WASTE INCINERATORS

(Underwriting and Technical Aspects)

M. BARDON
IMIA - September 1993

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1- WASTE INCINERATION

A market for the technical insurance

2.2 billions tons per year is the waste quantity produced by countries from the European community (E.C) which are

- 1.1 billion tons of agricultural waste
- 400 millions tons of extraction industries waste
- 239 millions tons of sludges treatment
- 160 millions tons of industrials waste
- 90 millions tons of domestics waste
- 1.9 million tons of usaged oils
- 160 millions tons of rubbles

- 60% of domestics waste into garbage
- 33% of domestics waste incinerated
- 7% of domestics waste composted

The average production of domestic waste is nearly of 513 Kg per year and per developped countries inhabitant although with important differences exist :

- 228 Kg per year and per unit in Austria
- 864 Kg per year and per unit in United states of America
- 304 Kg per year and per unit in France

Up to a recent past,always with regards to developped countries, the treatment by incineration , compostage or grinding were exception (annexe n°1). Ground garbage has been the rule .

Now day,more than an half of domestic waste are treated (62% for Japan).

In the near future and mainly under the environmentalist lobbies, authorities will likely be obliged to prepare legislations and regulations which will especially force local communities to treat domestic waste and, industrials to set up installations in order to recycle their products .

As a result , an important market should be created for treatment of domestic waste by incineration with heat recovery, including a market for insurers .

So far (until now) " breakdown machines " insurers and possibly covering incineration plants remained surprisingly discret .

To my best knowledge,it does not exist any available loss experience which could be considered like complete and reliable with regard to incineration plants .

The only information in my possession has been available for me come from the German market (relevant to the n°2 annexed part).

There is nor standard wording neither rules of rating taking into account the specificities of different categories of incineration plants.

This file can not allow me to solve just from now this lack of information but on the contrary to try hard to start working such a way that should lead to a useful file usable insurers .

Facing a market evolution,where the major problem is to minimize the investment costs notably by increasing the power of units, the question is know how insurers react and what kind of products they should have to propose .

In order to be able to performe this proposition and naturally if you wish to , each delegation should send me the questionnaires (attached to chapter n°6) as duty filled in as possible before 28/02/94 at the latest.

So I could give you in 1995 a file which will take into account your answers and consequently your experience.

Thank you for your help.

ANNEXE I

THE HOUSEHOLD WASTE TREATMENT PROCESSES

The three most important ways of household and comparable waste elimination are the followings:

- **dumping**, which moves from an old and not very flattering situation to the technical burying centers of controlled waste. In a near future, the new regulations should not allow any rough waste dumping and should therefore reserve the access of technical burying centers to the final waste which has been already treated.

- **composting**, which enables the organic part of waste to be reused in agriculture. This treatment process, which is particularly ecological, takes a good place in the elimination process of household waste. It is subject to two constraints : on one hand, it is necessary to have agricultural openings close to the plant, on the other hand a very close treatment process for the refuse.

- **incinerating** with or without energy recovery. This old technique has had an important development due to its high level of performance and reliability.

Each method can be complemented by a sorting-recycling process which evolves either with a selective collection with sorting at the source, or with installations added to the treatment plant.

A methane based process is under serious and encouraging R&D investigations.
It consists in attacking the organic part of household waste by anaerobes which produce methane.

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R E F U S E   F I R I N G   E Q U I P M E N T S   1 9 8 8 - 1 9 9 2

Damages	Phase Mo*	/ B*	Causes So*	P*	Mo**	Be*	F*	%	Amount x 10^3 DM	Number of Claims	Amount of Dam. (aver.) x 10^3 DM	%	Trend
damage position													
- unheated tubes		2		2				2	87	2	40	0,2	decreasing
- heated headers		2				2		2	19	2	10	0,04	constant
- evaporator	1	14		3		12		13	5.323	15	350	11	increasing
- superheater, reheater	1	5	1			4	1	5	1.098	6	200	2,3	slightly decreasing
- bricksetting, refractories	1	5			3	3		5	415	6	70	0,8	constant
- airheater in flue gas	2	3			2	3		4	102	5	20	0,2	slightly increasing
- refuse feeding/ ash removal		6		1		5		5	275	6	50	0,6	decreasing
- grate firing system	3	21				20	4	21	1.498	24	60	3,1	increasing
SUM 1	8	58	1	6	5	49	5	57	8.817	66		18	
flue gas pass	2	2			3	1		3	112	4	30	1	sl. increas.
SUM 2													
desulphurisation plants	36	11	1	12	28	5	1	40	39.021	47	800	81	sharply incr.
SUM 3													
division into erection and	Mo		1	6	32	5	2	39	43.078	46	900	90	sharply incr.
machinery breakd.	M		1	12	4	48	6	61	4.872	71	70	10	increasing
SUM 1 - 3			2 2%	18 15%	36 31%	55 47%	6 } 5% }	100	47.950	117		100	increasing

