From the desk of:

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Waste Management Branch

SAHWM

DATE 11/27/89

To: MR. STEVE BUSCH

Enclosing a copy of the Evaluation Guide as you have requested

Please call me at 886-6140 if you have any suggestions. (FTS NO.)

Thanks.

EPA ARM/HAZM
NOV 29 1989
Region VII K.C., MO

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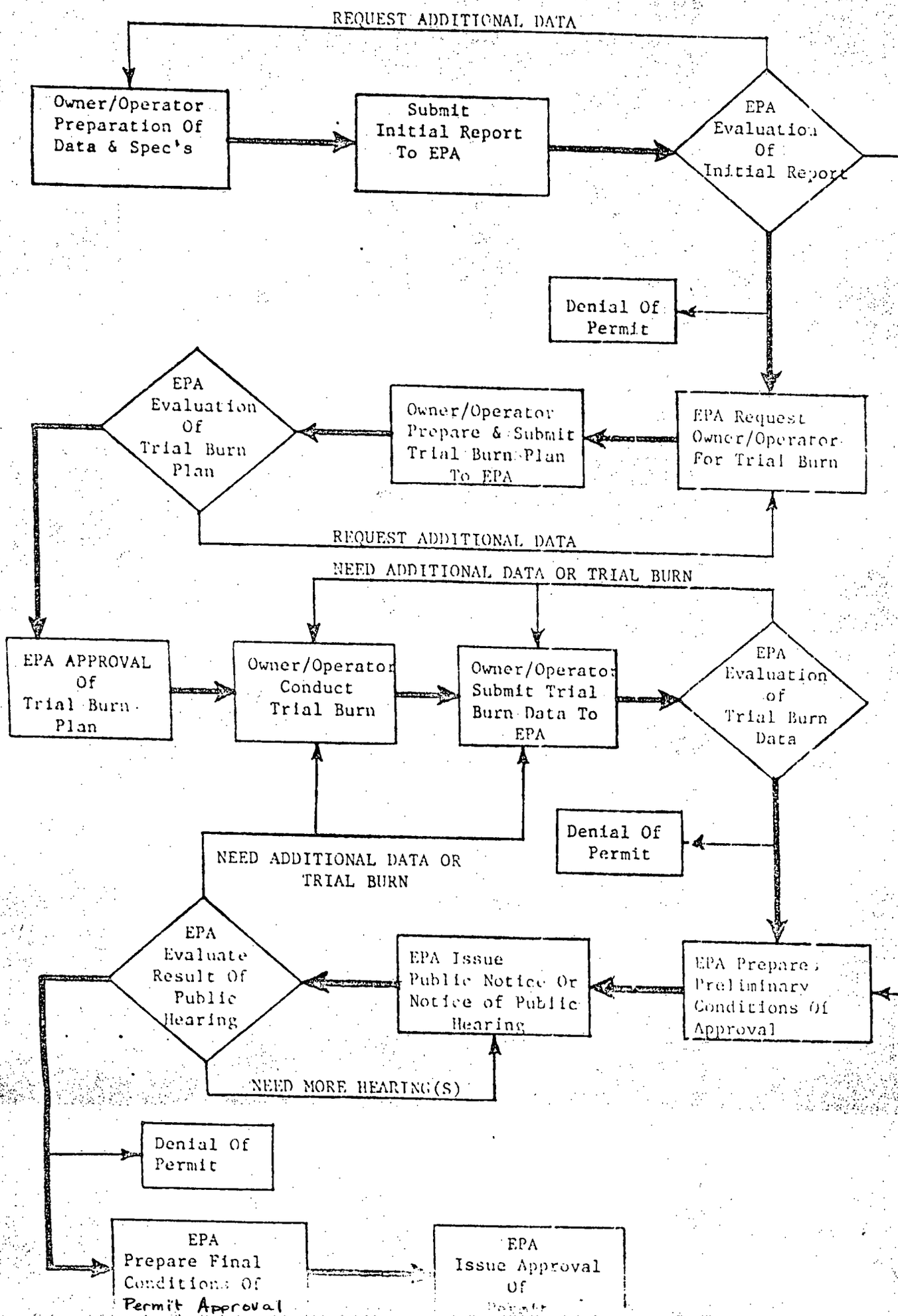
Superfund

