

INCINERATION EMISSION CONTROL USING WET TUBULAR ELECTROSTATIC PRECIPITATORS

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ABSTRACT

New regulations are restricting particulate, acid gas and organic emissions from waste incinerators to extremely low levels. Wet tubular electrostatic precipitators, with their ability to generate multi-stage, strong electrical fields in a wet, cooled atmosphere, have demonstrated particulate emissions less than 0.0003 gr/dscf, with toxic organic, heavy metals and acid mist collection exceeding 99%

INTRODUCTION

New and proposed regulations are restricting particulate, acid gas and organic emissions from hazardous waste incinerators to extremely low levels; with emphasis on heavy metal and toxic organic concentrations. Conventional scrubbing systems (wet or dry) are generally not effective in controlling sub micron emissions, consisting primarily of acid gas mists, condensed heavy metals and condensed organics. Wet tubular electrostatic precipitators, because of their ability to generate multi-staged, strong electrical fields in a wet, cooled atmosphere, have been shown effective in "polishing" the flue gas. The net results are demonstrated particulate emissions as low as 0.0003 gr/dscf; overall heavy metals collection efficiencies exceeding 99% and toxic organic removal greater than 99.9999%.

These units have been used as the primary air pollution control systems (Case II), or as retrofits to up-grade existing APC systems.

DESIGN DESCRIPTION

Beltran Associates has developed a unique wet tubular precipitator as a result of considerable research and development. The typical Beltran wet ESP is a vertical-flow, hexagonal or rectangular tube type precipitator. The schematic is shown in Fig. 1. Typically the flue gases enter at the bottom and rise through the precipitator. There are generally two sets of spray headers. The first set continually cools and saturate the flue gases. The spray header set at the top and directly below the collector washes down the collector and electrodes. These are operated on a periodic as needed basis.

The multi-stage tubular precipitator consist of a series of ionizing sections and a collection section. The discharge electrode is in the form of a rod or tube with a number of sharp corona generating discharge points. Various collecting tube geometries have been utilized over the years, the most common being the round. The square configuration and/or the hexagonal shape is chosen because of ease in manufacturing. These geometries are much more space efficient than the round shape.

The precipitator uses solid ionizing rods instead of wires. The unique electrode design with ionizing stars is capable of attaining higher average electric field strengths than any other plate and wire or tube and wire designs. This higher field strength results in higher particle migration velocities that translate into a reduced collector area.

Entrained particulate matter and fog droplets that enter the electrostatic section are charged by the high voltage produced by the electrode and collected on the grounded plates. Most of the particulates are flushed down into the bottom of the housing.

The high voltage insulators are kept clean continuously using a purge-air system. These features result in very low maintenance. Optional internal scrubbers to remove acid gases, can be installed in the lower part of the housing.

