Combined Heat Recovery and Dry Scrubbing for MWCs
To Meet the New EPA Guidelines

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INTRODUCTION

Both the UK and US Municipal Waste Combuster (MWC) markets have undergone upgraded regulatory control. In the UK, the government's Integrated Pollution Control (IPC) regime, enforced by the 1990 Environmental Protection Act (EPA) Standard IPR5/3 moved control of emissions of MWCs from local councils to the government Environmental Authority (EA). Existing MWCs had until December 1, 1996 to complete environmental upgrades. Simultaneously, the European Community (EC) was finalizing more stringent legislation to take place in the year 2001.

In the US, the 1990 Clean Air Act amendments required the Environmental Protection Agency (EPA) to issue emission guidelines for new and existing facilities. Existing facilities are likely to have only until the end of 1999 to complete upgrades.

In the UK, retrofits had considerable incentive to maximize energy recovery because of government incentives for energy production from renewable resources. Four facilities with a total capacity of 900,000 tpy opted for energy recovery and air pollution control. Our company in the UK received contracts, which included energy recovery equipment as part of Air Pollution Control (APC) contracts at:

1. Coventry and Solihull Waste Disposal Company(CSWDC), originally with a capacity of 175,000 tpy but upgraded to 260,000 tpy.
2. London Waste Company, Edmonton, with a capacity of 690,000 tpy.

In North America, our company had received contracts from Kvaerner EnviroPower AB, for APC systems on four new Refuse Derived Fuel (RDF) fluid bed boilers that incorporated low outlet temperature economizers as part of the original boiler equipment. The Fayetteville, North Carolina facility was designed for 200,000 tpy.

What all these facilities have in common is low economizer outlet temperatures of 285°F coupled with our Total Dry Scrubbing Systems. MWC or RDF facilities using conventional spray dryer/fabric filter combinations have to have economizer gas outlet temperatures about 430°F to allow for evaporation of the lime slurry in the spray dryer without the likelihood of wall build up or moisture carry over. Since the Totally Dry Scrubbing System can operate with economizer gas outlet temperatures about 285°F, the added energy available for sale from adding low outlet temperature economizer heat recovery can be considerable.(Figure 1). This paper focuses on Procedair's new plant and retrofit experience using "Dry Venturi Reactor/Fabric Filter combination with this lower inlet temperature operating conditions.

SYSTEM COMPONENTS

The principal components in designing a high heat recovery/dry scrubber system are:

1. Heat recovery economizer designed for low outlet temperature (less than 290°F).
2. Dry venturi reactor for hydrated lime and powdered activated carbon injection and primary gas reaction with the boiler flue gases.
3. Fabric filter dust collector for particulate collection and secondary gas reaction.
4. Material handling for recycle of partially reacted and unreacted reagent and waste disposal.

Heat Recovery Economizer

Gas temperature has a major effect on the performance of any dry-scrubbing system, particularly the SO_2 removal efficiencies as shown in (Figure 2). The designs utilized for the enhanced heat recovery for the Coventry and Edmonton retrofits utilized finned tubes to provide heat recovery in minimal space. Figure 3 shows typical designs of a single and double finned tube for economizers. Finned tube economizers have been used in Europe for this application for some time as shown in (Table1). The Uppsala economizer is installed after the primary electrostatic precipitators and therefore sees relatively little dust (about .02 gr/dscf). The SYSAV economizer is located after a primary cyclone separator, and therefore, sees only about 1.0 gr/dscf dust load. The economizers installed on the Coventry and Edmonton retrofits have no pre-cleaners ahead of them. They therefore see the total flyash load. They are also installed before the acid gases are removed from the gas.

The Coventry economizers have three banks of finned tubes. The first two banks have carbon steel fins and the third or outlet bank has cast iron fins. The Edmonton retrofit used a first-stage bare tube section followed two carbon steel finned tubed sections. Designs details from the Coventry economizer is shown in Table 2. Both systems were integrated into the existing boiler heat cycle. The economizer subcontractors undertook extensive studies of the existing economizers and boiler steam drum designs to insure the added steam production could be handled by the existing boiler design. Both systems feature water recirculation systems to control the exit flue gas temperatures between 275°F and 285°F. The first of the two economizers for London Waste was put on line in June, 1995 with subsequent units being added about every three months. The three economizers at Coventry were put on line between twelve to fifteen months ago. To date, no cleaning other than normal soot blowing has been required for any of the units at Edmonton or Coventry. The units have been inspected every boiler outage (between eight to ten weeks). However, there is no sign of dust build up or corrosion.

Dry Venturi Reactor

Our vertical dry venturi reactor shown in Figure 4 has been developed over more than 20 years. The gases pass through a convergent zone into the reaction throat where hydrated lime and powdered activated carbon are injected into the flue gas. The reactor tower is basically a vertical double annulus, which provides for both the homogenous mixing of totally dry reagents with the flue gas constituents and also insures the necessary residence time (contact time) for the reagent in the gas stream. This use of a vertical arrangement insures that there is minimal stratification with resultant uneven or poor neutralization. The injection of the reagents into the gas stream through a venturi insures complete distribution of the reagent in this turbulent flow section. Pressure drop across the Venturi Reactor is only 2" H_2O, compared to 10" H_2O for conventional fluid bed reactors and 2 ½" H_2O for spray dryer type absorbers.