EVALUATION GUIDE
APPLICATION FOR PCB INCINERATION

I. FLOWCHART - Application & Approval Sequence (Per Annex I, Subpart E)



II. TECHNICAL REQUIREMENTS FOR APPROVAL OF AN INCINERATION FACILITY

(1) LIQUID PCB's

(A) Combustion criteria:

(I) 2 seconds at $1200^{\circ} \pm 100^{\circ}C$ ($2192^{\circ} \pm 180^{\circ}F$) w/3% excess oxygen, or _____

(II) 1½ seconds at $1600^{\circ} \pm 100^{\circ}C$ ($2912^{\circ} \pm 180^{\circ}F$) w/2% excess oxygen _____

(B) Efficiency = 99.9% $\leq \frac{(CO_2) \times 100}{(CO_2) + (CO)}$ _____

(C) Rate and quantity of PCB's entering are measured and recorded regularly at intervals of no greater than 15 minutes. _____

(D) Temperature is continuously measured and recorded

(I) Based on Pyrometer, or _____

(II) Based on wall thermocouple-pyrometer correlation _____

(E) Flow stops automatically when:

(I) Combustion temperature drops below specified _____

(II) Excess O_2 drops below specified _____

(III) Failure in continuous monitoring of O_2 & CO _____

(IV) Failure in periodic monitoring of CO_2 _____

(V) Failure in recording of PCB rate & quantity _____

Or, submit approvable Contingency Plan for above conditions. _____

(F) Monitoring of emissions:

(I) When incinerator is first used _____

(II) If incinerator has been modified _____

(III) Monitor the following:

(a) O_2 _____

(b) CO _____

(c) CO_2 _____

(d) NO_x

(e) HCl

(f) Total chlorinated organics (RCL)

(g) PCB's

(h) Particulates

(IV) Continuously monitor the following:

(a) O_2

(b) CO

(c) CO_2 - Periodic (To be specified by EPA)

(G) Scrubbers shall be used for HCl control

(H) Scrubber effluent shall be monitored

(I) Alternate method of HCl control can be used if approved by the Regional Administrator

(2) NON-LIQUID PCB's

(A) Emissions $\leq$ 0.001 g PCB's/ kg PCB's entering

(B) Comply with (1)-(B), (C), (D), (E - except 11, excess O_2), (F), (G), (H), & (I)

(C) Flow shall stop if temperature drops below specified

(D) Operators shall stop immediately whenever excess O_2 falls below specified.

(3) APPROVAL OF INCINERATORS

(A) Initial report should contain:

(I) Location of incinerator
(II) Detailed description of incinerator
(III) Engineering reports on anticipated performance
(IV) Sampling and monitoring equipment available
(V) Waste volumes expected to be incinerated
(VI) Any State, local or Federal permits or approvals
(VII) Schedules and plans for compliance with this regulation

(4) STORAGE FACILITIES

(A) Roof and Walls to stop rain water from reaching PCB _____

(B) Is Storage Area continuously curbed? (Min. 6" High) _____

(C) Containment Volume, the larger of:

i. 25% of Total Internal Volume _____

ii. Two times the largest Container _____

(D) No Drain Valves _____. No Floor Drains _____. No Sewer Lines ___

No Expansion Joints _____. No other Openings _____.

(E) Floors & Curbing smooth and impervious? (cement concrete, steel, etc.) _____

(F) Is the Site above 100-year Flood Water Elevation? _____

(G) Spill Clean Up Equipment & Supplies provided? (Sorbents, Portable Pumps, Empty Containers - 18 Ga. & 24 Ga. for 55-Gal. & 5-Gal. Containers) _____

(H) Safety Equipment & Supplies

i. Gloves, Respirators, Goggles, Safety Shoes, etc. _____

ii. H-C Detectors or Sniffers _____

iii. Fence (?), or Warning Signs? _____

(5) RECORD KEEPING PROCEDURES (Per ANNEX VI.)

