بسم الله الرحمن الرحيم

AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region

MEAE - Middle East Alternative Energy Institute
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North Lebanon Alternative Power
www.nlap-lb.com

تنقية دخان مصانع التفكك الحراري
Flue Gas Purification
(Thermal treatment: incineration)

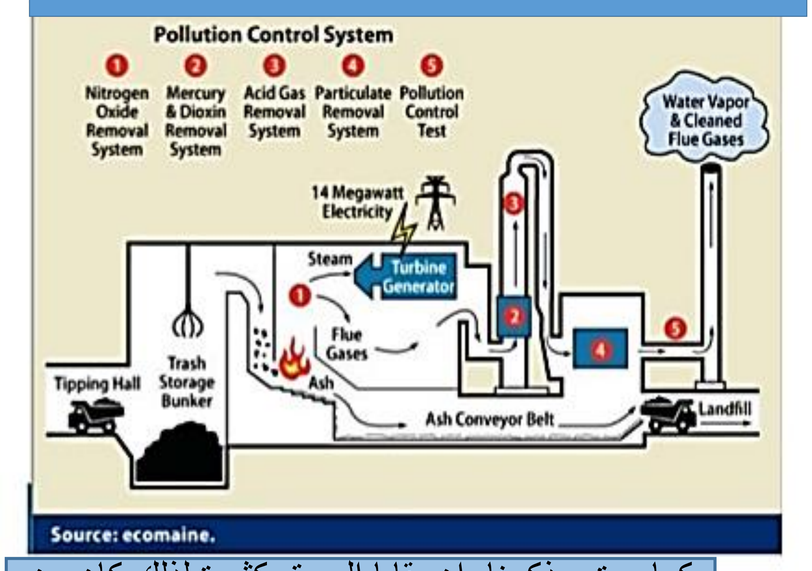
Residues of incineration of 1 ton of waste
700 kg of gas,
300 kg of solid residues including 30 kg of fly ash.

Division of emissions(depending on their size and the degree of severity:)

Challenges

- **Non-harmful to the environment** لا تضر بالبيئة → **Nitrogen (N_2), Oxygen (O_2), and water vapor (H_2O)**
- **harmful to the environment** تضر بالبيئة → **Acid gases: nitrogen dioxide (NO_2), nitrogen oxide (NO), Sulfur dioxide (SO_2), carbon dioxide (CO_2),HCl, Dust**
- **Toxic gases:** الغازات السامة → **Furans, dioxins, heavy metals (Hg from batteries, cadmium, plumb, zinc)**

Waste to energy diagram



كما سبق وذكرنا ,ان بقايا الحرق كثيرة لذلك كان من الضروري معالجتها .نبدأ بالنيتروجين الذي سيعالج عن طريق رش الأمونيا على دفعتين .ثانيا,الديوكسين و الزئبق الذي سيملر في خرطوشات الكربون المنشط.ثالثا,الغازات الحمضية ستم ازالتها برش ال بيكربونات الصوديوم.واخيرا ,الغبار سيتم ازالته ميكانيكيا وكهربائيا (ESP).اعتمادا على ذلك ,فان الانبعثات ستكون مطابقة لما ورد في الجدول التالي.

والبقايا الصلبة سيتم معالجتها في نظام خاص منفرد
ولمراقبة الانبعاثات بشكل متواصل ,سوف يركب أجهزة مراقبة على المحطة للتأكد من صحة الفلاتر المستعملة.

Emission limit values in mg / m^3 to 11% O_2 dry gas According to EC 20/09/2010 to an incinerator >6 ton/h

parameter	half-hour mean value	European Directive 2000/76 / EC of 04/12/2000 and French Decrees of 20/09/2002 and 03/08/2010	refectural stopped operating permit Flamoval of 17/06/2009
Total dust	1-20	10	3
Hydrochloric acid (HCl)	1-50	10	7
Hydrofluoric acid (HF)	10	1	0.7
Sulphur dioxide (SO_2)	1-150	50	15
Carbon monoxide(CO)	5-100	50	30
total organic carbon (COT)	1-20	10	8
Mercury (Hg)	0.001-0.03	0.05	0.04
Cadmium + Thallium (Cd + Tl)	-	0.05	0.04
Other heavy metals (Sb + As + Pb + Cr + Cu + Co + Mn + Ni + V)	-	0.5	0.4
Oxides of Nitrogen (NOx)	40-300	200	50
Ammonia (NH_3)	-	30	10
Dioxins and furans	0.01-0.1	0.1	-