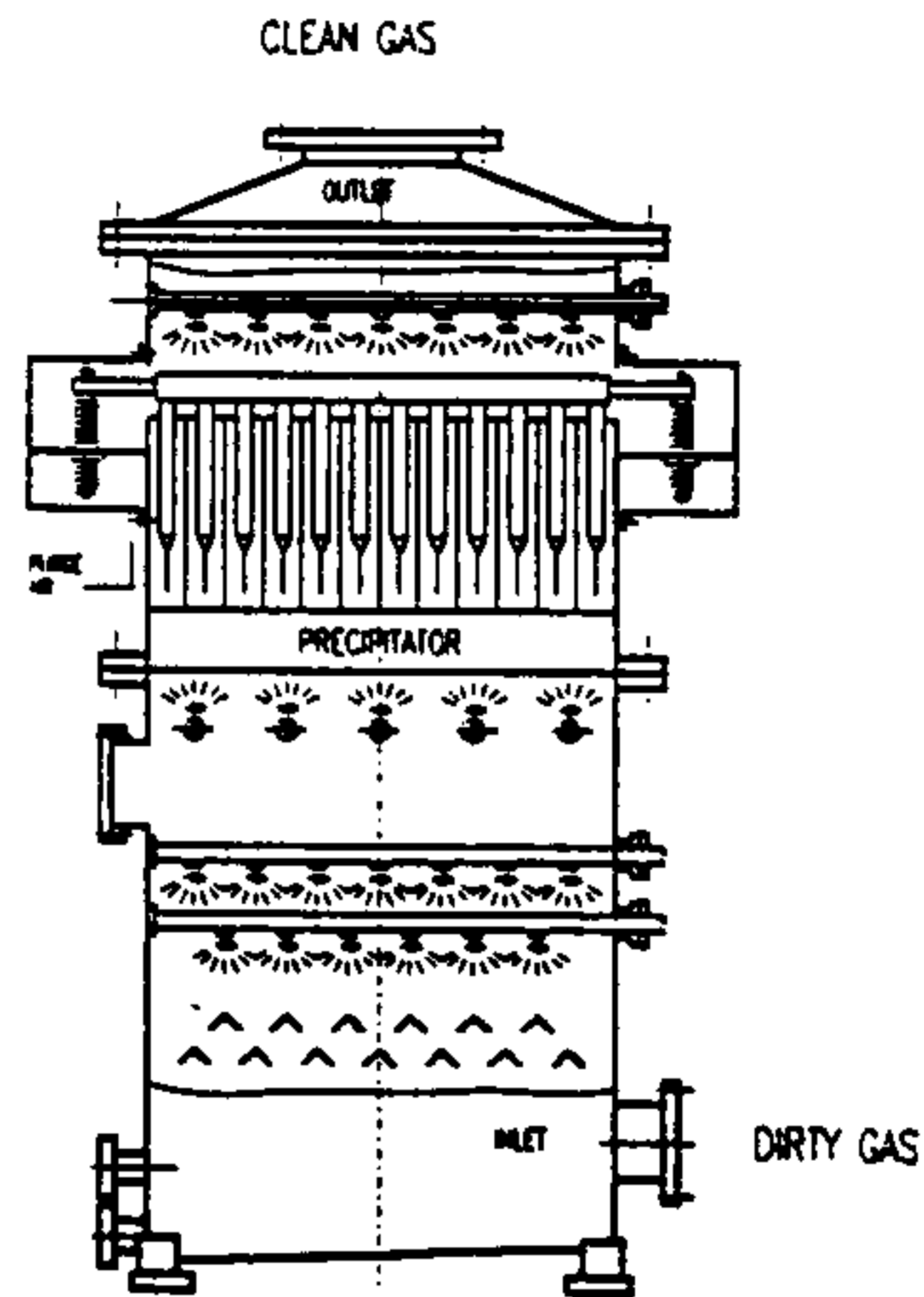


Fig. 1. Beltran wet electrostatic precipitator.

This design of a wet precipitator, originally employed for the collection of fine particulates, oil, smoke and acid mist, has been shown extremely cost effective for the collection of sub-micron particulates generated in the incineration of wastes.

WHY WET ESP?

The wet ESP is the most efficient sub-micron particulate collector. Its' collection mechanism is electrical charging as opposed to inertia in cyclones and scrubbers.

The unique electrode design allow for generation of a corona field 4 to 5 times more intense than standard wet or dry ESP's (Fig. 2).

Since fine particles do not have a significant mass, they generally go through cyclones and scrubbers with minimal collection. Also, high pressure drop is associated with cyclones, scrubbers and baghouses. The wet ESP has only a one-inch water column drop and is low in maintenance.

The Wet ESP provides low energy collection of sub-micron particles regardless of the physical or chemical nature of the collected material.

MATERIALS OF CONSTRUCTION

The incineration of waste materials, especially plastics, can generate the hydrochloric acid, hydrofluoric acid and sulfur oxides. The corrosive nature of these flue gases demands that special attention be given to the materials of construction.