(A) Manifest Forms _____

(B) Journal - Shipping (Incineration) & Receiving _____

(C) Inventory Forms - Wkly, Monthly, Yearly, etc. (Annual Report - Due July 1.) _____

III. SAMPLE CALCULATION - COMBUSTION DATA

Basis: Steady State Operation, Burning 100 lbs PCBs + 100 lbs. Fuel Oil #2

A. Material Balance

1. Input

a) #2 Fuel Oil (API Gravity 33^0), 100 lbs.

Component	Wt. %*	Reaction	lbs. O_2 Required
C	87.2	$C + O_2 = CO_2$	87.2 x 32/12 = 232
H_2	12.5	$H_2 + \frac{1}{2}O_2 = H_2O$	12.5 x 16/2 = 100
S	0.25	$S + O_2 = SO_2$	0.25 x 32/32 = 0.25
Total	100%		332.25 lbs. O_2

(*Source: Chem. Eng. Handbook)

b) PCBs

Stoichiometric Equation:

$$C_{12}H_{6.3}Cl_{3.7}^{*} + 12.65O_2 = 12CO_2 + 1.3H_2O + 3.7\ HCl$$

Component	Wt. %	Reaction	lbs. O_2 Required
C	51.2	$C + O_2 = CO_2$	51.2 x 32/12 = 136
H_2	2.2	$H_2 + \frac{1}{2}O_2 = H_2O$	2.2 x 16/2 = 17.6
Cl_2	46.6	$H_2 + Cl_2 = 2\ HCl$	
Total	100 %		153.6 lbs.

(*$C_{12}H_{6.3}Cl_{3.7}$ represents mean molecular composition of typical PCBs in use in the U.S.)

c) Total Theoritical Oxygen: 332.25 lbs. O_2 + 153.6 lbs. O_2

= 485.85 lbs O_2

d) Total Theoritical Air:

Composition: Oxygen : 20.6 Vol % = 22.7 Wt %

N_2 & Others: 79.4 Vol % = 77.3 Wt %

Theoretical Air: 485.85/0.227 = 2140.3 lbs.
Which includes: 485.85 lbs. O_2
1854.45 lbs. N_2

e) Excess Air (30 %*) : 2140.3 x 0.3 = 642.1 lbs.
Which includes: 642.1 x 0.227 = 145.8 lbs. O_2
642.1 x 0.761 = 488.6 lbs. N_2

(Note*: 30% is used to represent the practical level of excess air a waste incinerator can be operated on.)

2. Output (Basis 100 lbs. PCBs + 100 lbs Fuel Oil)

a) Weight of Flue Gas

Component	Weight, lbs.
CO_2	(87.2 + 51.2) x 44/12 = 507.46
H_2O	(12.5 + 2.2) x 18/2 = 132.3
SO_2	0.25 x 64/32 = 0.5
HCl	46.6 x 36/35 = 47.93
Theoretical N_2	1654.45
Excess Air	642.1
Total	2984.74

b) Volume of Flue Gas, STP

Component	Weight, lbs.	M Wt.	Moles	Volume, Ft^3
CO_2	507.46	44	11.53	11.53 x 360 = 4150.8
H_2O	132.3	18	8.82	8.82 x 360 = 3175.2
SO_2	0.5	64	----	
HCl	47.93	35	1.37	1.37 x 360 = 493.2
Theoretical N_2	1654.45	28	59.09	59.09 x 360 = 21272.4
Excess Air	642.1	29	22.14	22.14 x 360 = 7970.4
Total	2984.74			37,062 Ft3

c) Volume of Flue Gas, 2000°F

$$2000^{o}F \text{ Volume} = \text{Volume at STP} \times \frac{2000 + 460}{32 + 460}$$

$$= 37062 \text{ Ft3} \times \frac{2460}{492} = 185{,}310 \text{ Ft3}$$

B. SUMMARY OF MATERIAL BALANCE

1. Input*

Component	Weight, lbs.
Fuel Oil	100
PCBs	100
Theoretical Air	2140.3
Excess Air	642.1
Total	2982.4