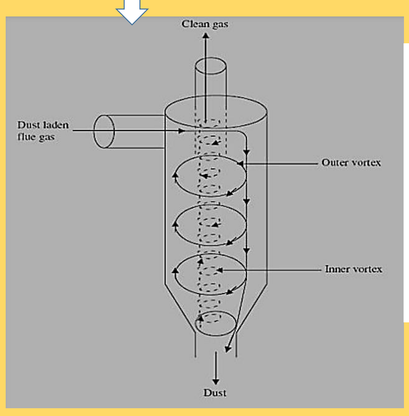
Elements (polluants)	<1 ton/h Maximum value(mg/m^3)	1-3 ton/h Maximum value(mg/m^3)	>3 ton/h Maximum value(mg/m^3)
Dust	200	100	30
Pb+Cr+Cu+Mn	-	5	5
Ni+As	-	1	1
Cd+Hg	-	0.2	0.2
Cl (HCl)	250	100	50
F (HF)	-	4	2
SO_2	-	300	300

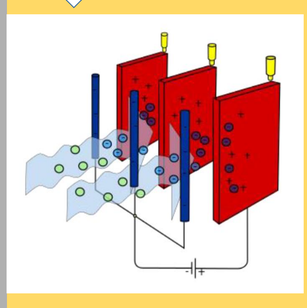
Emission limit values in mg /m^3 to respected (Lebanese environmental ministry

4.Treatment of dust (علاج الغبار)

Particles between 5 & 50 micron and volatized heavy metals → **Mechanical treatment** : العلاج الميكانيكي Cyclone(efficiency:91%)

Less than 5 micron → Electrical treatment : العلاج الكهربائي The electrostatic precipitator (ESP)(efficiency:95%)





3.Acid gas treatment technologies(HF, HCl and SO_2) تقنيات معالجة الغاز الحمضي

Depending on the concentrations, temperature, size of the flow to be treated and of further parameters, can be used different technologies for the treatment of acid gas emissions. Being a quick summary we can mention:

Bag filters with reagent injection(calcium hydroxide ($Ca(OH)_2$) or sodium bicarbonate))

The filters in flat bags are successfully used for the chemical absorption of acid gases such as HF, HCl and SO_2 in addition to the adsorption of other pollutant compounds. Generally it is used, among others, calcium hydroxide and sodium bicarbonate ($Ca(OH)_2$) of typical commercial quality, which is injected in the gas stream before entering the filter. To achieve proper compliance with the emission limits required, the additive should be added in amounts over-stoichiometric (from 1.5 to 3 times).
at least 130-200 ° C

- Treatment by $Ca(OH)_2$:

$Ca(OH)_2 + 2HCl \leftrightharpoons CaCl_2 + 2H_2O$

$Ca(OH)_2 + 2HF \leftrightharpoons CaF_2 + 2H_2O$

$Ca(OH)_2 + SO_2 \leftrightharpoons CaSO_3 + H_2O$

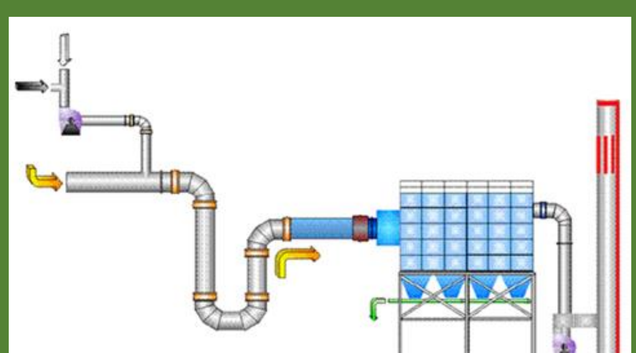
$CaSO_3 + 1/2\ O_2 \rightarrow CaSO_4$

- Treatment by $NaHCO_3$:

$NaHCO_3 + HCl \leftrightharpoons NaCl + CO_2 + H_2O$

$NaHCO_3 + HF \leftrightharpoons NaF + CO_2 + H_2O$

$2NaHCO_3 + SO_2 + 1/2O_2 \rightarrow Na_2SO_4 + 2CO_2 + H_2O$



1.Techniques for the reduction of nitrogen oxide(تقنيات للحد من أكسيد النيتروجين)

-Thermal NOx: When burning a portion of the nitrogen in the air is oxidized to nitrogen oxides. This reaction occurs only significantly at temperatures above 1300 ° C. The reaction rate depends exponentially on the temperature and is directly proportional to the oxygen content
-Fuel NOx: when burning a portion of the nitrogen contained in the fuel is oxidized to nitrogen oxides.

