Combustible Waste Incinerator Engineering

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INCINERATOR DESIGN

1-1. Definitions. Definitionsoftermsintheirapplicationtothis manual are asfollows:

a. Incinerator. A special type of structure for the reduction of refuse to inert gases and solids by burning.

b. Furnace. That part of the incinerator in which combustion takes place, including the ignition chamber, mixing chamber, combustion chamber, and charging hood if provided.

c. Arch. Thearchedceilingofthefurnaceovertheignition, mixing, and combustionchambers.

d. Grate. Thecastiron(C.I.)grateonwhichthedrymaterial1s burned.

e. Hearth. Aninclinedflooronwhichthewetmaterialisdried andburned. Itmaybeconstructedof firebrickorofcastirongrate bars.

f. Effectivegratearea. Thegrateareaplustheeffectiveareaof the hearth in terms ofgrate area.

g. Ignitionchamber. Thespacebetweenthegrateandthearchand between the hearth and thearch.

h. Mixing chamber. The chamber adjacent to the ignition chamber where the gases mix before passingtothecombustionchamber. Thisis often called the downpass.

i. Bridgewall. Thewallattheendofthegrateorhearthbetween theignition chamber and themixing chamber.

j. Combustion chamber. The final chamber of the furnace where combustion of the gases is completed.

k. Targetwall. Thewallbetweenthemixingchamberandthe combustion chamber.

l. Flue. Thehorizontalconnectionbetweenthecombustionchamber and the stack.

m. Damper. Theverticalmovablerefractoryslabinthefluefor draft control.

n. Damperbox. Theboxoverthedamperforhousingitinitsopen position.

o. Charginghood. Astructuredirectlyovertheignitionchamber providedwithadoor,throughwhich thefurnaceischargedwith refuse.

p. Chargingthroat. An extension from an opening in the arch to the charging floor, through whichthefurnaceischargedwithrefuse.

1-2. Typesofincinerators. Twotypesofincineratorsareconsidered inthissection: typeI-garbage andrubbishincineratorsandtype II - wet garbage incinerators. Standard designs have been prepared for types I and II, drawings for which are listed in appendix B. Type I of these standard designs is a

general-purpose incinerator and is the most suitable for the present-day needs at a majority of installations. It will burn refuse consisting of all rubbish or, by proper control of the damper, a mixture of 65 percent rubbish and 35 percent garbage by weight. Type II will burn a mixture of 65 percent wet garbage by weight and 35 percent rubbish without the use of auxiliary fuel. However, this type is not designed to withstand the high heat release that would result from burning refuse containing a high percentage of rubbish and will not be constructed except when the conditions are definitely unsuited to the use of type I.

1-3. Incinerator capacities. Requirements will be based on the expected waste from the particular post. At an average troop cantonment, the per capita waste will approximate 1.5 pounds of rubbish, 0.50-pound 6f non-edible garbage, (citrus peels, coffee grounds, etc.) and 2.0 pounds of edible garbage per day. Quantity determinations, however, will be based on an actual survey whenever practicable. Capacity will be provided for 25 percent excess over the average hourly needs in order to make allowance for irregularity in the delivery of refuse to the incinerator. For example, if 4 tons are to be burned in 8 hours, the incinerator will have a capacity of 1,250 pounds per hour. Capacity factor for troop expansion will not be used, as the incinerator can be operated 16 hours per day, if necessary, 8 hours remaining for cooling and cleaning. Little or no economy will result in designing special incinerators of sizes intermediate between the sizes indicated on the standard designs listed in appendix B.

1-4. Basic design requirements. The incinerator will be designed for the severest conditions that may reasonably be expected. For instance, a type I incinerator may be required to burn refuse consisting of all dry material and no garbage. The design, therefore, insofar as it involves heat release, gas quantities, velocities, etc., will be based on burning only dry materials. A drying hearth will be provided for the occasions when wet materials are to be burned. The design will conform to the following basic requirements:

a. Total furnace volume. The total furnace volume will be such that the heat release per cubic foot of furnace volume will not exceed 18,000 Btu per hour.

b. Hearth area. The hearth area will be approximately equal to the grate area for types I and II incinerators.

c. Effective grate area. For type I incinerators - 0.022 square foot for each pound of refuse per hour; and for type II - 0.04 square foot for each pound of refuse per hour. In determining effective grate area, the hearth may be considered to be 60 percent effective if made of firebrick and 80 percent if made of grate bars.

d. Gas velocity. A maximum of 15 fps through the combustion chamber and a maximum of 35 fps through the mixing chamber, flue, and stack.

e. Combustion-chamber volume. At least 30 cubic feet per pound of gas produced per second, including excess air required for cooling purposes.

f. Combustion-chamber temperature. Sufficient for complete combustion but not to exceed 1,600-degree F. (2,059 degrees F. absolute). This can be controlled by use of the damper and by the introduction of excess air.

g. Combustion time. A minimum of 1.5 seconds, total time required for the gases to pass through the furnace.

