

## CHAPTER 2

### INCINERATOR DESIGN

2-1. Definitions. Definitions of terms in their application to this manual are as follows:

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. The arched ceiling of the furnace over the ignition, mixing, and combustion chambers.

d. Grate. The cast iron (C.I.) grate on which the dry material is burned.

e. Hearth. An inclined floor on which the wet material is dried and burned. It may be constructed of firebrick or of cast iron grate bars.

f. Effective grate area. The grate area plus the effective area of the hearth in terms of grate area.

g. Ignition chamber. The space between the grate and the arch and between the hearth and the arch.

h. Mixing chamber. The chamber adjacent to the ignition chamber where the gases mix before passing to the combustion chamber. This is often called the down pass.

i. Bridge wall. The wall at the end of the grate or hearth between the ignition chamber and the mixing chamber.

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

k. Target wall. The wall between the mixing chamber and the combustion chamber.

l. Flue. The horizontal connection between the combustion chamber and the stack.

m. Damper. The vertical movable refractory slab in the flue for draft control.

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n. Damper box. The box over the damper for housing it in its open position.

o. Charging hood. A structure directly over the ignition chamber provided with a door, through which the furnace is charged with refuse.

p. Charging throat. An extension from an opening in the arch to the charging floor, through which the furnace is charged with refuse.

2-2. Types of incinerators. Two types of incinerators are considered in this section: type I - garbage and rubbish incinerators and type 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.

2-3. 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 of 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.

2-4. 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:

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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:

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

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

Loss through each 90 degree turn in the gas passage: computed as a stack or conduit, the length of which is 12 times the square root of

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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:

- T<sub>a</sub> - Atmospheric temperature in degrees F. (absolute).
- T<sub>s</sub> - 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).

2-5. 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

	<u>Type of incinerator</u>	
	<u>I</u>	<u>II</u>
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

Table 2-1. Preliminary Design Factors (Cont'd)

	<u>Type of incinerator</u>	
	<u>I</u>	<u>II</u>
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

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2-6. 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.