EXPERIENCE

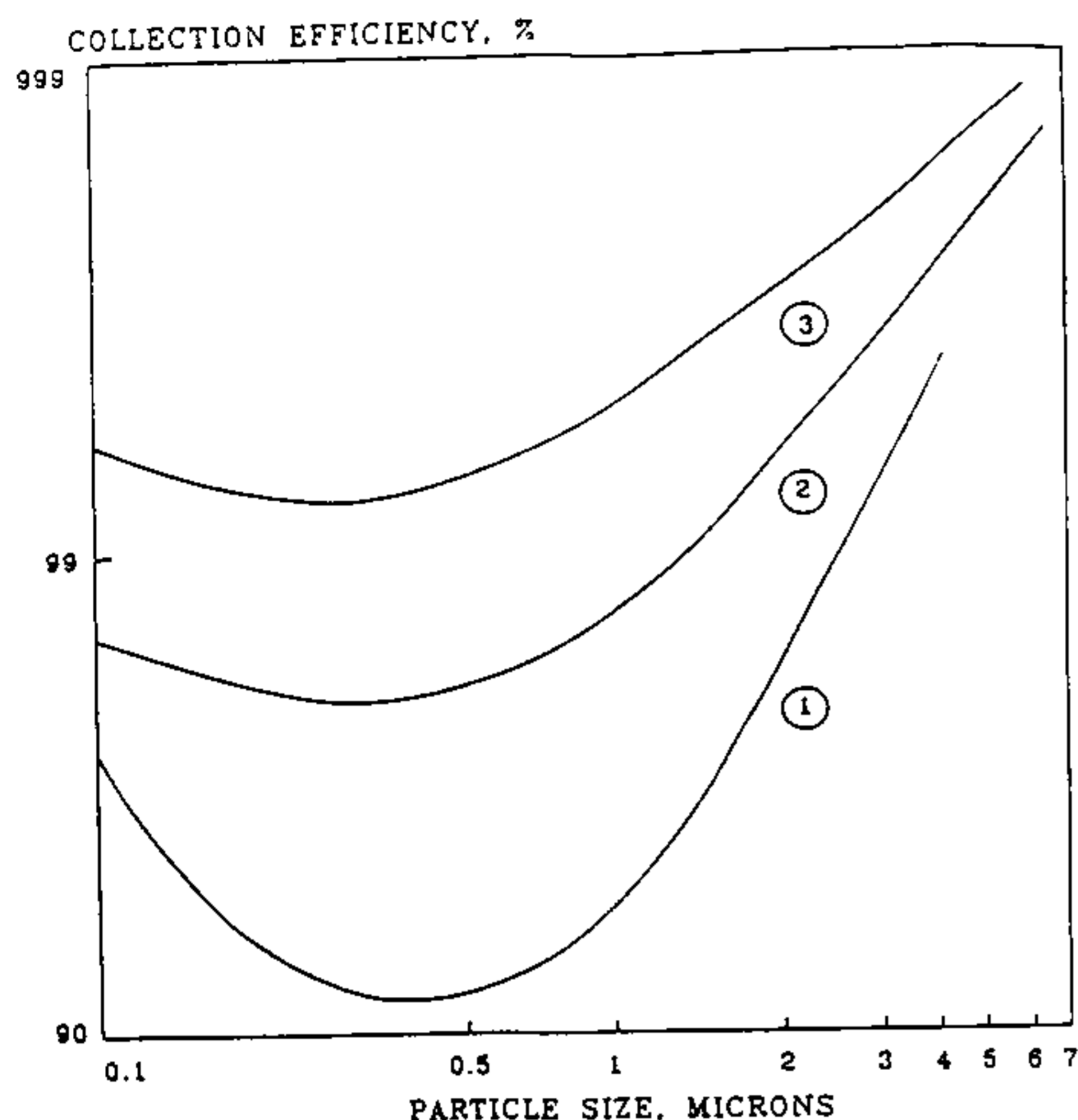


Fig. 2. Tubular electrostatic precipitator. Performance at Corona Power Levels of 1) 200, 2) 400, and 3) 1000 watts per 1000 CFM.

A reasonable alternative to corrosion resistant metals is to use fiberglass reinforced polyester (FRP). The electrically conductive sections of the ESP can be made from special conductive FRP.

The tubular precipitator has been used with great success in multiple industrial applications where fine particulate emissions are the major concern. Overall collection efficiencies in excess of 99% have been demonstrated on a consistent and reliable basis.