*) So = others; P = product faults; Mo+ = erection fault at site; Be = operational errors; F = external effects; No = erection; M = machinery breakdown; B = normal operation

ANNEXE 2

INSURANCE POLICY - WORDING

LOCATION OF DAMAGE	KIND OF DAMAGE	RECOMMENDED POLICY-EXCLUSIONS
damage position		
unheated tubes	crack, fatigue crack	
heated headers	crack, tube bursting	
evaporator	crack, tube bursting, fatigue crack, tube wear, deformation}	state of technical technology
super-/reheater	crack, leakage, tube bursting, tube wear }	clause of corrosion
bricksetting, refractories	broken-out area, crack, cracking area, tube wear, melt on	state of techn. technology
airheater in flue gas	leakage, tube wear, chemical action, deformation	clause of corrosion
refuse feeding, ash removal	fatigue crack, deformation	
grate firing sytem	forced fracture, tube wear, overheating, melt on, jamming	definition of the parts of wear and tear or excluded components
flue gas pass	crack, leakage, deformation, forced fracture, chemical action	clause of corrosion
desulphurisat. plants	burning, mechanical damage to surface, chemical action leakage, deformation, loosening/bubbling of coating	clause of coating
activated carbon filter	burning, consequential loss due to humidity, deformation	exclusion of operation medium clause of operation

^ - DATAS AND DEVELOPMENT OF THIS MARKET

2 - MARKET DATA AND DEVELOPMENT

Despite the lack of stastical data, may-be due to a lack of uniform nomenclature between countries or a lack of interest of some countries for this type of activity. On average, it can be estimated that 60% of the household and comparable waste are burried, 33% are incinerated, 7% are composted.

As a result, it appears that the waste tonnage burried in dumps is far from being negligible which therefore represents an economic loss, the energy contained in waste not being valorized.

This is particularly true for the European Economic Market (E.E.C). Moreover, combined to the yearly amount of waste exported out of the E.E.C (waste incinerated and dumped into the sea and waste burried in dumps located outside of the E.E.C), the previous data shows a lack of waste elimination plants in the E.E.C, especially for the incineration sites.

The French population generate each year 18,000,000 tons of household waste, which represents a volume of 200,000,000 of cubic meters. The average French production per inhabitant is one kilogram a day, roughly 400 kilograms a year (from 300 kilograms a year in the countryside to 500 kilograms a year in the cities). This production should become 450 kilograms a year in 1995.

In Germany, the household waste production is around 30,000,000 tons a year.

In the States, the production per inhabitant is around 860 kilograms a year which is about twice as much as the French production. However, it is to be noticed that the calorific value changes from a country to another.This is particularly true between France and the States; The last one has a calorific value 30% higher (American people using more plastic for example)

In France, the heterogeneous household waste consists of the following items:

- Papers, cardboards	20 to 37%
- Puetrescible materials	15 to 35%
- Glass	5 to 15%
- Metal	5 to 8%
- Plastic	3 to 6%
- Textile	1 to 6%
- Fine elements	10 to 20%

The average calorific value is about 1,800 thermies per ton and constantly increases each year.

France processes each year 6,500,000 tons of urban waste by incineration, 4,100,000 tons of them with energy recovery. This represents about 300 plants.70 of them are waste to energy facilities. The amount of plants without energy recovery is, as of today, the highest. They are on average 15 to 20 years old.

.../...

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Japan incinerates each year 32,000,000 tons of the 46,000,000 tons of urban waste it generates in 1,900 plants of various sizes.