PROCESS OF REDUCING NON-SELECTIVE CATALYTIC (SNCR):
the reducing agent (typically ammonia or urea) is injected into the furnace and reacts with nitrogen oxides. The reactions occur at temperatures between 850 and 1000 ° C, with higher reaction rates and lower in this range.

Selective Catalytic Reduction (SCR) is a catalytic process during which ammonia mixed with air (the reduction agent) is added to the exhaust gas and passes through a catalyst, usually a sieve (e.g. Platinum, rhodium, TiO_2, zeolites). When passing through the catalyst, ammonia reacts with NOx to give nitrogen and water vapor.

2.Treatment of dioxin and furans and mercury Hg(heavy metals) & CO_2(علاج الديوكسين والفيوران)

By activated carbon(can be also called "lignite Coke for odorous compounds.)
Activated carbon is in the form of a fine black talc. Its elementary particles are made porous by a suitable heat treatment so as to create therein pores having dimensions of affinity with the molecules to be filtered. So there are formulations of active carbon adapted to different molecules that one wishes to retain.

The Environmental Protection Agency (EPA) showed that dioxins broke down easily when exposed to temperatures in excess of 1,200 °C.

To obtain a minimum feeding rate (F(min)) of activated carbon (AC), It was found that dioxin removal efficiency(eta) increased with an increase in AC feeding concentration. This had an almost linear function to F/Q when F/Q was less than 65 g/Nm(3), where F was the AC feeding rate (mg/min), and Q was the volumetric flow rate of flue gas (Nm^3)/min). However, it did not seem to be affected by F/Q, when F/Q was larger than 150 mg/Nm^3). On the basis of the experimental data obtained in this study, the removal efficiency of dioxins by the application of AC could be correlated as eta (%)=100/[1.0+(40.2/(F/Q)(3))].

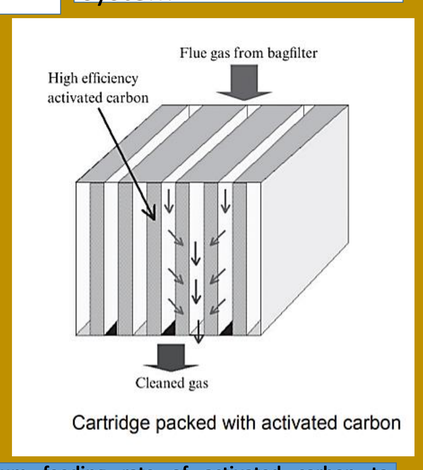
Measurement :The Intelligent Gravimetric Analyzer (IGA)
The system is an ultra-high vacuum (UHV) system and allows measurement of isotherms and accurate determination of the adsorption and desorption kinetic profiles for each pressure step. The system consists of a fully computer controlled microbalance, pressure admit system and temperature regulation system

Dioxins concentrations at activated carbon adsorber

	Dioxins concentrations (ng-TEQ/m^3-norm.) Inlet	Outlet	Removal-efficiency (%)
Electric furnace for steel	5.5	0.009 3	99.83
Ash melting furnace	1.8	0.000 80	99.96
Waste furnace	1.1	0.000 16	99.99

Hg concentrations at activated carbon adsorber

	Inlet (mg/m^3-norm.)	Outlet (mg/m^3-norm.)
Waste furnace	0.065	<0.005 (Under determination limit)
Ash melting furnace	0.57	<0.005 (Under determination limit)



Cartridge packed with activated carbon

Ref:Minimum feeding rate of activated carbon to control dioxin emissions from a large-scale municipal solid waste incinerator, Article in Journal of Hazardous

5.Continuous Emission Monitoring (CEM)

A series of sensors will be implemented to assure a continuous emission monitoring of different gas formed in the flue gas without the Dioxins and furans that measured by GC(gas chromatographic); Sensors of:CO,CO_2,NO,NO_2, SO_2,SO,HCl,heavy metals.

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