Three successful case histories are supplied using three different types of pre-scrubbing prior to the wet electrostatic precipitator. Case 1 (Fig. 3) can burn solid and/or liquid hazardous waste and utilizes a spray dryer/bag house followed by a saturator/wet scrubber ahead of the WESP. To minimize equipment corrosion, the WESP housing was constructed of veiled FRP. The collector was fabricated of electrically conductive FRP. All metal surfaces exposed to the flue gas, including the ionizing rods, are constructed of Hastelloy. This system has achieved extremely low particulate emissions and heavy metal concentrations during test burns. By injecting the WESP bleed-off into the spray dryer, a zero liquid discharge is obtained. Particulate emissions as low as 0.0003 gr/dscf were obtained. (Table I)

Case II burns solid and/or liquid hazardous waste and only utilizes a quench/packed tower absorber ahead of the WESPs. (Fig. 4) In this instance a rubber lined, carbon steel housing was used to reduce corrosion. The WESP collector, ionizing electrodes and remaining flue gas exposed surfaces were constructed of Hastelloy. No inertial type pre-scrubbing is used primarily because particulate sizing after the incineration is predominately submicron (Table II) By using two WESPs in series, particulate levels as low as 0.002 gr/dscf were achieved. (Table III) The cleanest water is circulated through the WESPs to the packed tower where the bleed off solids are concentrated and removed by a filter press for disposal.

TABLE I
Test Burn Emission Summary

(Limit)	Average Condition I	Average Condition II	Average Condition III
DRE' %			
PCB (99.9999)	99.999995	99.999943	99.999994
MCB (99.9999)	99.999919	99.999918	99.999969
HCE (99.9999)	99.999988	99.999983	99.999978
Metals Removal %			
Antimony	99.9914	99.7464	99.8274
Arsenic	99.9973	99.9943	99.9781
Barium	99.9989	99.9961	99.9974
Beryllium	99.9912	99.9960	99.9966
Cadmium	99.9971	99.8688	99.5516
Chromium	99.9967	99.9684	99.9822
Lead	99.9985	99.9716	99.9971
Mercury	95.6760	91.8541	98.1065
Silver	99.9803	98.9819	99.7859
Thallium	99.9087	99.7884	99.6372
Particulate			
gr/dscf (0.02)	0.0006	0.0009	0.0003
*Maximum liquid and direct burn			
**Maximum sludge burn			
***Maximum bulk solids burn			