Fabric Filter Dust Collector

Both the Coventry and Edmonton installations are equipped with our TGT pulse jet fabric filter units for the final cleaning stage. This is a modern state-of-the-art pulse jet fabric filters utilizes low pressure compressed air (25 to 45 psig), injected by means of our proprietary Integrated Action Piston (IAP) valve for high-volume low-pressure cleaning. The IAP valve replaces the conventional diaphragm valve and overcomes many of the disadvantages of this type of valve. Due to its large open section and piston operation, the pressure drop across the IAP valve is extremely low compared to a conventional diaphragm valve, with significant energy savings. The principal advantage, however, of the IAP valve is that unlike the diaphragm valve, which both snaps open and snaps shut rapidly, it permits a rapid opening with a slow controlled closing sequence. The snapping shut of the diaphragm valve causes the fabric to slap back onto the cage creating bag to cage wear, shock wave problems and thus dust carry through. With the IAP valve, the bag is rapidly inflated for maximum cleaning efficiency, but is deflated slowly. Reducing the pressure within the bag progressively permits it to regain its normal filtration position in a slow and controlled manner and to obtain for the fabric what is termed as a "soft landing." The use of soft landing reduces the wear of the fabric caused by the fibers rubbing against each other and also the shock of the fabric returning to the support cage. This translates into longer bag life and lower emission levels. Prior to the development of the IAP valve, the only method by which filter bag could be cleaned in a similar manner was to isolate individual cells from the main gas flow and to clean the bags in that cell of line. This however, frequently requires the use of an additional compartment to allow for off-line cleaning. This method of cleaning not only does away with the need for the additional compartments, but also enables longer filter bags (greater than 16 ft) to be cleaned by the pulse jet method. At both Coventry and Edmonton, the bags are 23 ft long. By using long bags, and on-line cleaning, the footprint of the filter unit is minimized, which can be a very important consideration when retrofitting, especially in cases like Coventry, where the majority of equipment had to be installed inside the existing glass-walled building.

The TGT dust collector makes use of a proprietary baffled inlet (Figure 5), that provides the following benefits:

1. Directs the gases upwards and across the bags reducing greatly the interstitial ("can velocity") velocity.
2. Deflects a large part of the dust directly into the hopper to reduce the dust load on the bags.
3. Allows units to operate with on-line cleaning at high filtering velocities of 4 fpm, which again reduces the equipment footprint:

Powdered Activated Carbon Injection

Increasingly, emphasis is being given by the Regulatory authorities to the emission of mercury and Dioxin/furans (PCDD/PCDF). Considerable work has been done on the removal of mercury and PCDD/PCDF from flue gas streams. With the Dry System, the Powdered Activated Carbon (PAC) is injected separately into the Venturi reactor. Procedair has considerable experience in the removal of polyhydrocarbons using dry injection of powdered coke or carbon products in to venturi reactors. This is derived from more than fifteen years of supplying APC equipment to control the hydrocarbon emissions from green anode plants in the primary aluminum industry.

Material Handling for the Recycling of the Partially Reacted Reagent

The fabric filter separates the flyash/acid salts and unused lime. These dry solid particles are constantly evacuated from the baghouse hoppers and, in the Procedair Dry System, are in the main recycled. Without recycling, it is a fact that even with a good reactor tower design and secondary neutralization in the filter cake in the bag house, there will be over 60% of the lime unreacted and going to waste. This has a major impact on operational costs due to the need for high stoichiometric ratios to achieve regulatory emission control levels. By using reactor product recirculation, there is a five-fold benefit created by the "apparent stoichiometric ratio" at the Venturi Reactor (Figure 6).

1. Unreacted lime will be afforded further opportunity to be used, lowering fresh stoichiometric ratios and operating costs.
2. Recirculation, at rates of between 30 and 50 times the fresh lime feed rate, means the mass of reagent within the gas stream increases the probability of contact by pollutant molecules with reagent, thus increasing removal efficiency.
3. The multiple handling and passage of the particulates due to recirculation causes a particle size reduction, partially through attrition, and partially due to reacted surface material breaking away exposing unreacted material.
4. The continuous mass of material recirculating throughout the process acts as a buffer dampening peak pollution production levels and compensates for any reduction or interruption in fresh reagent flow.
5. The high recirculation rate also provides for recirculation of the activated carbon. Without recirculation, activated carbon would have to work on a once-through basis. Recycling reduces the usage of activated carbon at the same time minimizing PCDD/PCDF and mercury emissions.

These aspects are demonstrated in Figure 7, which is a comparison of systems with and without recirculation. Consistent higher removal efficiencies are obtained at lower fresh lime stoichiometric ratios with recirculation. Higher predictability is gained with recirculation. With the commercial necessity to guarantee consistently low emission levels at minimized stoichiometric ratios, these advantages are very important.

OPERATIONAL FACILITIES

Dry scrubbing of MWC five gases has gone through three phases which are shown on Table 3. The first phase is dry-scrubbing from earlier installations, at temperatures of 400-450°F. Here emission levels were not as strictly regulated and the control of SO_2 frequently not required. The second is where the dry system is modified by the addition of an evaporative cooling tower between the boiler and the dry-scrubbing system. This permitted capture of SO_2 and consistent operation with the higher efficiencies required by earlier updates of regulations. The two reasons for this improvement over a dry-system are:

1. Inlet temperature to the scrubbing system can be very precisely controlled and for optimum performance lowered to 285°F without increasing corrosion risks in heat recovery equipment.
2. The relative humidity of the flue gas increased by the water which contributes to improved scrubbing performance.

