

THE WHEELABRATOR FALLS STORY — INTEGRATED RECYCLING, HIGHLY EFFICIENT ENERGY RECOVERY: AN UPDATE TWO YEARS LATER

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INTRODUCTION

Wheelabrator Environmental Systems Inc., based in Hampton, New Hampshire, has developed America's first privately initiated, totally integrated Materials Recovery Facility ("MRF") with a commercial trash-to-energy facility in Falls Township, Bucks County, Pennsylvania. The MRF is successfully recovering and marketing a variety of recycled products, while demonstrating that waste-to-energy and recycling are compatible and can be successfully integrated at a single site.

The energy recovery plant and the MRF have completed one year of operation, giving adequate time to evaluate the impact of project innovations. These innovations will have a significant impact on how future projects, including waste-to-energy, wastewater and biosolids processing, will be developed.

The energy recovery facility is capable of processing 1600 tons per day of municipal solid waste from the Bucks County area. The MRF currently processes recyclable materials, such as glass (amber, clear, and green), plastic containers (PET and HDPE), steel and aluminum cans, newspapers, corrugated and mixed papers. Since start-up, an eddy current separator has been added to further enhance aluminum separation.

Our previous paper presented the project's development history which will not be repeated here. This paper examines the results after two years of operation.

On May 29, 1992, final permits from the Pennsylvania Department of Environmental Resources ("PADER") were granted to build the facility and ground breaking began shortly thereafter. The completely private project resulted in record time construction from July 1992 to first fire in April, 1994 (20 months). The very strong cash position of Wheelabrator enabled the Company to build the \$192 million facility entirely with its own internal funds. This allowed expeditious ordering of long lead time equipment and reduced the construction schedule. It also saved the project significant amounts of money in legal fees, bond issuance costs and other attendant costs of financing not directly related to plant and equipment assets.

TECHNICAL INNOVATIONS

First in High Energy Efficiency

The Wheelabrator Falls Facility is the most energy efficient trash-to-energy facility in the world. This super high-efficiency was created by several modifications to the boiler and to the steam cycle. This was made possible by years of research and development focusing on the boiler tube metallurgy. Tube banks were installed in existing units, which allowed the testing of metallurgy, flow rates, and effects of changing temperatures on both the gas and steam sides of the tubes. The net effect of the final improvements made to the Falls Township Facility was approximately 10 percent more energy production created from the same amount of trash throughout with no additional emissions. The high energy recovery was accomplished by the following modifications:

- The use of pre-heated underfire air on a continuous basis. This pre-heat was recovered from what would otherwise have been waste heat sent to the cooling tower.
- The addition of heat transfer surface in the boiler, which increased the amount of heat absorbed from the flue gas, thereby reducing the boiler outlet flue gas temperature and improving boiler efficiency.

The effects of this upgraded steam cycle are several. By producing more electricity from the same amount of trash, the recycling of trash into much needed electricity is maximized; electricity which offsets the need to produce the equivalent amount by burning imported oil.

By generating more electrical power out of the same quantity of trash, emissions from other older utility boilers are offset. Although there will be no change in emissions from the stack, the total impact to the environment will be a net reduction in emissions per kilowatt consumed by the public.

By maximizing electric production, Wheelabrator was able to offer a lower trash tipping fee, thus benefitting the communities we serve through long-term disposal assurance at a competitive and dependable rate. Table 1 illustrates the various generations of boilers developed over the years and the

added “bonus” that the Falls Facility realizes.

The high efficiency steam cycle has since proven itself, performing dependably and as expected.

First Commercial Use of Tile Refractory

Wheelabrator has researched, developed and applied for a patent on a new high efficiency tile refractory and expansion joint arrangement for its steam generating boilers. This tile refractory and expansion joint system was first commercially installed in the Falls Township Facility and has been more recently incorporated into the Wheelabrator Lisbon facility. Patents on this system have been received and portions of that patent are attached. The flue gas resulting from the combustion of municipal solid waste can be corrosive in the combustion chamber. It is important to protect the boiler water-wall tubes from this corrosion. Corroded tubes can leak which can cause reduced plant efficiency and premature shut-downs for maintenance. Prior to the development of this system, the usual refractory systems consisted of a sprayed or hand troweled castable refractory, typically a silicon carbide refractory, which was applied over pin studs which were welded to the interior of the furnace wall.

There were several drawbacks to the castable refractory system. First, the refractory proved to be an insulator against efficient heat transfer. The castable refractory was susceptible to breaking or chipping (spalling), mostly due to the mechanical pressures associated with thermal expansion and contraction. If this type of refractory spalled during operation, it would leave the boiler tubes unprotected from the gases and flames in the combustion zone. Another drawback with the castable type refractory systems was that it had to be properly applied and cured during the installation process to achieve its expected quality and physical characteristics. Any lack of quality control during this refractory installation would result in a lower degree of protection for the boiler tubes. Another drawback of the pin stud arrangement of mechanical bonding is that the pin stud itself required welding on the boiler pressure parts, thus increasing the cost of welding and quality control. Failures of refractory of this type frequently caused the fingers to be pointed between the installation subcontractor, the engineer, the material suppliers and the owner — often with no firm technical resolution.

This tile system, now commercially installed in our Falls Township and Lisbon, Connecticut facilities has proven to be a dependable and cost-effective improvement:

- It provides a protective structure for the boiler tubes that is resistant to the harsh physical and chemical conditions found in the combustion zone of the furnaces. It is designed to withstand the expansion and contraction associated with normal boiler operation over an extended period of time.
- It extends the maintenance cycle of the boiler. When a boiler comes down for inspection, the repairs are accomplished more quickly and the unit is brought back on-line sooner.
- It does not require any anchoring studs to be welded to boiler pressure parts, thus decreasing assembly and final product costs.

The system consists of anchor studs that are welded to the water wall membrane (the non-pressurized metal between the boiler tubes) and that welding can be accomplished in the shop. A heat transfer bonding material is placed between the boiler tubes and the shielding tile to permit heat transfer and create a bond between the tile and the tube.

The face of the shielding refractory tiles is smooth on the furnace inside and it is contoured to match the boiler tube profile on the outside. These tiles are hand set over the pre-mounted anchor stud and pressed into the heat transfer bonding material. A washer and a nut is placed over the threaded stud, the tip of which is now recessed into a pocket formed in the tile itself. A protective cap is then placed over the recessed pocket to protect the nut, washer, and tip of the stud anchor.

The stud anchors are welded to the membrane in such a position that the final installed tile arrangement leaves a small gap horizontally and vertically between adjacent tiles. Heat transfer bonding material is then placed in many of these joints to form a rigid joint. In other joints, a compressible material is placed between the tiles, at predetermined intervals, to allow for expansion and contraction between the tiles, while at the same time providing the necessary tube protection.

One final additional advantage of the refractory and tile expansion system is that it can be retrofitted back into existing boilers which have previously applied the castable type refractory. After over two years of continuous operation, the refractory in the Falls Township boilers shows no sign of spalling, excessive slag buildup, or anchorage failure.

First in Air Emissions Control — National Leader

The Falls Facility was the first commercial use of selective non-catalytic reduction (SNCR) for NO_x removal used in conjunction with an activated carbon injection system for mercury removal.

There were several unknowns regarding the use of SNCR in conjunction with activated carbon and what effect that might have on other air emissions and the quality of the ash generated. It has now been demonstrated that the simultaneous use of these two systems can efficiently control NO_x and necessary emissions.

The Falls Township Facility underwent its initial compliance testing in August, 1994. A three page summary of those initial tests, performed on each boiler, is attached.

In addition, the Falls Facility underwent additional testing in January and February, 1995. A two page summary of those results is also attached. The net result is that this facility has repeatedly demonstrated full compliance with all of its permit conditions.

First to Maximize Electrical Return Through Private Interconnect Outside of Service Territory

In order to maximize the electrical return on this facility, Wheelabrator responded to an RFP from Public Service Electric and Gas of New Jersey (“PSE&G”). As a result of that solicitation, the Wheelabrator project was awarded a power sales contract with PSE&G.

The Falls Facility was located in another utility's service territory, specifically, Philadelphia Electric Company ("PECO"). Wheelabrator is now delivering power through a private interconnect directly to PSE&G. This arrangement, described in our earlier paper, has worked well.

First in Modularization, Scheduling and Construction Planning

The Wheelabrator Falls Facility received its Permit to Construct on May 29, 1992. Wheelabrator had already signed a contract with the City of Philadelphia that required Wheelabrator to take its committed portion of Philadelphia generated trash by May 31, 1994. The Wheelabrator Falls Facility successfully had its first fire on May 6, 1994 and went into commercial operations in August, 1994. This was the shortest construction schedule and the shortest start-up period of any facility of comparable size in the country.

Increased modularization was one key element of the construction planning. Items were pre-assembled in the shop to the maximum deliverable size or road weight. A barge unloading berth on the adjacent Delaware River was used to unload and deliver a pre-assembled turbine-generator. By use of the barge and river system, the turbine-generator was shop pre-assembled to a much greater degree than would have been available with over the road transportation. Boiler water-wall panels were pre-assembled in the Babcock & Wilcox shop to the maximum transportable size in order to eliminate field welding of pressure parts to the maximum extent possible. This saved considerable time and expense in field labor and field quality control. Construction, scheduling, and expediting was performed so that the major pieces of equipment could be off-loaded and set directly on their foundation or on the steelwork within the building. Structural steel erection was extremely well coordinated to provide "leave-out" steel where necessary to allow for this coordinated equipment setting. Over the top loading of boiler components allowed concurrent erection of the flue gas cleaning system, the refuse receiving, and turbine generator areas.

Many other systems have been modularized and skid mounted where applicable. By planning the equipment arrivals, having the necessary lifting capacity available on the arrival date, having the necessary foundations and structural steel ready and waiting and being able to place equipment as it arrives eliminates the need for double or triple handling of equipment, remote laydown yards, added manpower and extended schedules.

Sanitary Wastewater Handling: A Unique Combination

The Wheelabrator Falls Facility has a sewage interconnect with the adjacent Waste Management G.R.O.W.S. Treatment Facility. The G.R.O.W.S. Treatment Facility, which treats sewage from Waste Management's office complex along with leachate from the landfill, had excess permitted capacity. Since Waste Management owns controlling interest in Wheelabrator, this was not viewed as a public utility concern. It was viewed merely as one sister company helping another through a shared and available infrastructure. This unique arrangement has worked virtually trouble free.

To make steam, you need water and the water interconnect proved just as challenging. The Falls Township project also had some interesting challenges in its efforts to find a dependable and reliable source of adequate water. Problems associated with finding a suitable water source were described in our previous paper. The project eventually turned north to Morrisville Borough for water. Morrisville had the excess water capacity and the permits in place to increase their rate of withdrawal. A two mile water line was successfully constructed from the Morrisville line, through Falls Township, to the facility. Contracts were negotiated whereby TOFA would buy water from Morrisville, and the Falls Facility then would buy water from TOFA. Those contracts also called for the project to construct the line and then dedicate it back to TOFA. This line was successfully constructed, through numerous parcels of residential and commercial land, on schedule and under budget. This water line now makes municipal water and fire protection available to those residents and commercial establishments, as well as the adjacent industrial park, and has since operated trouble free.

RECYCLING INNOVATIONS

First Co-Located Materials Recovery and Trash-to-Energy Facilities

According to the Integrated Waste Services Association, the industry trade association, Wheelabrator Falls represents the first time that a state-of-the-art MRF has been co-located with a Trash-to-Energy facility.¹

The project has very unique contractual agreements with its municipal customers in support of the maximization of recycling. There is no put-or-play penalty for recycling. If at any time during the life of the contract, a community can show that it has lowered its committed tonnage due to increased recycling, that incremental amount will be reduced from its guaranteed annual tonnage agreement. The facility will also not accept trash from any community which is not acting to recover recyclables under Pennsylvania's Recycling Act 101.²

In the early phases of development, both Wheelabrator and Falls Township strongly agreed that the overall Falls Project should demonstrate a truly integrated approach to solid waste management. In keeping with the hierarchy of solid waste disposal as defined by the Environmental Protection Agency and the National Recycling Coalition,³ it was decided to design, procure and build a state-of-the-art Materials Recovery Facility to complement non-recyclable trash disposal at the trash-to-energy facility.

Having the recycling and disposal facilities on the same site offers participating communities the opportunity to examine their collection methods. Vehicles are in use today for the collection of both streams of municipal solid waste. Studies have shown that dual collection systems can have a positive effect on the recycling component collection costs.⁴

Wheelabrator contracted with Otter Recycling, the designated recycler for Lower Bucks County, to operate the MRF. Otter is responsible for the day-to-day operation, staffing,

maintenance and marketing of the finished product. This relationship has worked out extremely well, resulting in a well run and maintained facility.

The MRF cost five and one half million dollars and encompasses 33,000 square feet. The total tipping area for the comingled containers and paper is approximately 10,500 square feet. There are movable concrete block dividers allowing the tipping floor to be flexible, depending on need. Presently 7,000 square feet of floor space is dedicated to the comingled stream and 3,500 for paper. Indoor storage for baled material is 4,000 square feet and the office encompasses 2,000 square feet. The remaining 16,500 square feet, or half the total square footage, is taken up with the equipment layout, maintenance area, equipment storage, and traffic areas.

The MRF's throughput for 1995 averaged 188 tons per day. Staffing requirements for either one or two shifts changed on a weekly and often daily basis depending on the volume of incoming material. Otter utilizes an industrial placement agency for 20 of the staffing positions. This provides the operator with tremendous flexibility in his staffing needs. With just an hour's notice, he can increase or decrease the number of workers for a second shift or the following day's needs. The second shift is often staffed to process just one stream of material, such as newspapers, which require limited staff. It has been demonstrated that the design capacity of 150 tons in a single shift has been realized with the total daily capacity (two fully staffed, eight hour shifts) in the range of 250 tons per day.

The amount of out-throws, or non-recoverable material left over after the sorting process, amounted to 1,183 tons or just 2.8% of the total incoming material.

The material flow through the facility remains smooth and unencumbered. The building is divided into two sections, the left processing comingled glass (three colors), steel and aluminum cans, HDPE (colored and clear) and PET plastic containers. The right side processes paper: newspapers, corrugated, kraft bags and mixed paper. The material is brought to the facility either directly from curbside collection routes or in transfer trailers.

The comingled processing equipment was provided by C.P. Manufacturing, National City, California. The equipment supplier was flexible in accommodating the owner's system design.

Once deposited on the tipping floor, the material is moved and deposited onto a variable speed uptake conveyor capable of putting in excess of eight tons per hour of comingled materials into the system.

The material is conveyed into a trommel with a rotary magnet on the bottom end. The trommel has two-inch openings for the removal of broken glass, ceramics, stones, grit, and other contaminants. This material falls through the screen openings onto the center lane of a three-lane conveyor belt which carries it straight ahead beneath the glass sorting platform and into a glass crusher and screening system. The glass is crushed to 3/8 inch minus aggregate and conveyed to an outside storage bunker.

As the remaining clean material reaches the end of the trommel, the steel cans are removed by magnets, which ride

on the outside of the trommel (98 percent removal). The cans are carried around the inside parameter of the trommel and are released over a small hopper and slide into a storage bunker below.

The remaining heavy fraction (glass) and the light fraction (plastics and aluminum) enter an air classifier. A blower sends the light fraction to the sorting platform. The glass drops out of the air classifier onto a conveyor belt, which moves past four sorting drop chutes on each side (back to back) in the center of the platform.

Sorters perform a positive pick for green and brown glass and deposit it into the designated chutes. The clear glass remains on the two sorting conveyors and is negative sorted for contaminants. All colored glass is then conveyed to outside storage bunkers.

A recent modification to the glass processing system has been made by altering the chutes that sorted glass is deposited into. Now, depending on the dollar value of the different color glass streams, they can be marketed to glass companies as semi-crushed cullet or it can be easily diverted and blended with the mixed broken stream, processed through the glass crusher, and marketed as landfill cover. The operator intends to market the crushed cullet in the future as aggregate material for glassphalt, road base fill, or other construction applications.

The light fraction which was blown to the vertical sorting platform first travels through a cyclone which removes dry paper, low density plastics, and other contaminants. The light fraction then falls onto a vibrating divider separating the plastics and aluminum onto two sorting belts similar to the glass sorting system. The entire light fraction platform sits atop large storage bunkers. Three types of plastics (HDPE colored, HDPE clear, and PET) are positive hand sorted and placed into the chutes. The containers pass through a flattener/perforator and then drop into the dedicated storage bunkers. The aluminum cans continue on each sorting conveyor (negative sort). At the end of the belt, the cans fall across a small screen for the removal of any remaining contaminants. They are conveyed into a can flattener and dropped into their dedicated storage bunker.

Presently, Wheelabrator is contracting with C. P. Manufacturing to install an eddy current magnet at the end of the light fraction platform for the separation of aluminum. This modification will enhance the cleanliness of the final product, improve throughput, and reduce the total number of sorters needed for the light fraction. Installation of this piece of equipment is scheduled to be completed in May of 1996.

When the bunkers are full (usually once per shift), the individual materials are pushed onto a horizontal conveyor, transported, and deposited into the main baler. The baler is a Mosley Gorilla 200T-4 series and is central to the entire processing system. It is a two ram, high density baler with two 100 HP motors making bales with average bale weights of 1,400 lbs. All of the sorted and processed materials (other than glass) is baled in this machine. After two years and approximately 5,000 operating hours, this machine has proven to be extremely reliable and has a spectacular overall performance record.

Creative Use of Recycled Glass

Mixed glass cullet has historically been one of the most difficult materials to successfully market in the United States.

This material is a by-product of glass processing and is a costly disposal item for most MRF's. There are no accurate records of how much of this contaminated glass is generated and disposed of on an annual basis. *Solid Waste Technologies*, which conducts an annual survey of operating MRF's, identified 392 MRF's which handle comingled or source separated glass as of mid 1994. They estimated that annually, in excess of 200,000 tons of this glass is disposed of in landfills throughout the country due to lack of adequate markets. Only a small percentage is used for alternative applications, such as pipe bedding or glassphalt.⁵

In the construction phase of building the MRF, Wheelabrator became interested in utilizing crushed, mixed color glass cullet as a demonstration of on-site beneficial use as fill material.

Through close cooperation with PADER, