Environmental Performance Test of Hazardous Waste Incinerator in Indonesia

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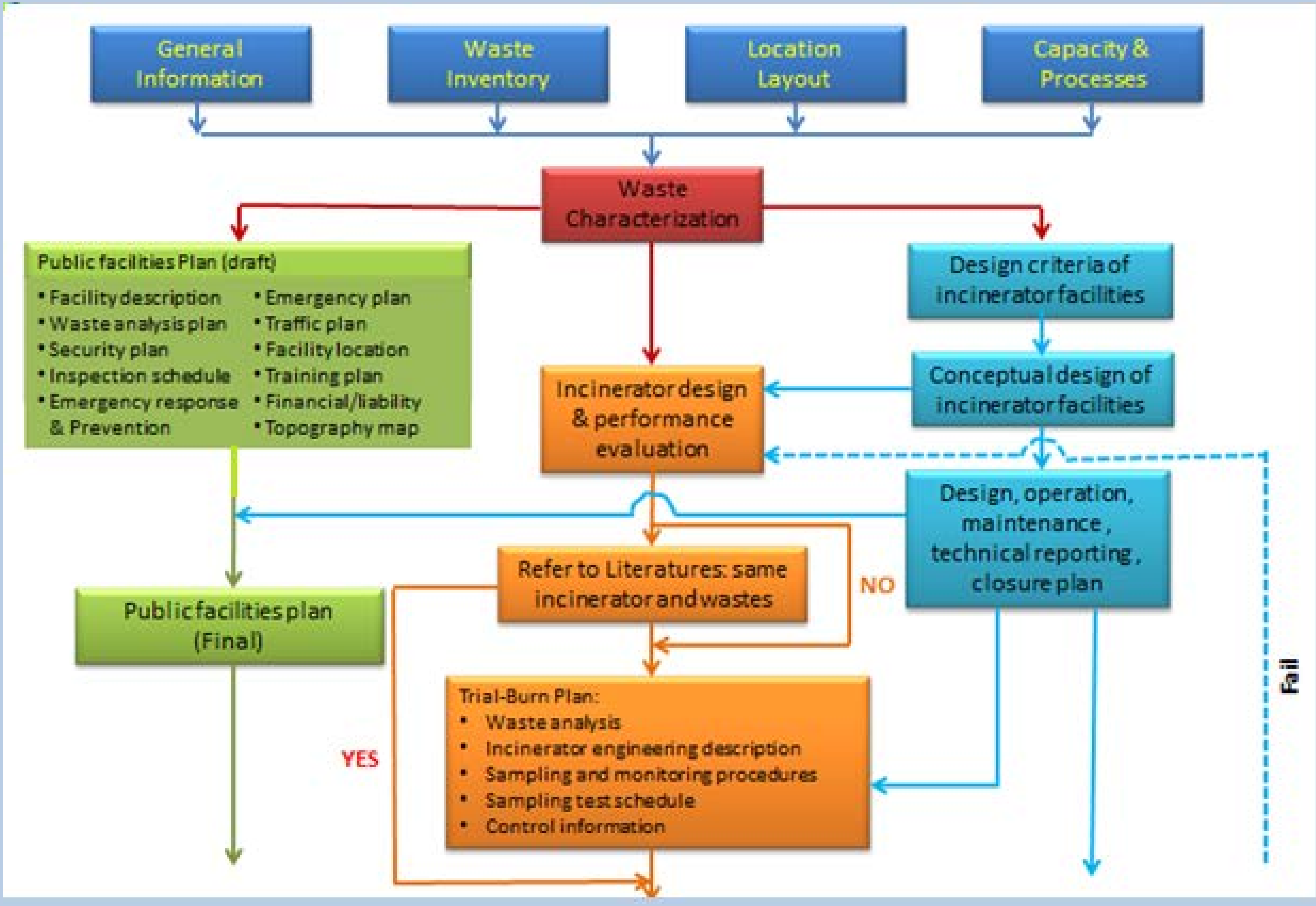
1. INTRODUCTION