The third, our present generation operating systems utilizing low outlet temperature economizers with totally dry-scrubbing systems to achieve the latest regulatory emission control levels.

BCH Energy, Fayetteville, NC.

The BCH Energy facility comprised two Kvaerner bubbling fluid bed combustors burning RDF. Each combustor was rated at 300 tpd. Economizers, provided for the boilers by Kvaerner, cool the gases below 290°F. It was felt that the use of the bubbling fluid bed would lead to higher flyash production due to the carryover of bed sand particles with the RDF flyash. For this reason the APC equipment starts with a cyclonic precleaner to reduce the dust load to the APC system. The design conditions for the BCH Energy project are shown in Table 4. The scope of supply for the equipment for the APC equipment is shown on Table 5. Results of the emission tests performed on the two boilers in 1996. Shown in Table 6, indicates that the APC equipment performance was better than that required by the permit.

Coventry and Solihull Waste Disposal Company (CSWDC)

At the time of tendering, the CSWDC facility comprised three mass burn water wall incinerators utilizing Martin grate technology with a unit capacity of 320 tpd of MSW. The original operating permit for the facility was based on any two furnaces operating at one time; therefore, the existing air pollution control equipment consisted of only two lines of electrostatic precipitators for flyash removal through a manifold system at the outlet of the three boilers.

The CSWDC facility added an electrical generating steam turbine in 1991 to take advantage of the revenue available from electricity generation. The retrofit contract called for three sets of air pollution control equipment to allow the facility to operate all three at a time. This increased both the waste throughput revenue and the electrical generation revenue.

During the bidding process, extensive visits were made to other facilities in Europe and North America by the Coventry operational personnel. After talking directly to the operational staff at these facilities, two opinions were formed.

1. Despite having demonstrated its ability to meet the required emission standards, the semi-dry process (spray-dryer with lime slurry with fabric filter) in its various forms had the considerable disadvantages of requiring the preparation and handling of lime slurry and its atomization into the flue gas stream in a spray dryer.
2. The totally dry-scrubbing technology was seen to offer the potential to meet the new required standards with fewer potential operational difficulties and maintenance requirements. It was realized also that this system would allow the recovery of additional energy using an extended economizer rather than wasting energy by spraying water into the spray dryers.

The scope of work for the CWSDC retrofit is shown in Table 7 and the design criteria for the CWSDC system in Table 8. The Coventry facility has been tested and the test results are shown in Table 9.

London Waste Limited

The London Waste Limited, Edmonton facility was originally owned and operated by five London Boroughs. These formed a joint venture with SITA (GB) Limited, to form a company called London Waste Limited (LWL). The facility consists of five, 450 tpd mass burn grates and boilers, giving a capacity of 690,000 tones/year. Each boiler was equipped with an economizer for heat recovery and electrostatic precipitator for dust removal. At the LWL facility, a decision was made during the bidding stage that the upgraded facility would be capable of meeting the more stringent European Community (EC) legislation for 2001. This meant that the outlet HCl emission had to be guaranteed at 10 mg/Nm³ (6 ppmdv) against a high potential inlet condition of 2,000 mg/Nm³ (1230 ppmdv). At the time, it was thought necessary to combine the precise temperature control and added humidification from a conditioned dry system with the heat recovery/dry system in order to have no risks on the guarantees. As a result, the LWL facility decided to upgrade the performance of the economizer but only to reduce the flue gas outlet temperature down to 330°F and install an evaporative cooling tower, to further cool the gases to 285°F. This condition would insure compliance with the UK standard IPR 5/3. To meet the more stringent EC standards, the economizer outlet temperature could be raised to 365°F allowing for increased humidification of the flue gas. It should be noted that CWSDC decided to take the maximum heat recovery during the early stages of the operation so increasing the energy income until 2001. Space, however, has been left in the facility building to allow the retrofitting of evaporative conditioning towers to provide conditioned dry systems should CWSDC need this in order to meet the EC 2001 regulations.

The design conditions and scope of supply for Edmonton are shown in Tables 10-11. The facility has undergone performance tests and the results are shown in Table 12. These show that the units can practically meet the more stringent EC 2001 when operated at the lower economizer outlet temperature.

CONCLUSIONS

The use of a Heat Recovery/Dry-Scrubbing System for retrofit MSW installations provides the following:

1. Increased energy recovery from an existing facility is possible within the existing boiler design parameters. The finned tube economizers can reduce the gas outlet temperatures to below 285°F and control the outlet temperature at this level when combined with a temperature control system.
2. The capital costs for the Heat Recovery/Dry-Scrubbing System is competitive with conventional spray-dryer/fabric filter combinations. The facility gains the extra benefit of the added revenue from increased energy production.
3. The Heat Recovery/Dry Scrubbing System can provide performance levels that exceed those currently envisaged by the most recent EPA regulations for MWCs.
4. The footprint for the Heat Recovery/Dry-Scrubbing System is generally smaller than that required for the spray dryer/fabric filter combination.
5. The total gas volume to be handled by the dry scrubber is reduced by heat recovery instead of humidification, resulting in less fan horsepower. The pressure drop for the enlarged economizer/venturi reactor is approximately the same as for a spray dryer.
6. The use of powdered activated carbon (PAC) within the dry-scrubbing system is highly effective for the removal of mercury and PCDD/PCDF compounds. This removal is achieved at low consumption rates for PAC due to the recycling of the PAC with the other reagent compounds.
7. Finned tube economizers can operate with dirty gas and low outlet temperatures for extended periods without plugging and corrosion.

The heat recovery/dry scrubbing system has particular application to those facilities selling electricity or steam. The additional steam raised can be turned into useful energy, generally within the capability of the existing boiler/turbine combination. This extra energy will supply the parasitic power needed for the APC equipment, and will allow additional export of power for revenue purposes.

Acknoledgements

The authors wish to Acknowledgments the assistance given by CSWDC and LWL personnel in providing information for this paper. They also wish to thank Kvaerner and BCH Energy for their help with test data.

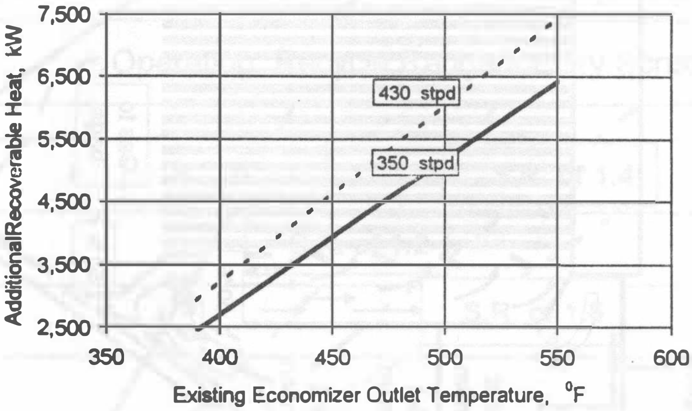


Figure 1. Additional Heat Recovery from Municipal Waste Boilers assuming 290 °F from New Economizer Section

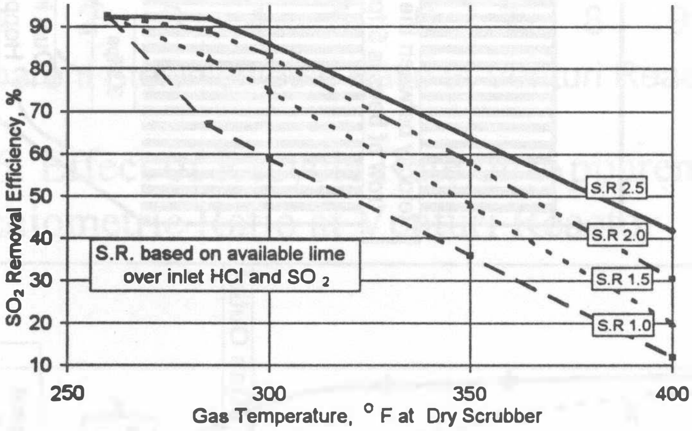
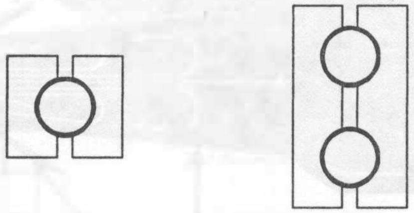


Figure 2. SO_2 Removal Efficiency by Dry Scrubbing at Various Gas Temperatures and Stoichiometric Ratios (S.R.)



Typical Data
Tube Diameter: 48.3 mm
Wall Thickness: 4 mm
Fin Size: 95 mm x90 mm
Fin Thickness: 2 mm
Pitch: 10 mm to 30 mm
Heating Surface: 0.6 to 1.5 m ²/m

Typical Data
Tube Diameter: 38.0 mm and 48.3 mm
Wall Thickness: 3.6 mm and 4 mm
Fin Size: 70 mm x 145 mm and 95 mm x 195 mm
Fin Thickness: 2 mm and 3mm
Pitch: 10 mm to 30 mm
Heating Surface: 0.8 to 3.3 m ²/m

Figure 3. Typical Specifications for Single and Double Finned Tubes for Economizers for MSW Boilers

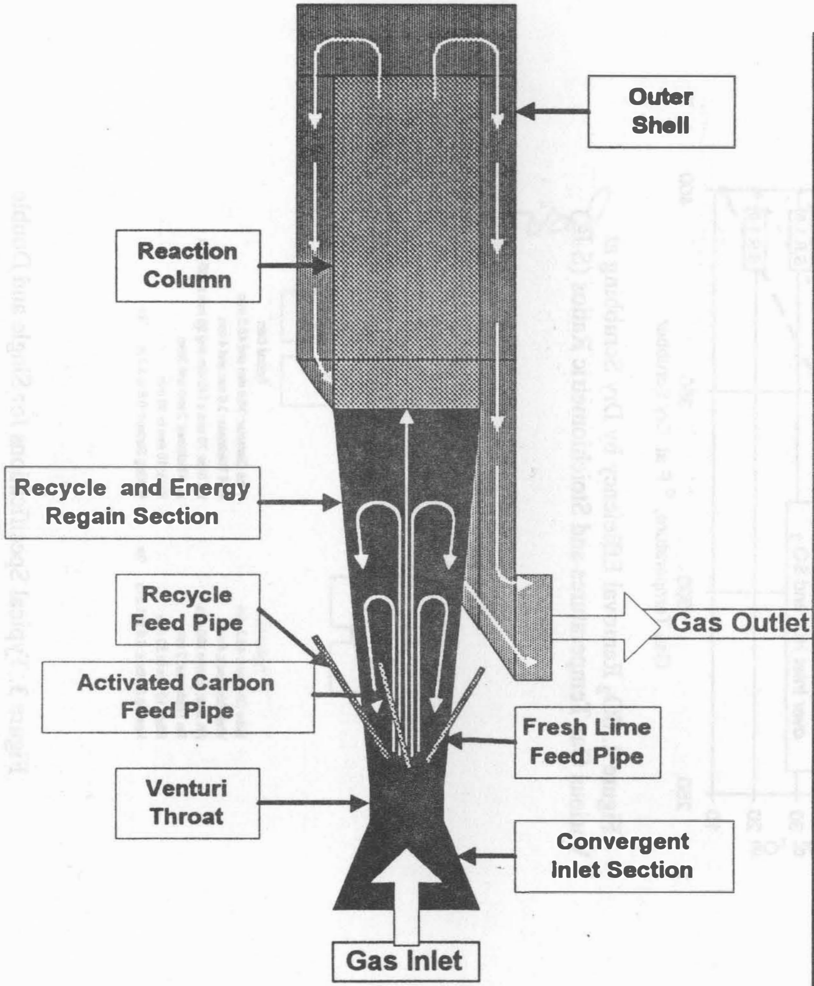


Figure 4. Dry Vertical Venturi Reactor

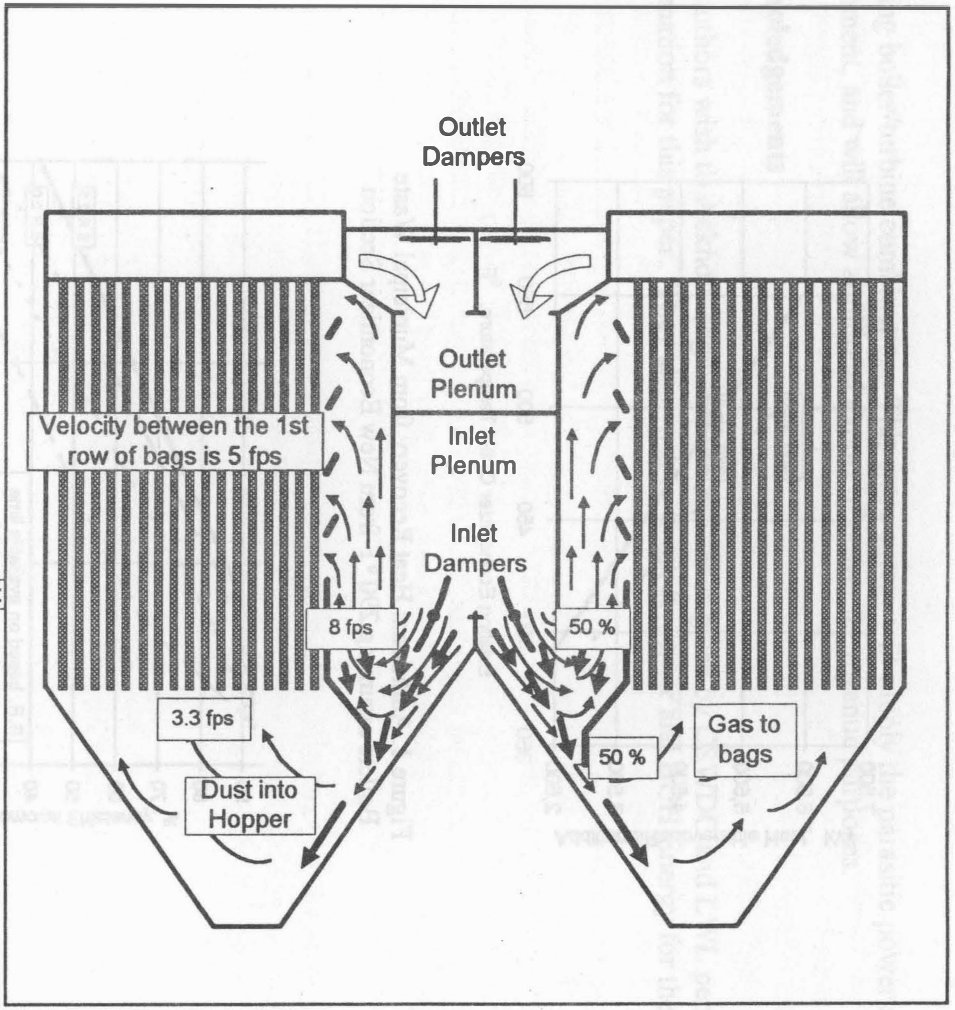


Figure 5.Baffled Inlet Design for TGT low pressure jet filters

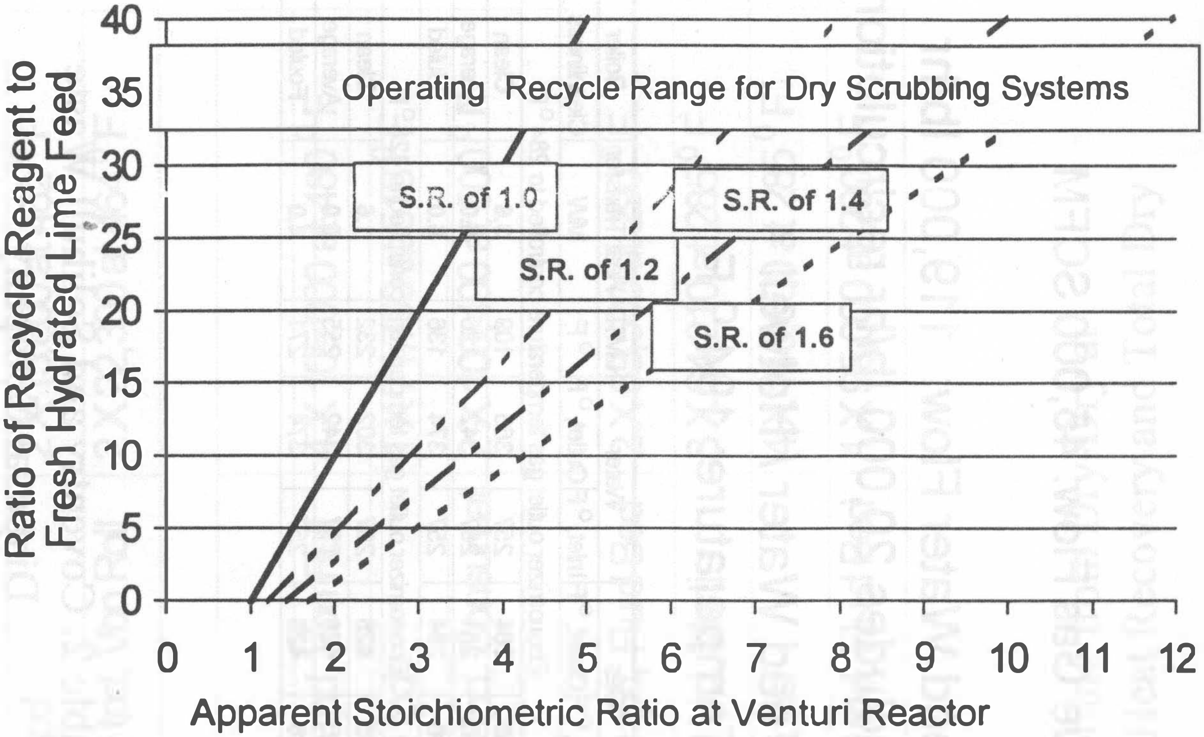


Figure 6. Effect of Recycle Rate on Apparent Stoichiometric Ratio at Venturi Reactor

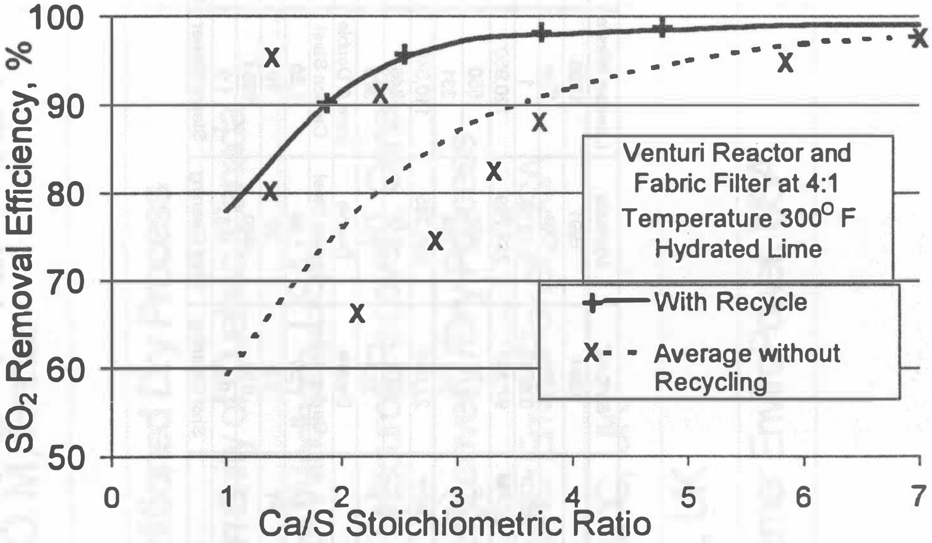


Figure 7. Pilot Plant Dry Scrubber System SO$_2$ Removal Capabilities

		SYSAV	Uppsala	London Waste	Coventry
Delivery Date		1994	1991	1995	1996
No. Units		One	One	Five	Three
Dust Load	Gr/SCF	0.8740	0.0218	1	4.0
Gas Flow	ACFM	97,347	236,789	120,950	92,628
Inlet Temperature	° F	572	482	550	626
Outlet Temperature	° F	354	284	331	284
Water Flow	Lb/Hr	22,046	855,385	110,340	146,826
Inlet Temperature	° F	275	248	248	266
Outlet Temperature	° F	333	284	370	388
Tube Type		Double	Double	Bare & Double	Double
Material		Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel
Tube Diameter	In	1.50	1.50	1.50	1.50
Tube Length	Ft	8.5	20	19	15
No. Finned Tubes		630	660	1584	1584
Fin Pitch	In	0.8	0.8	1.0	0.9
Cleaning Method		Shot Cleaning	Shot Cleaning	Steam Blower	Steam Blower

