

Step 2. The Destruction and removal efficiency:

$$\text{DRE} = 1 - \exp(-k*t)$$

where $t = 3.8 \text{ sec}$ (dwell time)

Values for DRE are also presented in Table I. 1-1 of CD .97.

- a. In verification of the DRE calculation, staff notes that using a flame temperature of 2108 °K and dwell time of 3.8 seconds that

$$\text{DRE} = 1$$

for all components of the HWF. In other words one would expect total destruction of all components of the HWF.

- b. Repeating the calculation using the k values reported in Table I. 1-1 and the dwell time of 3.8 seconds, the DRE values of Table I. 1-1 are obtained.
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EMISSIONS RATES FROM A HWF FIRE

- a. Air emission rates are presented in Tables I. 1-3. In our verification the evaporation rate of waste fuel during the fire was calculated for each component.

For example:

emissions of acetone = (evap. of acetone)*(1 -DRE) or

$$\text{evap. of acetone} = \frac{\text{emissions of acetone}}{(1 - D R E)}$$

This calculation was repeated for each component of the HWF and

$$\text{total evaporation rate} = 236 \text{ g/sec}$$

- b. Since the HWF must vaporize before it can burn, the evaporation rate should- be equal to or greater than the burn rate. But instead

$$\frac{\text{total evaporation}}{\text{burn rate}} = \frac{236}{9970} = 1/40$$

BURN RATE AND EVAPORATION RATE

- a. SWPC writes the equation for the heat released by combustion as follows:

$$H_c = \text{burn rate} * \text{heat content}$$

- b. Ref. #2 writes the equation for the heat released by combustion as follows where "b" is the burn eff.

$$H_c = b * \text{fuel evap. rate} * \text{heat content}$$

- c. It then follows that:

$$\text{Burn rate} = b * \text{fuel evaporation rate}$$

- d. If $b = 1$ then fuel evaporation rate = burn rate
- e. For large fires Ref. #2 estimated that $b = 0.64$ and therefore fuel evaporation rate = $1.56 * (\text{burn rate})$.
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WHAT DRE WOULD BE EXPECTED FOR AN OPEN POOL FIRE

SWPC

	DRE
nonchlorinated HWF constituents	0.9396 to 0.99483
chlorinated HWF constituents	0.4541 to 1

Ref. # 2

for pools less than 100 cm diameter

	Burn eff.
1. methanol	0.95
2. kerosene	0.73

for pools greater than 100 cm diameter

1. As diameter increases, burn efficiency should decrease.
 2. In models of fires of diameter greater than 100 cm. 0.64
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AIR EMISSIONS USING REF. #2'S COMBUSTION EFF.

In general form emissions = $(1 - \text{DRE}) * \text{burn rate}$.

- a. Based upon the SWPC DRE values for nonchlorinated chemical constituents:

Emissions are less than $(1 - 0.9396) * \text{burn rate}$
or $0.04 * \text{burn rate}$

- b. Based upon the least efficient burn efficiency of Ref. #2:

Emission are about $(1 - 0.64) * \text{burn rate}$
or $0.36 * \text{burn rate}$

- c. Thus emissions would be about nine times greater using the Ref. #2 combustion efficiency.
- d. Including this factor of nine with the previous observation that evaporation rate was only about 1/40 of the burn rate suggests the values for emission rates of Table I. 1-3 of nonchlorinated constituents may actually be 1/360 th instead of 1/40 th of actual emissions.
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FLAME RESIDENCE TIME CALCULATION

From PETERS, Ref #4 SWPC presents

- A. For heat transfer from turbulent flow inside a circular pipe the heat transfer coefficient is:

$$h_t = 0.0144 * C_p * G^{0.8} / D_{0.2}$$

- B. For free natural convection of gases the heat transfer coefficient is:

$$h_{nc} = K * (T_p - T_a)^{0.25}$$

- C. SWPC than writes the equation:

$$h_t = h_{nc}$$

and solves for mass flow G.