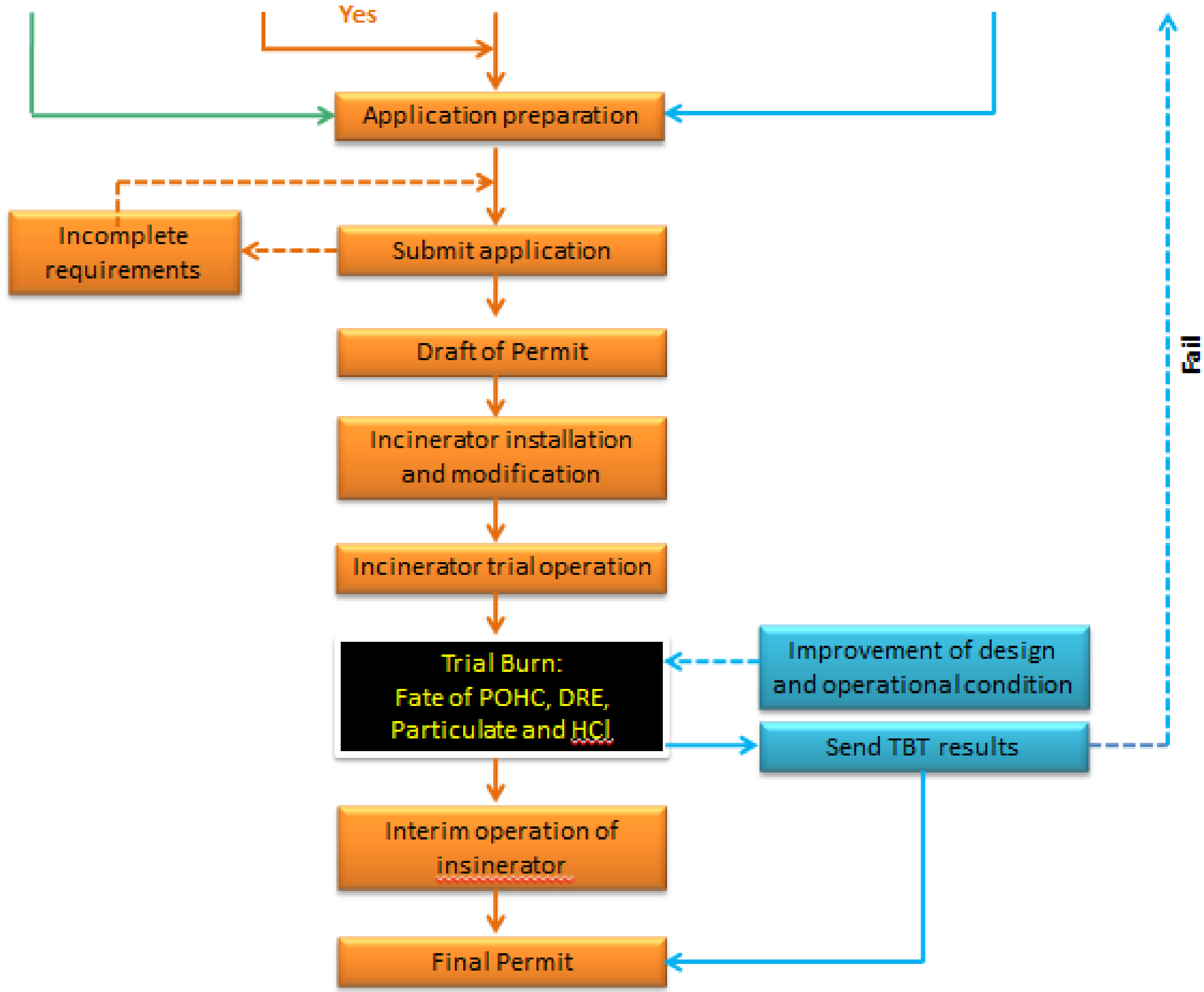
- Hazardous wastes (HW) in Indonesia has increased due to industrial development.
- If not properly managed, HW will degrade the environment and then affect other sectors: economy, social and health.
- Landfill as primary HW disposal cannot be continuously employed due to land scarcity.
- Incineration is now becoming more attractive method to landfill disposal for HW treatment.
- Thus, incinerators attract many HW related business people in Indonesia to use them.
- They are starting to submit to the Government for having permit.

1. INTRODUCTION

- Incinerator destroys toxic organic compounds and reduces the volume of hazardous waste by converting solids and liquids to ash.
- It needs proper mixing of air, waste and fuel; produces high temperature, and requires adequate time to allow destruction of organic constituents.
- Performance test is required to meet the regulated standard values of the parameters tested.
- Demonstration to show the environmental performance of the incinerator is known as trial burn test (TBT).
- This presentation will show you how a such business occurs in Indonesia.