Table 1. Typical Finned Tube Economizers

Flue Gas Flow: 45,000 SCFM

Feed Water Flow: 119,000 lb/hr (includes 20,000 lb/hr recirculation)

Feed Water / Hotwell Temperature: 194 ° F

Gas		Water		LMTD	Heat Transfer	Boiler
Inlet, ° F	Outlet, ° F	Inlet, ° F	Outlet, ° F	° F	MW	Cleanliness
Economizer outlet gas temperature controlled to 284 ° F						
536	284	257	365	109	3.6	Clean
626	284	257	342	126	5.0	Average
698	284	257	374	136	6.0	Fouled
Economizer outlet gas temperature controlled to 428 ° F						
536	428	257	302	232	1.6	Clean
626	428	257	342	255	3.0	Average
698	428	257	374	271	4.0	Fouled

Table 2. Coventry and Solihull Waste Disposal Company Economizer Heat Transfer Data

Dry Process	Year	Size	Gas Volume- acfm
Roselare, France	1987	2 X 100 tpd	2 X 30,400 at 482 ^{0}F
Edegem, Belgium	1987	2 X 50 tpd	2 X 15,800 at 482 ^{0}F
U. I. O. M, France	1988	2 X 100 tpd, Von Roll	2 X 22,300 at 464 ^{0}F

Conditioned Dry Process			
Community of Quebec, Canada	1988	4 X 250 tpd, Von Roll	4 X 105,000 at 480 ^{0}F
City of Windham, USA	1989	1 X 200 tpd	1 X 71,700 at 518 ^{0}F
Peel Resource Recovery, Canada	1992	4 X 100 tpd, Consumat	2 X 103,400 at 500 ^{0}F
Heat Recovery /Dry Process			
Kvaemer EnviroPower, USA	1994	2 X 300 tpd, Fluid Bed	2 X 63,500 at 290 ^{0}F
CSWDC, UK	1995	3 X 320 tpd, Martin	3 X 64,210 at 285 ^{0}F
LWL, UK	1995	5 X 450 tpd	4 X 110,000 at 285 ^{0}F
Kvaemer EnviroPower, USA	1997	1 X 600 tpd, Fluid Bed	1 X 95,000 at 290 ^{0}F

Table 3. Progression of Dry Scrubbing from Dry-Dry at High Temperature to Conditioned Dry to Heat Recovery and Total Dry

● Gas Flow	62,400 ACFM	
● Temperature	293° F	
● Gas Analysis	H_2O	13.1 to 17.3
% by vol	CO_2	11.0
	O_2	6.1
	N_2	69.7
● SO_2 Concentration	240 ppmdv	
● at 7% O_2		
● HCl Concentration	761 ppmdv	
● at 7% O_2		
● HF Concentration at 7% O_2	35 ppmdv	
● Dust Concentration gr/dscf at 7% O_2	4.5	

Table 4. BCH Energy Design Inlet Conditions

- One (1) Hydrated Lime Handling System with Redundant Feeders
- Procedair Activated Carbon Storage and Metered Feed System
- Two (2) Procedair Duplex Cyclones
- Two (2) Procedair Dry Venturi Reactors
- Two (2) Procedair Pulse jet Baghouses,
- Reagent Recycling and Dust Handling System
- Controls and Instrumentation

Table 5. Equipment Supplied to Kvaerner for BCH Energy, Fayetteville. NC.

	Stack Emission
Particulate	< 0.002 gr/dscf
SO2	< 0.25 ppmdv
HCl	< 1.5 ppmdv
Opacity	0
Mercury	< 1.0 μg/dscm
PCDD/PCDF	< 3.0 ng/dscm

Heavy Metal	mg/dscm @ 7% O_2	
	Unit No 1	Unit No 2
Arsenic	<0.0003	<0.0004
Berylium	ND < 0.0001	ND < 0.0001
Cadmium	<0.001	<0.0004
Chromium 6	ND < 0.0001	
Lead	<0.015	<0.002
Mercury	<0.001	<.002

Table 6. BCH Energy, Stack Emissions Averaged from Performance Test Data

- One (1) Hydrated Lime Handling System
- Three (3) Vertical Counterflow Economizers
- Three (3) Procedair Venturi Reactors
- Three (3) TGT Low Pressure Pulse Baghouses
- Recycling, Waste Handling and Ash Silos
- Controls and Instrumentation and CEMs
- Activated Carbon Injection System
- Three (3) new Induced Draft Fans and Motors
- Three (3) pair of oil-fired Auxilliary Burners

Table 7. APC Equipment supplied and installed under the Contract with CSWDC

● Gas Flow	94,000 ACFM	
● Temperature	630 °F	
● Gas Analysis		
● % by vol	H_2O	11.0
	CO_2	11.0
	O_2	10.0
	N_2	68.0
● SO_2 Concentration ppmdv at 7% O_2		195
● HCl Concentration ppmdv at 7% O_2		950
● Dust Concentration gr/dscf at 7% O_2		4.0