It is estimated that the energy recovery from one ton of waste is equivalent to 400 kWh or 2 tons of steam in a heating network.

For the years to come, the development of the different waste treatment processes should benefit from a mixed system gathering sorting-recycling process with waste to energy process. This would be realized to the detriment of the dumping method (the estimated gain for incineration is about 5% in 5 years, tonage and calorific value increasing).

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3 - COST FOR INCINERATION TREATMENT

3 - INCINERATION TREATMENT COSTS (see annexe III)

For the waste to energy process, gross costs (depreciation and operating costs) range from $48 to $100 per ton. Sales of the recovered energy (heat or electricity) generate revenues estimated between $6 and $29 per ton for the local communities which enable the financing of 10 to 35 % of the treatment costs and enable to get net costs down from $39 to $80 per ton.

Regarding the incineration without energy recovery, gross costs range from $27 to $70 per ton. Net costs are about the same due to a lack of revenue from the scrap sales. Actually, only 15% of the produced scrap is sold. The remainder is given for free without considering the transportation costs to be added. One third of local communauties are using clinker on their own civil works fields,the others are temporarely stocking it.

The investment cost of a waste to energy incineration unit designed to support the needs of 200,000 inhabitants is estimated at $29,000,000 or more. Regarding the incineration without energy recovery, the cost is estimated at $5,000,000.

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4 - MARKET OPPORTUNITIES

4 - MARKET OPPORTUNITIES

Europe (France, Germany, Switzerland) and Japan have developed the incineration treatment process since the begining of the century, while countries with large spaces have chosen the easiest solution of dumping.

Countries like Spain, Italy, Portugal, and Greece hardly use this treatment process. Great-Britain which knew very well this technology seems to have abandonned it for the past years.

Regarding France, it is estimated that 160 incineration units would be built in the next ten years, which represents an investment of about $3,200,000,000.

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5 - TECHNICAL ASPECTS

5.1 - Introduction

5.2 - Choice of site location

5.3 - Waste processing

5.4 - Flue gas-air circuit

5.5 - Flue gas treatment

5.6 - Furnaces

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5 - TECHNICAL ASPECTS

5-1 Introduction

This "depollution" technique transforms the household waste in :
. flue gas mainly consisting of steam and carbonic gas.
. combustion residues minéraux (clinker and fly ash).

Under this transformation the initial volume of waste is reduced by 90 %. However, difficulties raise with some elementary conpounds (chlorine, sulphur, nitrogen, heavy metals, arsenic) which create pollution by transformation. Additional systems need to be added to treat this type of pollution. By-products (clinker and fly ash) are treated this way.

Until now, the main difficulties about waste treatment are to reduce a non homogeneous combustible material into ashes, to succeed in its total combustion and to avoid bottom ash fusion and if possible, to provide a constant flow of steam.

Since the regulations of June 1986 and January 1991, one needs to add to the previous criteria the need to avoid the creation and production of polluting substances. Although the creation or degradation mecanisms of these substances are not all known, it can be said, as of today, that optimization of incineration requires to master the combustion, the temperature, the prevention of kiln malfunctions as well as the chemical flue gas treatment.

Finally, the three main problems of an incineration unit are:

- combustion
- corrosion
- flue gas treatment

Combustion seems to be mastered pretty well now. Corrosion remains the main problem for the boiler. Flue gas treatment is not yet mastered and is under some R&D development (see enclosed annexe).

Regarding the corrosion problem, provisions on equipment are realized. It is estimated that the additional investment costs due to maintenance is about 3 to 5 % per year of the initial investment.

Concerning the most important units in a waste to energy plant, allocations can be made as follows:

- Combustion	40%
- Civil works	20%
- Flue gas treatment	20%
- Energy recovery and miscellaneous	20%