2. HW INCINERATOR PERMIT PROCESSES

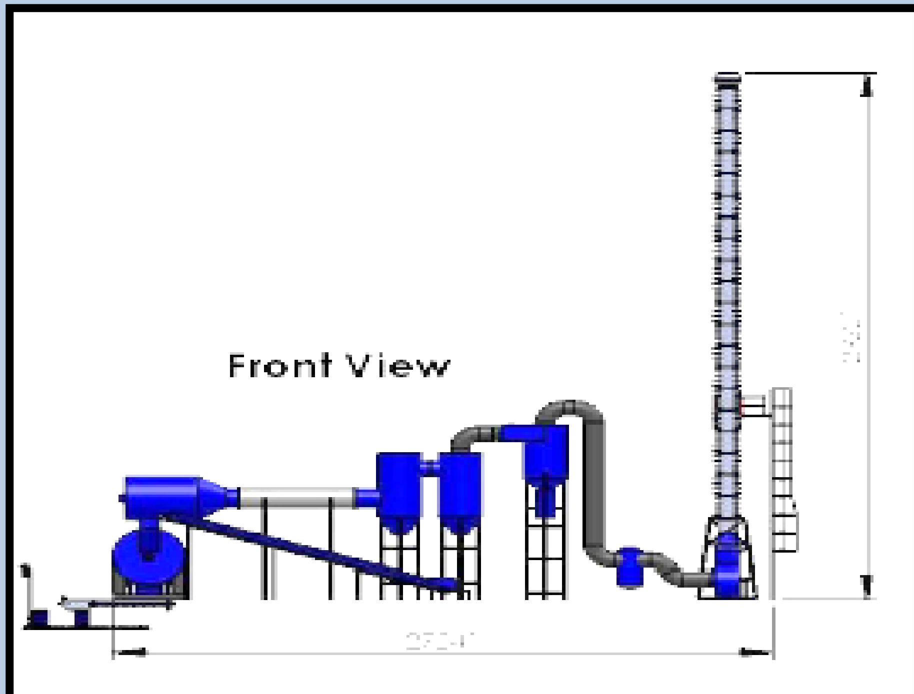


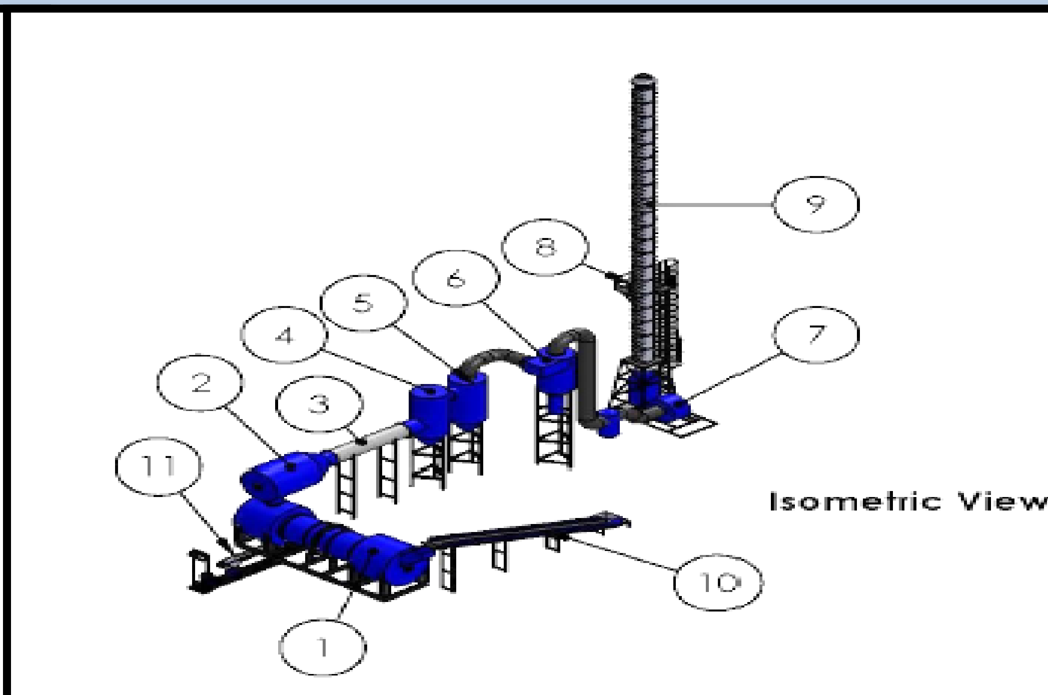

Yes
Application preparation
Incomplete requirements
Submit application
Draft of Permit
Incinerator installation and modification
Incinerator trial operation
Trial Burn:
Fate of POHC, DRE,
Particulate and HCl
Improvement of design and operational condition
Send TBT results
Fail
Interim operation of insinerator
Final Permit

3. FACILITIES OF INCINERATOR

- There are several types incinerators used for HW destruction in Indonesia, for example: liquid spray; pressure jet and rotary kiln type incinerators.
- Two chambers are commonly constructed: 1st and 2nd chamber.
- APC devices used are mostly cyclone and scrubber to collect particulate as well as acid gases.
- They are installed with a stack at certain height to vent the gaseous emissions resulted from the incineration of HW.
- Sampling facilities such as platform, safety stair and isokinetic sampling holes are provided.