Table 8. Unit Design Inlet Conditions for CSWDC

	Inlet Levels		Outlet Levels	
	g/Nm^3 @ 11% O_2	ppmdv @ 7% O_2	g/Nm^3 @ 11% O_2	ppmdv @ 7% O_2
Dioxins TEQ			0.025	
HCl	423	365	4.9	4.2
HF	1.8	2.8	0.1	0.16
SO_2	165.6	81.3	0.5	0.25
	g/Nm^3 @ 11% O_2	gr/dscf @ 7% O_2	mg/Nm^3 @ 11% O_2	gr/dscf @ 7% O_2
Particulate	2.46	1.40	3.2	0.002
Total Metals	0.021	0.012	1.4	0.0008

	mg/dscm @ 7% O_2		mg/dscm @ 7% O_2
Tin	.07	Chromium	.07
Cadmium	.01	Copper	.11
Lead	.07	Mercury	.81
Nickel	1.6	Arsenic	.01

Period- 1996	HCl			SO2			Hydrated		Gas	
	Inlet	Outlet	Efficiency	Inlet	Outlet	Efficiency	Lime		Volume	Temperature
	ppmdv	ppmdv	%	ppmdv	ppmdv	%	lb/hr	S.R.	acfm	0 F
Aug 7 to 10	551	15	97.35	120	14	88.55	242	1.92	62,536	284
Aug 18 to 21	537	12	97.84	131	12	91.23	271	2.04	46,986	280
Aug 23 to 26	492	14	97.17	128	20	84.66	239	2.10	55,579	286
Aug 31 to Sep 2	501	10	98.05	147	10	93.34	235	1.61	44,714	271

Table 9, CSWDC Emission Summary Line 1
Independent Performance Tests performed 7/8/96

● Gas Flow	208,000 ACFM	
● Temperature	930 °F	
● Gas Analysis		
● % by vol	H_2O	10.0
	CO_2	9.0
	O_2	9.4
	N_2	71.6
● SO_2 Concentration	180 ppmdv at 7% O_2	
● HCl Concentration	1720 ppmdv at 7% O_2	
● Dust Concentration	0.4 gr/dscf at 7% O_2	

Table 10. London Waste Limited, Edmonton Design Inlet Conditions

- One (1) Hydrated Lime Handling System
- Five (5) Economizers
- Four (4) Evaporative Conditioning Towers
- Four (4) Procedair Venturi Reactors
- Four (4) TGT Low Pressure Pulse Baghouses
- Recycling, Waste Handling and Ash Silos
- Controls and Instrumentation and CEMs
- Activated Carbon Injection System
- New Induced Draft Fans and Motors

Table 11. APC Equipment supplied and installed under the Contract with LWL

Test to IPR 5/3			HCl Emissions			SO_2 Emissions			Hydrated Lime	
			Limit	Actual	% of Limit	Limit	Actual	% of Limit	Actual	Actual
Date	Test	Start	ppmdv	ppmdv	%	ppmdv	ppmdv	%	lb/hr	S.R.
2/9/97	1	11:00	25.9	8.5	33.0	147.3	6.0	4.1	420.6	1.73
	2	12:00	25.9	5.8	22.3	147.3	3.3	2.3	419.1	1.86
	3	13:00	25.9	3.5	13.3	147.3	3.1	2.1	416.7	1.52
	4	14:00	25.9	7.8	30.0	147.3	6.8	4.6	412.9	1.29
2/11/97	1	10:00	25.9	3.9	15.0	147.3	2.7	1.8	447.8	1.47
	2	11:00	25.9	3.7	14.3	147.3	4.5	3.0	445.5	1.44
	3	12:00	25.9	7.0	27.0	147.3	4.2	2.9	448.4	1.57
	4	13:00	25.9	6.8	26.3	147.3	4.9	3.3	446.4	1.81
2/11/97	1	14:00	25.9	7.9	30.7	147.3	6.1	4.1	451.1	1.85
	2	15:00	25.9	7.2	28.0	147.3	4.3	2.9	443.3	1.75
	3	16:00	25.9	11.2	43.3	147.3	11.8	8.0	442.7	1.41
	4	17:00	25.9	13.7	53.0	147.3	12.0	8.1	446.7	1.56
2/14/97	1	13:00	25.9	6.7	26.0	147.3	11.2	7.6	361.8	2.52
	2	14:00	25.9	5.1	19.7	147.3	5.4	3.6	358.9	2.03
	3	15:00	25.9	2.6	10.0	147.3	4.4	3.0	358.5	1.8
	4	16:00	25.9	3.2	12.3	147.3	3.1	2.1	360.2	3.12
2/15/97	1	12:00	25.9	4.7	18.0	147.3	6.9	4.7	438.7	1.69
	2	13:00	25.9	4.4	17.0	147.3	6.4	4.4	433.4	1.78
	3	14:00	25.9	4.9	19.0	147.3	7.8	5.3	436.3	1.89
	4	15:00	25.9	4.3	16.7	147.3	7.2	4.9	435.4	1.7
Mean			25.9	6.1	23.8	147.3	6.1	4.1	421.2	1.79

Table 12. Performance Test Results to IPR 5/3 for London Waste Limited, Edmonton