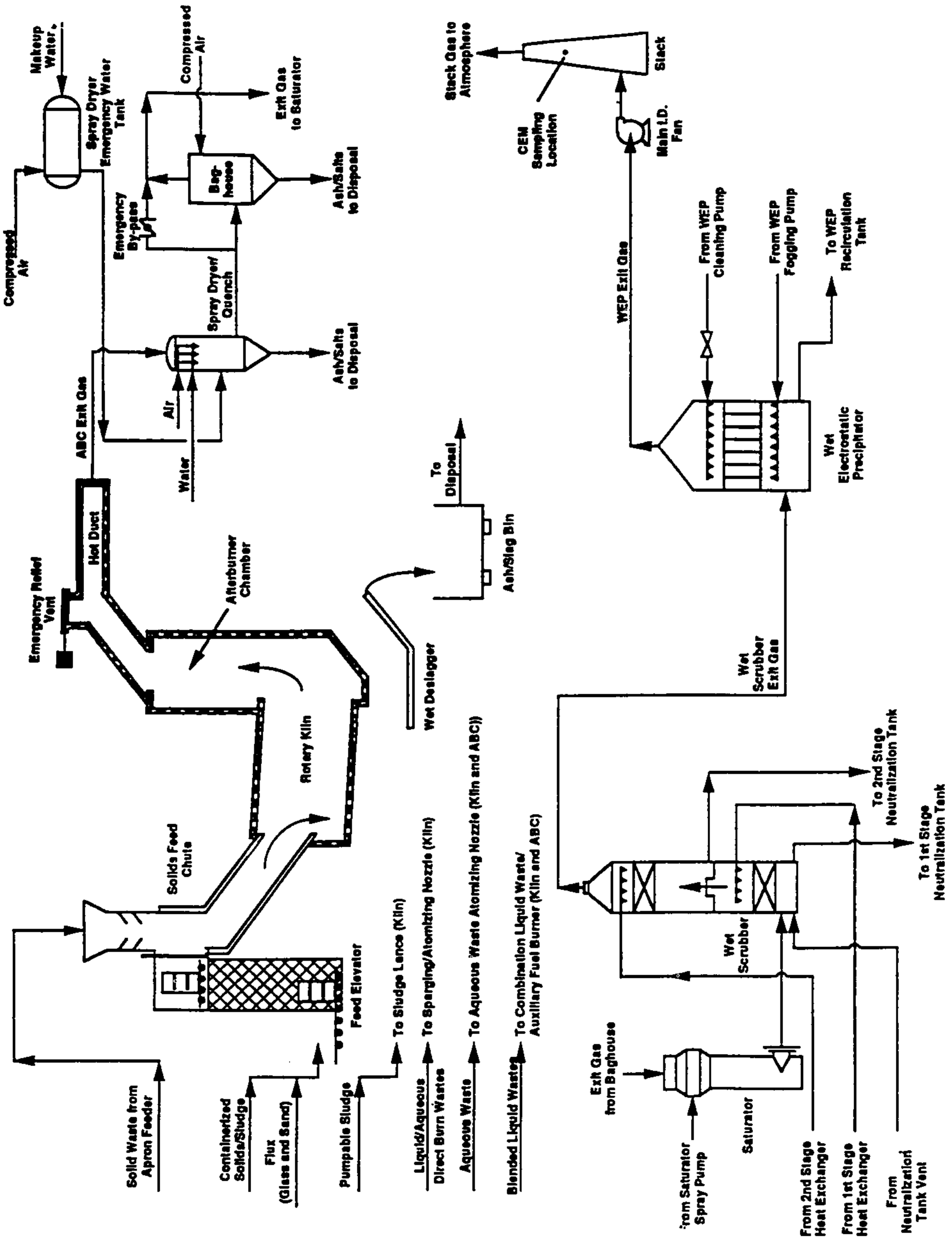


Fig. 3. APTUS Environmental Services-(Case I).