3. FACILITIES OF INCINERATOR





ITEM	DESCRIPTION
1	Chamber-1 (Rotary kiln)
2	Chamber-2
3	Heat exchanger
4	Water scrubber-1

ITEM	DESCRIPTION
5	Water scrubber-2
6	Cyclone
7	IDF
8	Platform & sampling holes

ITEM	DESCRIPTION
9	Exhaust stack
10	Waste feeding conveyor
11	Ash screw conveyor

3. FACILITIES OF INCINERATOR

A rotary kiln type incinerator, 600 kg of hazardous waste sludge per hour was studies as a case study.

4. HAZARDOUS WASTES BURNED

Parameter of Waste Burned	Limit	Unit
Sulfate (SO_3^-)	≤ 800	ppm
Nitrite (NO_2^-)	≤ 1000	ppm
Hydrogen Fluoride (HF)	≤ 10	ppm
Hydrogen Chloride (HCl)	≤ 70	ppm
Arsenic (As)	≤ 30	ppm
Cadmium (Cd)	≤ 20	ppm
Chromium (Cr)	≤ 2500	ppm
Lead (Pb)	≤ 7500	ppm
Mercury (Hg)	≤ 5	ppm
PCBs	≤ 5	ppm
Heating Value	>1650	kkal/kg
pH	4 – 11	-
Ash content	≤ 2	%
Sediment	≤ 10	%
Density	0.6 – 1.3	g/cm^3
Boiling point	20 - 250	^oC

No	Type of Waste	Composition
1	Sludge WWT	20%
2	Sludge oil	40%
3	Paint sludge	40%
Total		100%

5. PERFORMANCE TEST PARAMETERS OF HW INCINERATOR

Emission Parameter	Standard Emissions for Incinerator	Unit
Particulate	50	mg/m^3
Sulfur dioxide (SO_2)	250	mg/m^3
Nitrogen dioxide (NO_2)	300	mg/m^3
Carbon monoxide (CO)	100	mg/m^3
Hydrogen chloride (HCl)	70	mg/m^3
Hydrogen Flouride (HF)	10	mg/m^3
THC – as CH_4	35	mg/m^3
Arsenic (As)	1	mg/m^3
Cadmium (Cd)	0,2	mg/m^3
Chromium (Cr)	1	mg/m^3
Lead (Pb)	5	mg/m^3
Merkury (Hg)	0,2	mg/m^3
Thallium (Ti)	0,2	mg/m^3
Opacity	10	%

1. Combustion Efficiency : 99.99%
2. Gas residence time : ≥ 2 seconds
3. DRE-POHC: 99.99%
4. DRE-PCDDs/PCDFs : 99.9999%
5. DRE-PCBs : 99.9999%

This TBT did not do sampling of:

1. DRE-PCDDs/PCDFs : 99.9999%
2. DRE-PCBs : 99.9999%
3. HF

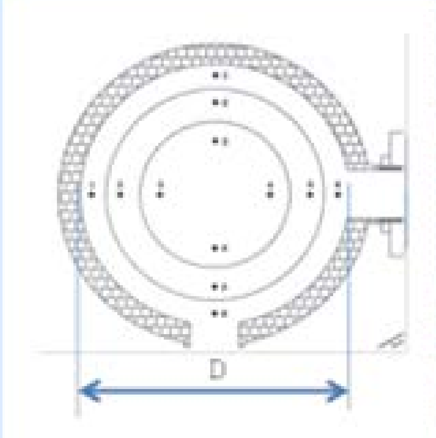
6. SAMPLING AND ANALYSIS:
Stack Sampling Plan

Sampled parameters	May 2015			
	9	10	11	12
A. DRE POHC:				
• 80%- Run1	■			
• 80%- Run2	■			
• 80%- Run3	■			
• 100%- Run1		■		
• 100%- Run2		■		
• 100%- Run3		■		
B. Other pollutants				
• 80%-Run 1			■	
• 80%-Run 2			■	
• 80%-Run 3			■	
• 100%-Run 1				■
• 100%-Run 2				■
• 100%-Run 3				■

- Date of stack sampling: May 9-12, 2015.
- Load: 80% and 100% of waste capacity, 3 runs per load.
- Other pollutants:
  1. Particulates and metals (As, Cd, Cr, Pb, Hg, Tl);
  2. HCl;
  3. Total hydrocarbon as CH_4, CO_2, CO, SO_2, NO_2;
  4. Opacity