h. Stack height. Sufficient to provide the necessary draft and determined by the formula:

$$H = \frac{D}{0.52\ B\left(\frac{1}{T_a} - \frac{1}{T_s}\right)}$$

i. Draft. Sufficient to discharge the gases of combustion and required excess air. The total draft requirements will be determined in accordance with the following allowances for losses expressed in inches of water:

$$Velocity\ head = \frac{0.119BV^2}{14.7T_s}$$

$$Friction\ loss\ through\ the\ stack\ and\ flue = \frac{(1.1 \times 10^{-6})T_s W^2 LP}{A^3}$$

Loss through each 90 degrees turn in the gas passage: computed as a stack or conduit, the length of which is 12 times the square root of the area of the opening. Loss through grate: varies according to type of grate, quantity, and type of refuse burned, quantity of air and attention given to stoking. Under average conditions this loss may be considered to be 0.25 in type I incinerator and 0.15 in type II when the furnace is operating at rated capacity.

Abbreviations of terms used in the preceding formulas are:

Ta - Atmospheric temperature in degrees F. (absolute).

Ts - Average stack-gas temperature in degrees F. (absolute).

H - Stack height above the grate (feet).

A - Average inside cross-sectional stack area (square feet).

B - Barometric pressure (psi).

D - Static stack draft (inches of water).

V - Gas velocity (fps).

W - Weight of gas including excess air (pounds per second).

L - Stack height above flue plus length of flue (feet).

P - Inside stack perimeter (feet).

1-5. Preliminary design. A preliminary design will be made first and then checked and adjusted to assure compliance with the basic design requirements. For this purpose, table 2-1 may be utilized. The design of an incinerator is illustrated in appendix A.

Table 2-1. Preliminary Design Factors

	Type of Incinerator	
	I	II
Effective grate area per pound of refuse per hour (square feet)	0.022	0.04
Ratio of hearth area to grate area	1	1
Effectiveness of hearth area in terms of grate area (percent):		
Firebrick hearths	60	60
C. I. grate bars	80	80
Horizontal cross-sectional area of mixing chamber in terms of effective grate area (percent)	25	20
Horizontal cross-sectional area of combustion chamber in terms of effective grate area (percent)	60	30
Cross-sectional area of flue in terms of effective grate area (percent)	25	10
Cross-sectional area of stack in terms of effective grate area (percent)	22	10
Ratio of height of arch above grate to width of furnace not to exceed	1	1

1-6. Design analysis. A design analysis will accompany all requests for authority to construct incinerators and all incinerator plans and specifications, other than standard plans and specifications. The analysis will indicate the type of material to be incinerated and the basis upon which the capacity requirements were established.

MATERIALS AND EQUIPMENT CONSIDERATIONS

2-1. General considerations. The structural design and the specifications relating to materials and to will provide construction for sturdy construction of all parts of in this the incinerator. respect, the effects of expansion and contraction due to high-temperature change will be considered. The type of construction will, in general, be as indicated on the standard drawings and in the guide, specification listed in appendix B.

2-2. Furnace. The furnace will be constructed with an inner and outer shell. The walls of the inner shell and the arch will be approximately 9 inches thick and constructed of high-duty fire-clay brick or constructed of refractory plastic material having equivalent qualities. Firebrick will be laid in high-temperature, air-setting, bonding cement. The arch will be covered with a 2-1/2-inch layer of insulating material. The side walls of the outer shell will be 8-inch common brick walls securely braced to prevent settling and cracking. The bracing will consist of upright corner angles and intermediate upright channel buck stays, tied with rods and horizontal steel angles. The tie rods will be entirely outside the inner shell and will not be in contact with the refractory material at any point. The top, forming a part of the outer shell, will be reinforced concrete. If the top is not needed as a floor or as a roof for protection against the weather, it may be omitted and the arch covered with a 4-inch layer of common brick on top of the insulating brick. There will be no physical connections between the inner shell and the outer shell except the skewbacks of the arches, where the outer shell will be properly braced to take the arch thrust, and except around openings. The inner and outer shells will be separated by suitable insulating material or air space. The bridge wall and target wall will be 13-1/2-inches thick in incinerators of 1,000 pounds per hour capacity or larger and 9 inches thick in smaller sizes.

2-3. Stack. The stack will be constructed with an inner shell of fireclay brick for the entire height and an outer shell of common brick. The outer shell will be separated by a 2-inch air space from the inner shell and will have no physical contact with it at any point. The stack may be square or circular; however, the cross-sectional area will be the same for either shape.

2-4. Damper. The damper will be a movable vertical slab constructed of refractory material, steel shapes, and tie rods. It will be located in the flue and will fit freely in guide grooves. Suitable means, such as a chain hoist or cables, pulleys, and counterweights, will be provided for raising and lowering the damper. A damper box will be provided for housing the damper in its open position.

2-5. Furnace doors. The size, type, and location of the furnace doors will be determined with a view toward convenience of incinerator operation. The following comments relate to the doors of incinerators of 1,000 pounds per hour capacity or larger: Types I and II incinerators require means of charging the drying hearth with wet material. This can be accomplished through a charging throat extending from the furnace arch to the operating floor above. A removable lid will be provided for the

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