Vue en coupe de l'Usine

LEGENDE	KEY
1 - Hall de déchargement	Unloading area
2 - Salle de commande	Control room
3 - Fosse à ordures	Storage fit
4 - Pont roulant à ordures	Overhead Bridge crane
5 - Trémie de chargement	Refuse feeding hopper
6 - Grille CNIM-MARTIN	Grade
7 - Chaudière	Combustion chamber
8 - Economiseur	Economizer
9 - Electrofiltre	Electrostatic precipitator
10 - Laveur	Wet gas scrubber
11 - Aérocondenseur	Condenser
12 - Ventilateur de tirage	Air fan
13 - Cheminée	Stack
14 - Ventilateur de combustion	Combustion air fan
15 - Réchauffeur d'air	Air pre-heater
16 - Transporteur de suies	Fly ash conveyor
17 - Extracteur	Discharger
18 - Transporteur vibrant	Slag vibrating conveyor
19 - Fosse à mâchefers	Slag storage area
20 - Pont roulant à mâchefers	Slag bridge crane
21 - Turbo-Alternateur	Turbo-alternator
22 - Monte-Charge	Hoist

IDENTIFICATION DES ZONES SENSIBLES A LA CORROSION
(CORROSION SENSITIVE AREAS)

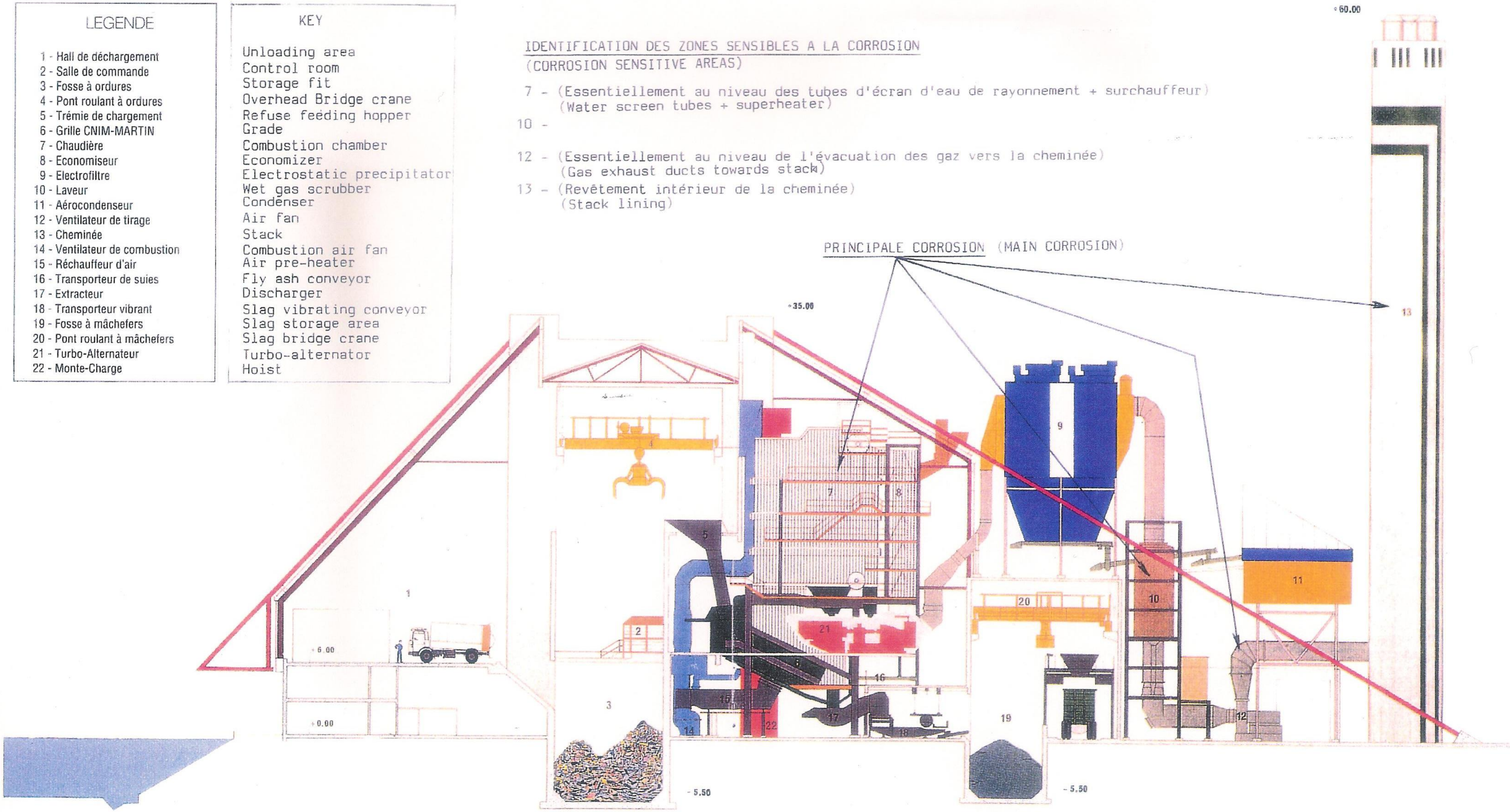
7 - (Essentiellement au niveau des tubes d'écran d'eau de rayonnement + surchauffeur)
(Water screen tubes + superheater)