6. SAMPLING AND ANALYSIS:
Stack Initial Data

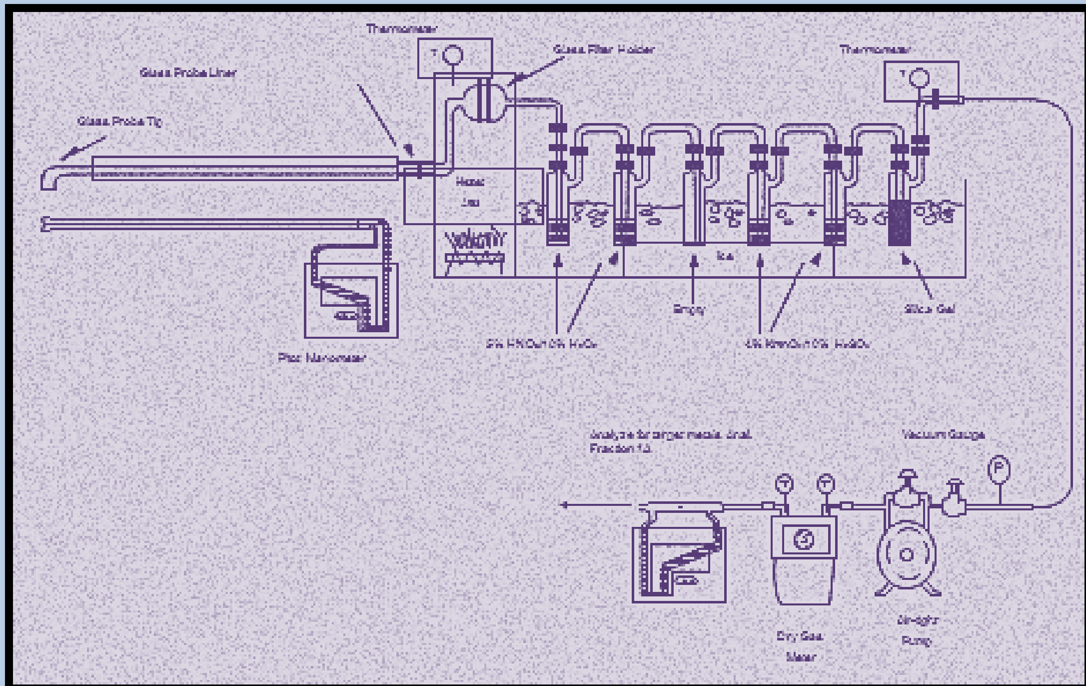
Stack specification	Size
Stack height from the ground, h	17.0 m
Stack diameter, D	0.75 m
Sampling hole position from the ground	12.2 m
Disturbance free stack height, H	13,0 m
Stack height of equivalent diameter	17.3 D
Sampling hole distance from upper disturbance, H_A	4.8m (6.4 D)
Sampling hole distance from lower disturbance, H_B	8.2m (10.9 D)



Distance from the wall	cm
1	3.30
2	10.95
3	22.20
4	52.80
5	64.05
6	71.70

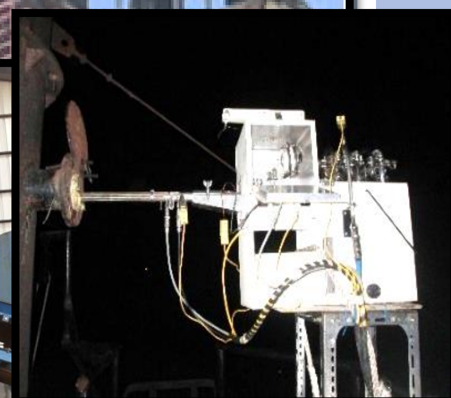
- Linier stack gas velocity: S-type pitot tube
- Dry gas molecular weight: Portable gas analyzer
- Gas moisture content: absorbent bottles

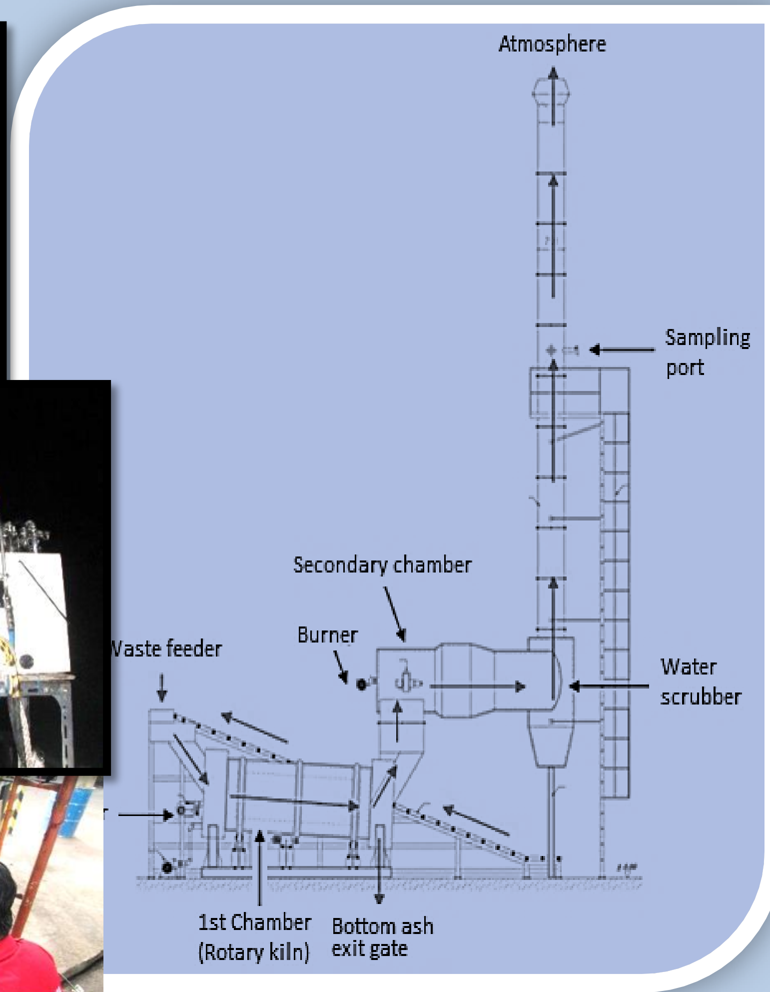
6. STACK SAMPLING: Particulates and heavy metals