PONTYPOOL PLANT

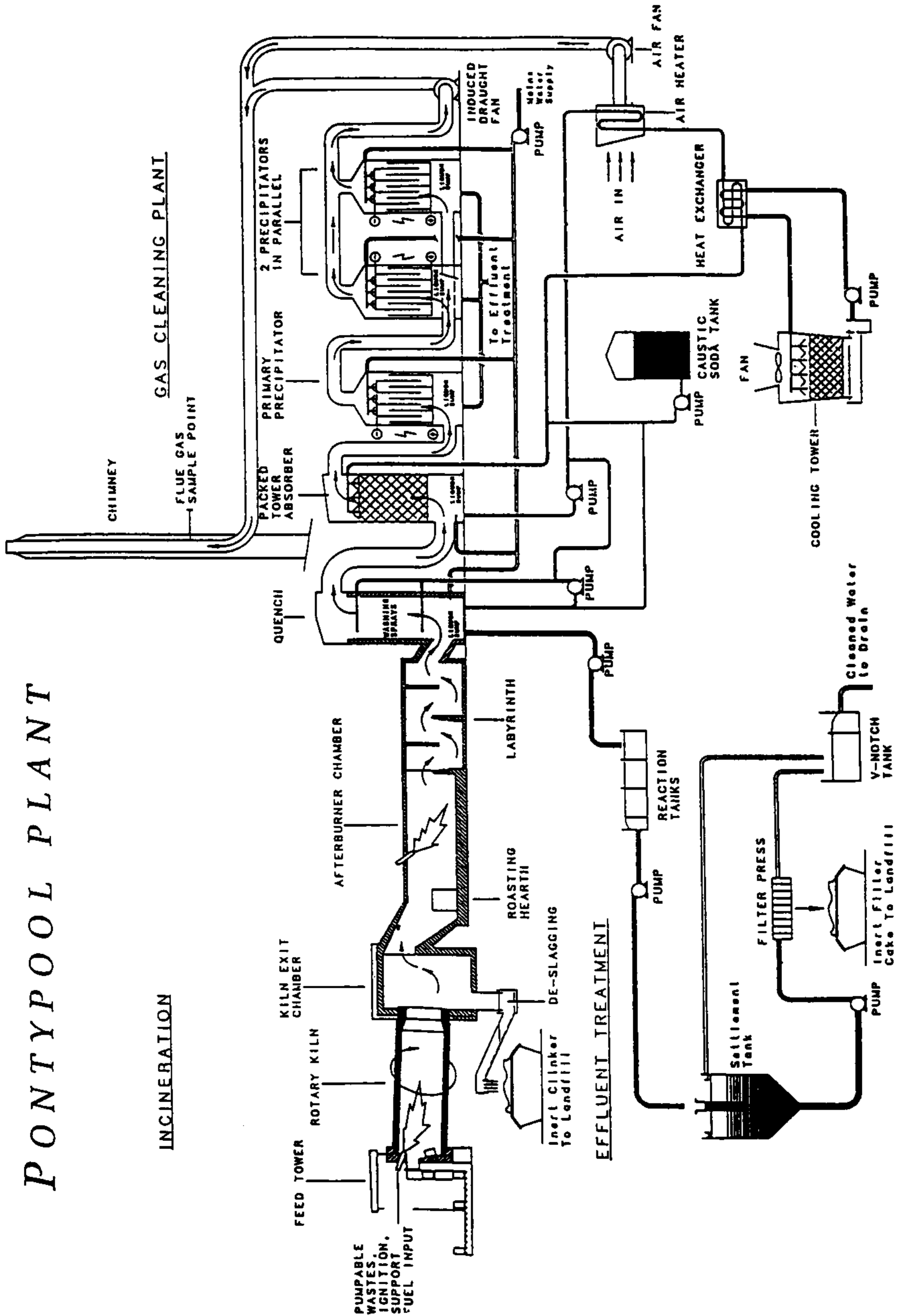


FIGURE 4

CASE II

* Particulate Emission < 0.002 gr/dscf
Gas Flow Rate 28,000 scfm

Fig. 4. Pontypool Plant (Case II).

TABLE II
Cascade Impactor Particle Size Distribution

Stage	Effective Cut Diameter (um)	Weight (g)	% in Size Range	Cumulative % Less Than Cut Diameter
0	16	0.0001	.058	100
1	11	0.0000	0	99.42
2	7	0.0002	1.16	99.42
3	4.6	0.0000	0	98.26
4	3	0.0000	0	98.26
5	1.5	0.0004	2.33	98.26
6	0.95	0.0019	11.05	95.93
7	0.65	0.0029	16.86	84.88
Filter	<0.65	0.0117	68.02	68.02
Total		0.0172	100	100

Case III burns liquid organic waste and uses a high energy scrubber ahead of the WESP. (Fig. 5) This unit is constructed of 316 S.S. material for corrosion inhibition. Again, the cleanest water is first circulated through the WESP, with bleed off used and concentrated in the scrubber. Even at ΔP 55" w.c. the scrubber was unable to maintain acceptable emission levels. (Table IV)

TABLE III

Compound	Inlet CONC Typical	Outlet CONC Mean Value	% Removal	Permitted
PCB	1 mg/m ³	.86 ug/m ³	*	.90 ug/m ³
Total Particulate	1000 MG/m ³	2.6 MG/m ³	99.74	50 MG/m ³
Chromium	10 MG/m ³	0.007 MG/m ³	99.93	----
Mercury	.1 MG/m ³	<.05 MG/m ³	>50	0.5 MG/m ³
Total Organics	10 MG/m ³	2.5 MG/m ³	75	25 MG/m ³
Total Free Halogen	10 MG/m ³	< 1.0 MG/m ³	>90	10 MG/m ³

* Corresponds to > 99.99995 Destruction at Incineration Rate of 5 Tons/day

With the ability of the wet electrostatic precipitators to operate effectively at low flue gas temperatures, VOC and heavy metal condensation occurs with corresponding high percentage removal. In case I and II, flue gas subcooling was used to assure maximum metal and organic removal.

All three cases allows the use of existing exhaust fans due to the low pressure drop through these units (< 2" w.c.). The upflow designed WESPs allow all scrubber mists to be collected in the unit without requiring an additional mechanical demister. The mist collection also irrigates the collector tubes, maintaining cleanliness and minimizing washing requirements.