10 -

12 - (Essentiellement au niveau de l'évacuation des gaz vers la cheminée)
(Gas exhaust ducts towards stack)

13 - (Revêtement intérieur de la cheminée)
(Stack lining)

PRINCIPALE CORROSION (MAIN CORROSION)



USINE D'INCINÉRATION
DES ORDURES MENAGÈRES
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5.2 CHOICE OF THE SITE LOCATION

Without going into administrative particulars precisely defining all necessary conditions enabling the obtention of authorisations for building a waste incinerator,it seems useful to underline that roads,electrics and water networks are keyfactors.

As far as necessary areas are concerned, we can indicate a scale of measurement :

for a 200.000-inhabitant city unit,the factory would cover from 2000 to 3000 square meters plus road accesses,clinker storage,maybe landscape and so on... for an approximative total of 10.000 to 12.000 sqm.

In a rough approach, a linear proportion between the number of inhabitants and the necessary areas would lead to the estimation for bigger cities.

5.3 WASTE PROCESSING

1) Reception of skip-lorries

2) Automatic rubbish weighing

3) Dumping and pit storage

The pit is usually rectangular,relatively narrow compared to the lenght and rather deep.The pit efficiency can be caracterized by the depth/ width ratio.

However,the construction cost of a pit increases very quickly with the depth.

The pit is depressurized in order to avoid dust and smell emissions by taking the primary air of the furnace using suction fans.

The handling of waste is carried out by travelling bridge cranes above the pit which are equipped with 1 to 4 cubic meters capacity multiblade grabs.

These travelling bridge cranes directly supply charging hoppers of the incineration furnace.

The waste handling can be a manual or a semi-automatic or an automatic one.

In France, for medium-size installations,this handling is in most cases an semi-automatic process.

4) Possible waste treatment before handling

Screening is carried out through a rotative cylindrical drum in view to eliminate inert fines before going into the furnace.

Grinding is unusual on account of installations size,maintenance and cost.

Shearing is preferred because it is cheaper.

Metal separation is carried out in most cases on a magnetic line but is mainly realized after burning (clinker treatment) .It is not really interesting economically.

5) Waste charging

the system hopper/chute loading must satisfy the two following conditions:

a) A regular charging without stuffing .

b) The existing of a waste provision (stopgap) in order to insure the furnace airtightness for the air supply and the burned gas evacuation .

The system hopper/chute loading undergoes an heavy abrasion which manufacturers have to deal with.

It is also necessary to provide the following devices

- Waste level indicator
- Temperature indicator (fire prevention from the firebox)
- Airtightness register (also used in view to isolate the furnace while it is stopped)

6) Clinker extraction

This mechanism provides two functions :

extraction)
　　　　　) while keeping airtightness of the firebox
cooling)

The temperature of clinker is between 700°C et 300°C . Its cooling down is carried out by water immersion,giving a steam emission containing more or less fine ashes . This ashes are collected by an ash-collector below the grate .
The more usual devices :

- Drag extractor made up of an inclined trough full of water and in which there is a sliding chain with bars which bring up the cooled clinker .

- Stopper extraction operates on an alternative movement basis which pushes the clinker along a slope from a tank full of water and in which the hot clinker falls from the grate .

In both cases, clinker are cleared towards their storage location on a conveyor belt which is often with equipped magnetic selection (sometime also electric) in order to separate metallic components .The extraction devices always suffer a very heavy and continuous abrasion .So,reliability and longevity depend on the optimal reactivity speed chosen by the manufacturer .

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5.4 AIR-FLUE GAS CIRCUIT

1) Reaction of combustion

It is in the firebox that the process of incineration is carried out . Theoriticaly,it is very easy to establish the necessary and sufficient air quantities for an ideal combustion of combustible components, knowing each quantities and writing exothermic oxydation reaction (energy release during the reaction) . Furthermore it is the right proportion of air/combustible which provides the highest temperature .

