquid could collect. They should terminate outside the building at a point not closer than 2 feet vertically or horizontally from any building opening. The vent pipe should terminate in a weatherproof vent cap or fitting or be provided with a weatherproof hood. All vent caps should have a minimum free area equal in size to the cross-sectional area of the vent pipe. The vent cap, fitting, or hood should be fitted with a screen not finer than 4 mesh. The vent line termination should be above the possible snow buildup level.

3.18 Buried fuel tanks can be steel or fiberglass construction. If the soil condition is corrosive, fiberglass should be considered. Apply two coats of asphaltum paint to all steel tanks before back-filling. Interior tanks and aboveground tanks should be constructed of steel.

3.19 All tanks should have a device located at the fill connection that will audibly or visibly indicate when the tank is filled to the safe top level.

3.20 All tanks should have sufficient tappings to provide for the following connections (Fig. 2):

- Fuel oil supply line
- Fuel oil return line
- Vent line
- Fill pipe
- Sounding and sample drawoff
- Level indicator (gauge)
- Manhole access.

Note: Manhole access is suggested for tanks storing heavy oil. This provides access for cleaning in the event of oil sludging or maintenance of heating coils when installed.

3.21 All piping run from the tank to the building should have swing joints to protect against relative movement of the tank and building and should pitch back to the tank.

3.22 A tank level indicator should be of the type that works on the principle of reading the head of oil in the tank. The indicator should be located in the boiler room.

3.23 The fill pipe should have a weathertight cap or enclosure. Consideration should be given to providing a locking cap or cover.

3.24 The sounding and sample pipe should make a straight run from the tank and be fitted with a watertight cap or enclosure.

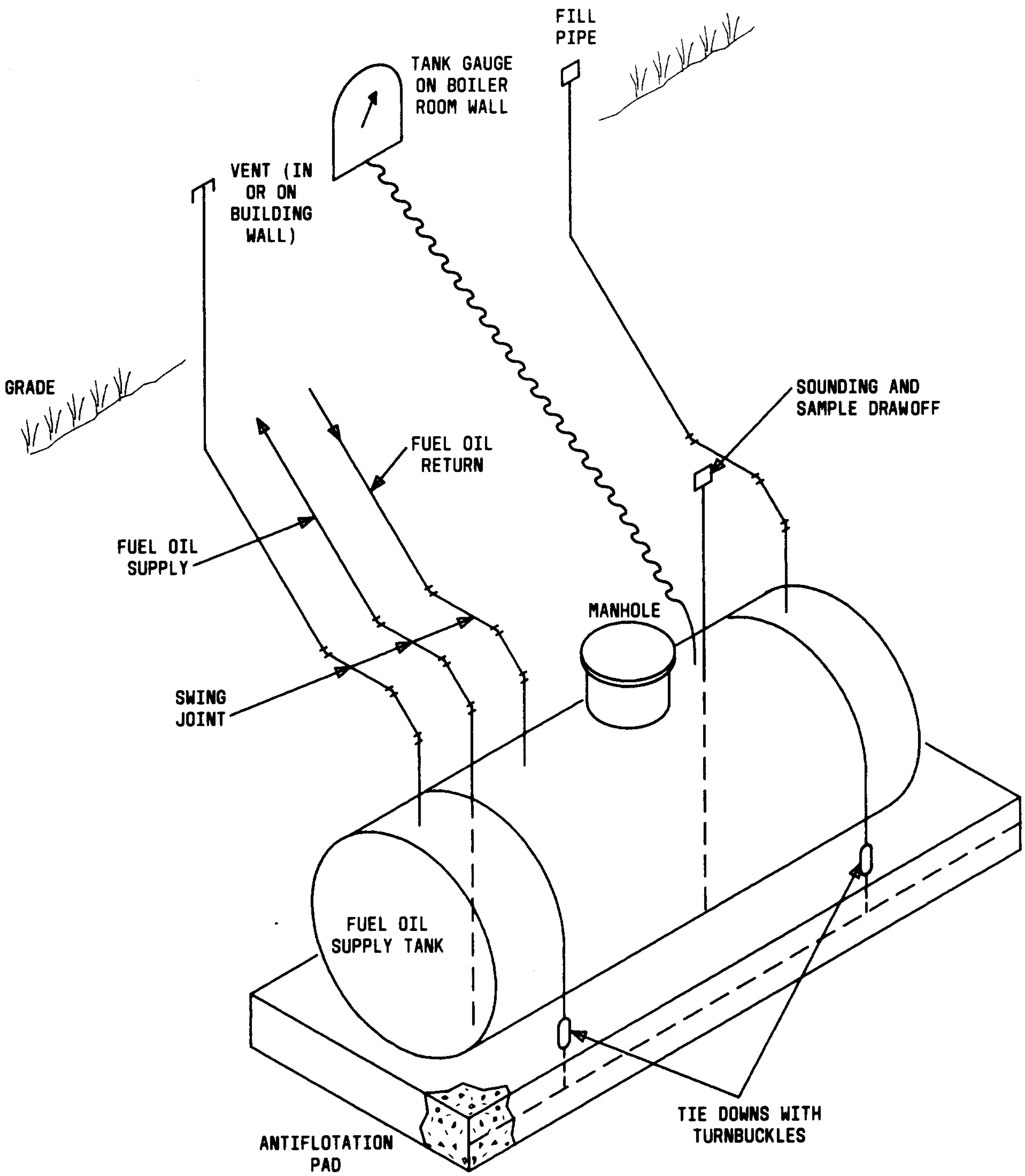


Fig. 2—Fuel Oil Supply Tank