Maintenance requirements are minimal because of heavy duty construction of ionizing rods (3/8" dia), external filtration of fogging/cooling water and external purge air fans and filters.

CONCLUSION

The application of the wet tubular electrostatic precipitators demonstrates that tough particulate regulations can be easily complied with by this design and that sub-micron particulates, resulting in high opacity, can be removed.

ACKNOWLEDGEMENTS:

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TABLE IV
Burroughs Wellcome
Greenville, N.C.
Liquid Hazardous Waste Incinerator
Particulate Emission Results

Feed Rate: 200 #/hr Chloroform 570 #/hr Process Waste with 5.2% NaCl				
Test	Scrubber ΔP	Scrubber Discharge (est)	WESP ΔP	WESP Discharge
1	55" w.c.	0.065 gr/dscf	1.0" w.c.	0.00658 gr/dscf
2	55" w.c.	0.059 gr/dscf	1.0" w.c.	0.00594 gr/dscf

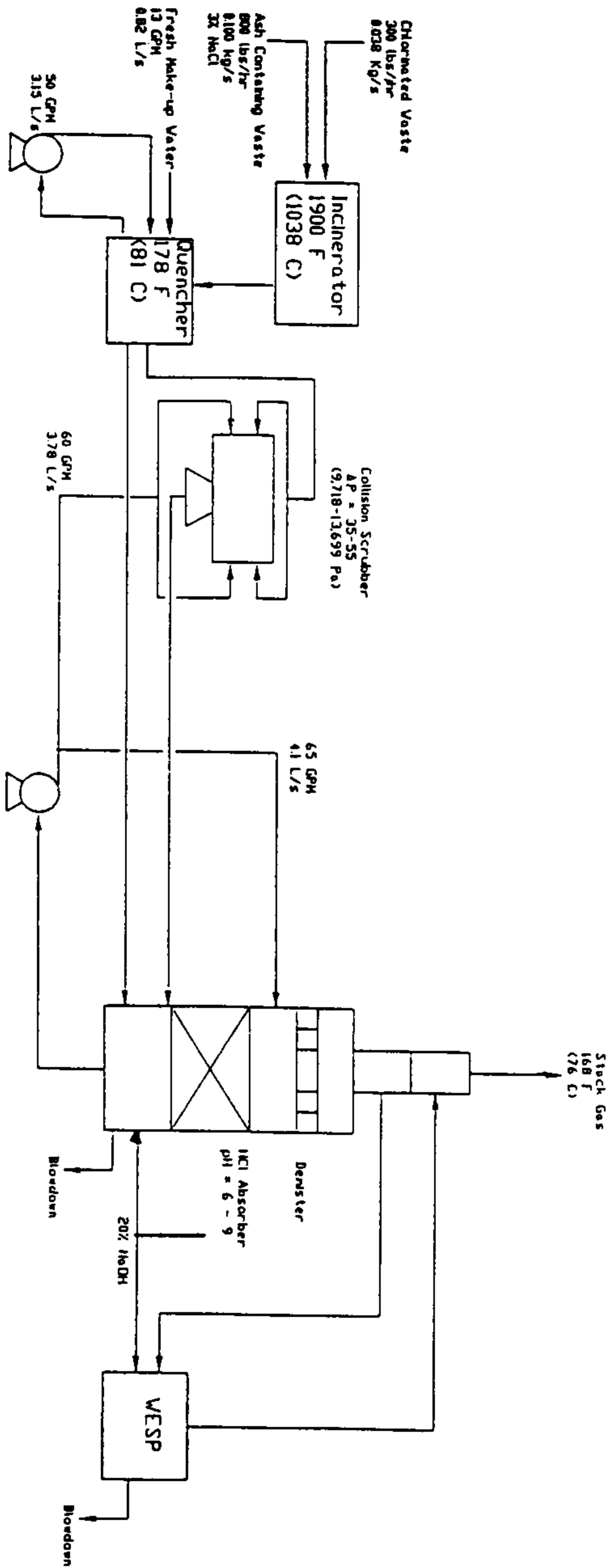


Fig. 5. System flow diagram (Case III).