For domestic waste,the following equations are the most important :

	$C+O_2$ ------------------> CO_2 + 94 mth/ mole
Carbon combustion	$C+1/2O_2$ --------------> CO + 26.4 mth/mole (1st step)
	$CO+1/2O_2$ --------------> CO_2 + 67.7 mth/mole (2 nd step)

Hydrogen combustion	$H_2+1/2O_2$ --------------> H_2O + 58 mth/mole (steam state)
	$H_2+1/2O_2$ -------------> H_2O + 68 mth/mole (liquid state)

We can immediatly note that carbon can be burned in two steps. The first C into CO transformation represents only 28% of the available thermic energy;The second one represents 72% of the total. It is ,then,absolutely necessary (for the maximum thermic energy released) to get at least the minimum amount of oxygen to complete the two steps .

With regards to Hydrogen oxydation (combustion), in case of waste incinerator (also for traditionnal power station), combustion gas will always stay above the condensation temperature (100°C atmospheric pressure) for corrosion reasons,the recovery of thermic energy will only be 58 mth/mole,water staying at a steam state.There are also some other combustible components in various quantities (e.g:sulphur) but their influence are insignificant in regard of hydrogen and carbon roles. Furthermore without knowing their quantities it would be illusory to involve them in equations .

Domestic waste is heterogeneous (compactness,water content,various components), it is very difficult to obtain the right air-combustible mixture .So far,it is necessary to increase the theoric oxygen quantity (air) in order to obtain a perfect combustion . Though this air in excess (quite well defined empirically) will allow a full combustion but his temperature will be below the maximum temperature.

Contrary to what one might think, this has a good effect because for technological reasons we try to limit temperature to 950°C inside the firebox

To sum up, the theoricical quantity of air required for a full combustion should increased for two different reasons :

- Obtention of a perfect mixture air-heterogeneous combustible .

- To limit the temperature at a desirable level in the firebox .

For information and with simplifying hypothesis (without taking into account the influence of the variation of water content in waste) we can roughly establish the air required for a theorical combustion of 1 kg of waste with a given calorific value .

Va = PCI/1000 with PCI = low calorific value in mth/kg
Va = volume in normal cubic meter (0°C at 1013 mb)

Neverthless, the volume of flue gas produced by the complete combustion coming out from firebox is :

Vg = PCI/850

If we limit temperature at 950°C by adding air excess , the volume of gas coming out from the combustion chamber will increase approximately to

Vg 950 =3PCI/1000

Thus, volume of air in excess may be very important :

Ve = Vg950-Vg (this excess can reach 180%)

However ,we have to consider that those empiricical expressions give results by excess, and the increase in humidity content of waste reduces the need of air excess

Anyway,the exact value of the air excess can only be determined with CO2 and O2 measurements getting out from the combustion chamber and should be adjustable according to calorific values of waste .

Practicaly,the combustion is carried out by inflating air under the grate through the waste layer (primary air) and also inflating air into the combustion chamber above the waste (secondary air) in order to complete the combustion of the waste. The secondary air concerns mainly the reaction

$CO + 1/2O_2$ -----------------> CO_2 + 67.7 mth/mole

which release more than 2/3 of the thermical energy available by carbon combustion .

2) Usage of flue gas

What could become 950-1000°c gas which come out from the combustion chamber ?

a) If the amount of flue gas (energy) is not enough to justify economically building up a recuperation system (boiler) ,there is no other solution than dissipate it in the atmosphere .

b) The amount of energy included in the flue gas can economically justify a recuperation installation .

* * * * * * *

If we can not use this thermical energy included in the gas, it is absolutely necessary to cool it down before sending in an installation which is able to dissipate it in the atmosphere (enviromental problem).

The problem is quite simple on the thermodynamic aspect : A given quantity of gas (high temperature) have to be transformed in an acceptable temperature through a treatment mechanism for going out in the atmosphere .

Two practical solutions can be studied according to economical reasons :

- Mixing fresh air with flue gas in order to obtain a 250°C- 300°C temperature .