- Isokinetic sampling – withdraw the flue gas via nozzle so that the linear velocity of the gas entering the nozzle is as close as the velocity of gas flowing in the stack.
- Particulate emission is collected on a heated filter and a probe line in front of the filter for gravimetric determination followed by digestion process for heavy metals detection.
- The gas is collected in 5% HNO_3/10% H_2O_2 acid solution contained in the impinger # 1 & 2 (for all heavy metals analysis but Hg), and in 4% $KMnO_4$/10% H_2SO_4 acid solution contained in the impinger # 4 & 5 (for Hg analysis).
- All recovered sample is digested and then analyzed for Hg by CVAAS and for other heavy metals by GFAAS.

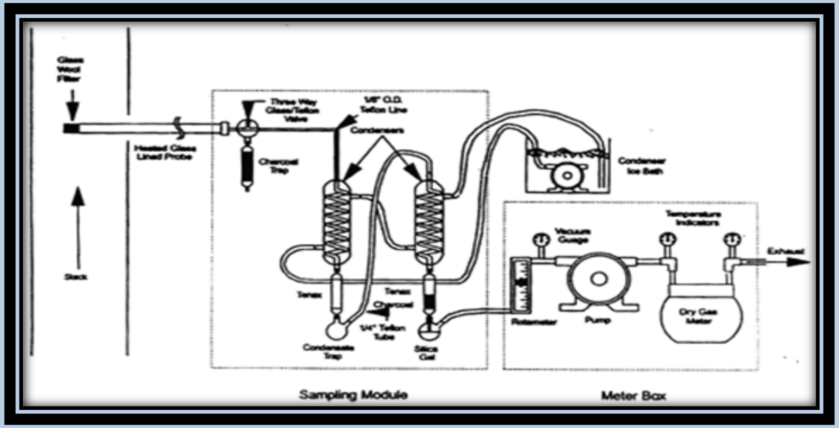
6. STACK SAMPLING: Sampling for Particulate and Metals; US-EPA Method 29





6. STACK SAMPLING: Particulate and Metals Sample Recovery

6. STACK SAMPLING: VOST, US-EPA Method 30 – POHC (TCE)



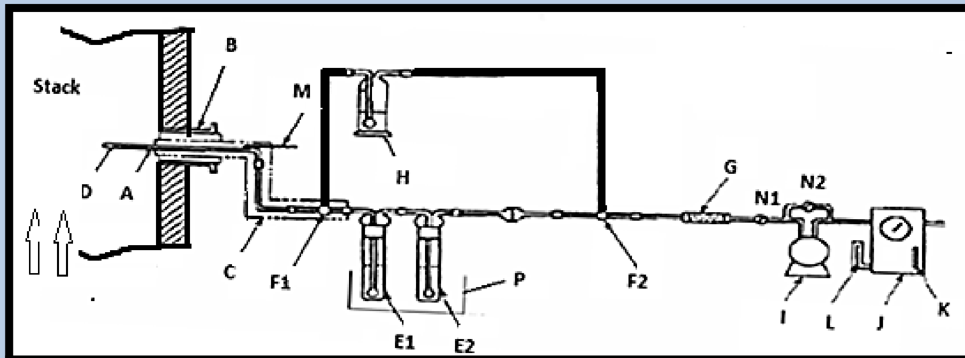
Sampling train for POHC (DRE)