2. Output

Component	Weight, lbs.
Fuel Oil	
CO_2	319.73
H_2O	112.5
SO_2	0.5
PCBs	
CO_2	187.73
H_2O	19.8
HCl	47.93
Theoretical N_2	1654.45
Excess Air	642.1
Total	2984.7

(* Note: If Fuel Oil or PCB contain moisture it should be included as inert material)

C) ENERGY BALANCE

1. Input (Basis = 100 lbs. fuel oil + 100 lbs. PCBs)

a) Heat of Combustion of fuel oil

#2 Fuel Oil = 33 API, 131500 Btu/ga*
= 131500 Btu/ga ÷ 7.5 lb/ga
= 17533 Btu/lb x 100 lbs
= 1,753,300 Btu

(* Source: Chemical Engineering Fundamentals)

b) Heat of Combustion of PCBs

PCB = $C_{12}H_{6.3}Cl_{3.7}$

Cl = 46.6 %

* Hc = 8962 Btu/lb x 100 lbs.

= 896,200 Btu

(* Source TRW, Inc.)

c) Total Heat Input

= 1,753,300 + 896,200
= 2,649,500 Btu

2. Output

a) Enthalpies of combustion products
(Basis: 100 lbs. fuel oil + 100 lbs. PCBs)

General Equation:

$$H_{T_1} = A(T_2 - T_1) + B\left(\frac{T2}{100}\right)^2 - \left(\frac{T1}{100}\right)^2 + C\left(\frac{T2}{100}\right)^3 - \left(\frac{T1}{100}\right)^3$$

$T_1 = 2000\ ^oF$

$T_2 = 60^oF$

$T_2 - T_1 = 1940$

$$\left(\frac{T2}{100}\right)^2 - \left(\frac{T1}{100}\right)^2 = 399.64$$

$$\left(\frac{T2}{100}\right)^3 - \left(\frac{T1}{100}\right)^3 = 7999.784$$

*Combustion product	A	B	C	H_{t_1} . Btu/mole
CO_2	6.85	23.7	-0.254	20728.5
**H_2O	6.89	18.25	-0.106	19812.1
N_2	6.30	5.05	-0.036	13956.2
O_2	6.13	8.3	-0.083	14546.0

(** Includes evaporative heat losses)

Combustion product	Moles	H_{T_1} , Btu
CO_2	11.53	239,000
H_2O	8.82	174,743
N_2	76.54	1,068,208
O_2	4.56	66,33o
HCl	1.37	-172,620
Total		1,375,661 Btu

(*Table from Chemical Engineering Fundamentals)

b) Heat Losses

(I) Radiation and convection heat loss
= 20 % of total heat input*
= 0.20 (2,649,500 Btu)
= 529,900 Btu

* This figure will vary according to geometry of incinerator thickness or refractory, etc. It is desired that the applicant provide his or her own figure based on sound engineering calculations.

(II) Evaporative Heat Loss

= (lbs. H_2O input in PCB and fuel) (H evap) *

* Evaporative Heat Losses are assumed to be zero for this specific calculation, but this will not always be the case.

(III) Total Heat Loss
= Radiation and convection + Evaporation
= 529,900 Btu

c) Final Energy Balance

Heat input - Heat output = Heat accumulation*

2,649,500 Btu - 1,375,661 Btu - 529,900 Btu = Heat Accumulation

Heat accumulation = 744,839 Btu

* If the accumulation term is positive, the incinerator design is sufficient to incinerate the given percentage of chlorine in the fuel and PCB mixture (in this case 23.3 % chlorine). However, if the accumulation term is negative, the ratio of PCBs to fuel must be adjusted in order to provide for adequate incineration of the PCBs.

Note: If atomizing steam is used the amount should be included in the material and energy balance.