Temp height

695 K 34 M

804 K 27 M

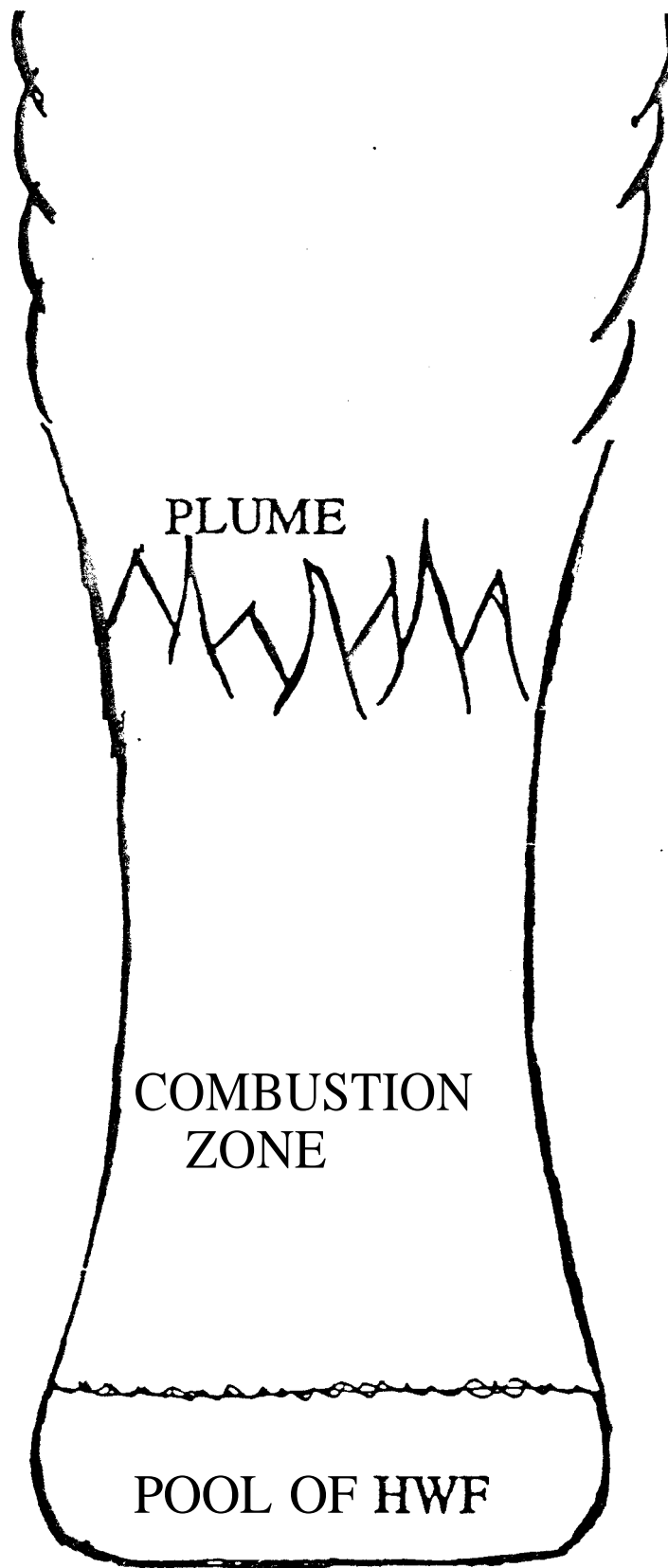
918 K 20 M

1180K 14 M

1102 K 11 M

1013 K 7 M

596 K 0 M



Schematic of a fire in the containment area showing the various temperature zones (based on Ref. 5, Figure 4)

FLAME HEIGHT CALCULATION

- a. SWPC calculated flame height using the following eq. from Ref #1.

$$Z = \frac{84r[m_c(2gr)^{0.5}]^{0.61}}{\text{density of air at the flame temperature}}$$

	Flame temp. -----	Flame height -----
SWPC temp.	2108 °K	64 meters
Ref s temp.	1100 °K -----	33 meters

This shows that a discrepancy in flame temperature will lead -to a discrepancy in flame height.