The consequence is that the volume of the flue gas at this temperature will become about :

Vg 250 = 8 PCI/1000

With this solution, the power of the extraction fans has to be very important .

- Flue gas cooling can also be obtained by water injection . The heat required to transform the injected water into steam uses up the calories of flue gas and this process will cool them down .

This solution is very efficient but represents an important water consumption and the need of a chemical treatment against the acidity of the waste water.

* * * * * * *

If flue gas quantities and quality allow a heat recovery , steam or overheated water boilers will be introduced in the air + combustion circuit . These boilers are not very different from those of thermic power station .

Details concern mainly the reinforcement of the proctection against corrosion of radiation screen tubes and super-heaters exposed to the hot and corrosive flue gas action (between 500°C and 700°C)

Anyway,it is always planned some chimney-sweeping installation (steam or more rarely compressed air) in order to avoid as much as possible the tube fouling up (corrosion prevention) and the progressive lost of thermical flux transmission .

We can note that for the last 15 to 20 years, constructions are orientated towards " furnace/ cast in one piece boiler " units.

Roughly, we can note that with medium calorific value waste, one metric ton of combustion produce between 1.5 to 2.2 metric ton of steam.

Thus ,it is the boiler which undertakes to cool down the flue gas to an acceptable temperature level so that it could be treated before rejecting into the atmosphere.

3) Conclusion

Criteria between heat recovery or dissipation in the atmosphere are not rigorously defined.Therefore, descision parameters depend on local factors, financing ability,political context, cost of energy and so on...

UAP ASSURANCES

5.5 FLUE GAS TREATMENT

Whatever will be the purpose of the flue gas coming out from the combustion chamber or the recovery boiler,they have to be cooled down to a 250°C -200°C temperature .However,they can not be rejected into the atmosphere without an enviromental pre-treatment of some forbidden components which are :

- Dust

- Gas chemical components as Cl, Fl, NOx, SO2, SO3, Heavy metals, and so on....

It is important to separate them from the flue gas before their injection across the chimmey into the atmosphere (having a respect for the E.C regulations which are rather strict).

*

* *

* Dust separation problem is today almost completely solved by :

- Electrofilters where gas full of solid particules of dust is getting along between plates . Which are faised to a 10kV and50 kV electrical potential difference . Dust are charged negatively and are capted by positive electrods .We collect dust at regular intervalls by a mechanical action (shaking process mainly).

- Mechanical filtration (sleeve filtration, like a sock hanging perpendicularly) which carried gas full of dusts through some incombustible lays of material . Efficiency is excellent but the word "incombustible" have to be considered with prudence .Even most recent materials contituted by glass materials and/or composite materials can not be resist very long time to temperatures over 200°C-250°C (their life time is anyway very limited) .

* For gaseous components, the problem is far from to be solved as the dust one .

Today, the process usually used (it is not a very recent process) is to wash flue gas with water. Inside a washing tower ,combustion gas go through a very thin water atomized screen . The water will absorb gas componants as Fl, Cl , SO2 , SO3 , etc ..., plus a big quantities of dust swollen with water .However it will be necessary to solve the water suppliyng and dust treatment (pH falling down between 1 to 2).

Wet treatment process is quite efficient for eliminating Cl, 1 liter of water can absorbs about 400 liters of HCl.

Because of the high acidity of the water, these washing towers are mainly built in acids resisting steel (at their best) and coated by marerials like ebonit,epoxy,composite materials,and so on...., resisting to the acid attack on the surface in contact .

The problem is mainly the high temperature resistivity of these organic materials(they go to soft around 120°C-150°C temperature)

Any bubble or micro-crack provoqued by the temperature ,even confined,carry out the destruction by corrosion of the steel frame.Just because, acid water will percolate and the corrosion will become ineluctable at short time .

The only solution known today is a complete refurbhisment of the washing tower lining.So, it almost means a complete changement of the tower re-coated with some new up-dated organic components with better caractheristics

* Another process is a calcinated calcium carbonate injection into cooled flue gas . This process is efficient (but expensive) for sulphur treatment . However with the following chemical reaction ,at the same time,we are also proceeding to the HCl reduction .

$$2HCL + Ca(OH)2 \longrightarrow CaCL2 + 2H2O$$

This process could be either a dry or a semi-dry process .

One of the direction of calcinated calcium carbonate treatment researches is to increase their specific surface. Using alcoholized water one can double the specific surface of the calcium carbonate (presently about 17 m2/g). At the same time, manufacturers try to reduce the density from 400 g/l to 170 g/l . Thus,the calcium carbonate becomes much more reactive with acids and the epuration process needs less calcium carbonate. Neverthless this is presently not yet developped on a large industrial scale

To sum up the waste incinerators enemies are :

N°1 § ***Corrosion of the water screen tubes in the combustion chambers and overheaters .***

§ ***Corrosion of the flue gas epuration installation.This corrosion can be also developped in the duct connexion leading to the chimmey .***

N°2 § ***Combustion chamber parts, grate and furnace alimentation mechanisms abrasion .***

§ ***Abrasion from the clinker extraction process .***

§ ***Wearing effect by abrasion for fans which are insuring air and flue gas circulation .***

5.6 FURNACES

In order to realise the combustion process, the furnace constitue a central and major installation.It represents between 25% to 50% of the gross cost. It depends on the incinerator chain importance .It is constituted by the grate which is as well the handling component as the combustible support and the combustion chamber which insure the full gas combustion.

Modern furnace grates are made up of devices which the means are :

- Waste introduction into the firebox
- Combustion support
- Progress, reversal,and waste stirring
- Primary air introduction

As long as waste advances on the grate, we can observe three distinct steps , even if they are not perfectly delimited :

- Drying as soon as admission
- Heating up to the inflammation temperature which varies between 200°C and 600°C (it depends on the type of waste).
- Beginning of the combustion and its progress. It is completed by that of the gas released by the precombustion in the combustion chamber above waste layer .

Above the grate ,the combustion chamber is covered up with refractory products. If there is heat recovery, the upper part is equipped with water screen tubes. The role of the combustion chamber is to realise the mixture between secondary air and the uncompletely burned gas in view to optimise combustion and warming up by radiation the cold and wet waste.

Obviously,the furnace is equipped with extra burners for starting up and which can be used in a continuous manner if the calorific value and /or waste quantities are not enough to maintain a self-combustion.

Amongst grates,designs could be very different but they have all in common (with very few exceptions):

- Most of them are equiped with a descending band in order to facilitate by gravity the progress of waste .
- They are constituted by bars, rollers, sections or others elements in order to obtain reversal,mixing, stirring progress of waste.
- These cyclic and alternative movements are mainly got by hydraulic jacks or by bracket mechanisms. They are adjustable and located outside of the hot area .
- They are equipped with primary air suppliers,adjustable as well in volume ,as in pressure (up to 500 mm of water) and very often pre- heated between 200°C and 300°C depending on the waste calorific value .

Note:

The total air excess is the sum of primary air excess and secondary one (injected into the combustion chamber). The ratio between them is defined by the furnace manufacturer who will define it according to the grate caracteristics.

The firebox is depressurized in order to insure an isolated and hygienic running .

A device is located under the grate for receiving flue-ashes and fines getting through the grate .

Amongst grates movement we could be tempted to distinguish those which:

- have a translation movement.
- have grates (like conveyor belts) with several descending floors .
- have basculating bars
- have rotative and/or oscillating combustion chambers.

Combustion chambers are often covered with a high content of aluminous silicate refractory concrete in order to increase the resistivity against heat shocks.

All around the grate,the combustion chambers are submitted to a very strong abrasion due to friction from moving wastes .

Along this line the refractory lining is often substituted by silicon carbide which very resisting against abrasion .

However, manufacturers try to decrease the relative speed between the waste and the grate in order to reduce the abrasion phenomenon .Unfortunately,it is in contradiction with a good mixing and reversal .

So, they have to find the best compromise .

Furnace capacities are extremely variable from 1.5 t/h-25 t/h up to50 t/h of incinerated waste. Naturally with the capacity ,complexity (especially mechanical) is growing up..

Today it is admitted that below a 1 t/h capacity it is very difficult to maintain the self combustion and additional burners are required for a continuing combustion process .

At last, for all type of furnace,reliability and longevity will be improve if there are a running as continuous as possible .Each stop and start up or changement of speed in operation carries thermic shocks,over temperatures, unburned production, corrosion by dew point on metallic components , and so on ...