Sampling into stack

Spiking TCE into waste

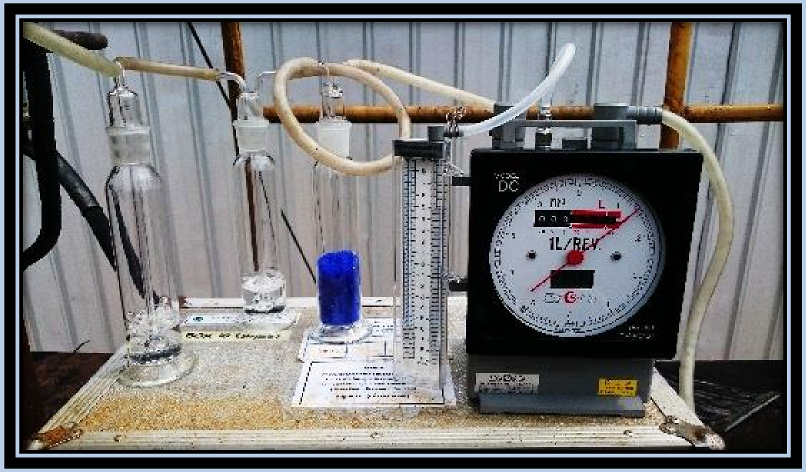
Meter Box

6. STACK SAMPLING: Sampling train for HCl gas



NOTE:

A : probe
B : flange
C : heating element
D : glass wool
E1, E2 : impinger, 250 mL
F1, F2 : three-way valve
G : dessicator
H : rinsed bottle
I : suction pump
J : gas meter
K : thermometer
L : manometer
M : temperature regulator
N1 : closing valve
N2 : flow rate regulator
O : flurorubber pipe
P : cooling bottle



6. STACK SAMPLING: Flue gas sampling using Portable Flue Gas Analyzer

Gas analyzer used to measure emitted gases from the stack

6. STACK SAMPLING: Opacity Detection

10 sacles

Smoke opacity measurement equipment based on ASTM D 2156-2003

Opacity measurement using telescope completed with a 5-scale Ringelmann

7. RESULTS OF INCINERATOR PERFORMANCE TEST

Parameter	80% Waste feed			100% Waste feed		
	Run-1	Run-2	Run-3	Run-1	Run-2	Run-3
Total sampling time, min.	60	60	60	60	60	60
Vol. of sampled gas, $V_{m(STD)}$, m^3	1,466	1,522	1,512	1,419	1,532	1,281
Stack temperature, °C	231	236	217	228	217	213
Gas linear velocity, m/s	11,12	11,07	10,77	10,10	9.67	9,81
Gas flow rate, ACT. m^3/h, db.	17676	17589	17128	16052	15371	15593
Gas flow rate, STD. m^3/h, db.	9637	9481	9625	8770	8781	8422
O_2 content, %	11,2	11,6	12,3	11,4	11,4	11,4
Isokinetic value, %	102,5	106,9	104,3	109,7	107,2	102,4
Fuel consumption, CFM	85	85	85	85	85	85
Waste feeding rate, kg/h	480	480	480	600	600	600
Gas retention time, second	2,38	2,35	2,25	2,43	2,42	2,75
Temperature of 1st chamber, °C	1256	1332	1315	1377	1322	1226
Temperature of 2nd chamber, °C	1109	1139	1129	1177	1198	1134

Incinerator operational conditions

7. RESULTS OF INCINERATOR PERFORMANCE TEST

Parameter	80% Waste feed			100% Waste feed			Standard Value
	Run-1	Run-2	Run-3	Run-1	Run-2	Run-3	
Sampling time, min.	60	60	60	60	60	60	
Particulate, mg/Nm^3	36,16	37,82	35,62	44,73	49,00	48,89	50
As, mg/Nm^3	<0,0191	<0,0191	<0,0191	<0,0191	<0,0191	<0,0191	1
Cr, mg/Nm^3	0,2562	0,6905	<0,0025	0,1277	0,2840	0,2552	1
Pb, mg/Nm^3	0,2136	0,6077	0,1266	0,2461	0,1801	0,1478	5
Cd, mg/Nm^3	0,0204	0,0198	0,0231	0,0211	0,0228	0,0239	0.2
Tl, mg/Nm^3	<0,0144	<0,0144	<0,0144	<0,0144	<0,0144	<0,0144	0.2
Hg, mg/Nm^3	<0,00056	<0,00056	<0,00056	<0,00056	<0,00056	<0,00056	0.2

Particulate and metals emission

7. RESULTS OF INCINERATOR PERFORMANCE TEST

$$DRE = \frac{W_{in} - W_{out}}{W_{in}} \times 100\%$$

Capacity	Run 1	Run 2	Run3
80% (480 kg waste/h & 85 CFM fuel)			
W_{in} (ng)	3.25×10^7	3.25×10^7	3.25×10^7
W_{out} (ng)	1503.5	1403.63	1299.71
DRE (%)	99.995	99.996	99.996
100% (600 kg waste /h & 85 CFM fuel)			
W_{in} (ng)	3.25×10^7	3.25×10^7	3.25×10^7
W_{out} (ng)	989.78	942.48	894.92
DRE (%)	99.997	99.997	99.997

DRE-POHC (TCE)

Run No.	80% Load, mg/Nm^3	100% Load, mg/Nm^3
1	19	23
2	22	24
3	21	24
Standard	70	70

Emitted HCl concentration

7. RESULTS OF INCINERATOR PERFORMANCE TEST

$$CE = \frac{[CO_2]}{[CO_2] + [CO]} \; x \; 100\%$$

Parameter	STD Value	Unit	80% Load Capacity				100% Load Capacity			
			Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average
NO_2	300	mg/Nm^3	45	50	48	48	57	63	60	60
SO_2	250	mg/Nm^3	12	13	19	14	19	3	3	8
THC (CH_4)	35	mg/Nm^3	10	<0,6	3	5	26	7	<0,6	11
CO	100	mg/Nm^3	9.1	<1	<1	3.0	10.3	<1	6.2	5.5
CO_2	---	%	6.8	6.7	6.9	6.8	6.8	7.0	6.5	6.8
O_2	---	%	12.2	12.9	12.5	12.5	12.4	12.5	12.7	12.6
CE	99.99	%	99.993	100	100	99.998	99.992	100	99.995	99.996

Note: Limit of detection of THC (Total Hydrocarbons) as CH_4 = 0.6 mg/Nm^3 and CO = 1 mg/Nm^3

Gas emissions and combustion efficiency of operated rotary kiln incinerator, corrected at 10% O_2.

7.RESULTS OF INCINERATOR PERFORMANCE TEST

Incinerator flue gas opacity

Opacity at 80% Load Capacity			
Run 1	Run 2	Run 3	Average
< 10%	< 10%	< 10%	< 10%
Opacity at 100% Load Capacity			
Run 1	Run 1	Run 1	Run 1
< 10%	< 10%	< 10%	< 10%

Gas residence time

$$t = \frac{V_{chamber}}{Q_{chamber}}$$

Parameter	Unit	Beban 80%			Beban 100%		
		Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
The average of gas residence time for rotary kiln incinerator = 2,61 seconds							
First Measurement							
Chamber 1	second	1,57	1,54	1,48	1,59	1,61	1,84
Chamber 2	second	0,81	0,81	0,77	0,84	0,81	0,91
Total	second	2,38	2,35	2,25	2,43	2,42	2,75
Second measurement							
Chamber 1	second	1,89	1,76	2,30	1,76	1,87	1,99
Chamber 2	second	1,00	0,91	1,20	0,90	0,96	1,11
Total	second	2,89	2,67	3,50	2,66	2,83	3,10

8. CONCLUSIONS AND RECOMMENDATIONS

Parameter	Sampling Data Value	STD Value
Isokinetic, %	101.6 – 109.7	90 - 110
Particulate, mg/Nm³	9.16 – 49.00	50
SO_2, mg/Nm³	3 – 19	250
NO_2, mg/Nm³	34 – 63	300
CO, mg/Nm³	< 1 – 10.3	100
HCl, mg/Nm³	< 4 – 24	70
HF, mg/Nm³	< 0.8 – 2.7	10
THC as CH_4 ,mg/Nm³	< 0.6 – 26	35
As, mg/Nm³	< 0.0191	1
Cd, mg/Nm³	0.0192 – 0.0239	0.2
Cr, mg/Nm³	<0.0025 – 0.284	1
Pb, mg/Nm³	0.1266 – 0.607	5
Hg, mg/Nm³	< 0.00056	0.2
Tl, mg/Nm³	<0.0144	0.2
Opacity, %	< 10	10
CO_2, %	6.5 – 6.9	-
O_2, %	12.2 – 12.9	-
CE, %	99.992-100.00	99.99
DRE, %	99.994 – 99.996	99.99
t_R of gas, s	10.08	≥ 2

- Stack specification of the rotary kiln incinerator : 17 m height from ground; 13 m height from disturbance free, 0.75 m diameter, sampling holes at 8.2 m from downstream disturbance and at 4.8 m from the upstream disturbance, that resulting 12 traverse points.
- TBT under 80% and 100 % HW capacity of 600 kg/h is working properly.
- HW burned consisting of WWT sludge (20%), oil sludge (40%), and paint sludge (40%) was actually difficult to maintain.
- All TBT results comply the standard values regulated but some of the results barely close to their standard requirement .
- Particulate emissions at the 80% capacity is 35.62 - 37.82 mg/Nm³ with an average of 36.53 mg/Nm³, and at 100% capacity, it is 44.73 - 49 mg/Nm³ with an average of 47.54 mg/Nm³.
- To avoid particulate levels exceed the standard concentration, it needs to improve the work of scrubber by redesigning type of scrubber used and its spray nozzles' position .
- Needs redesign on chamber-2 volume to have ≥ 2 s of its gas residence time.


THANK YOU
GUYS
Chairman
Chairman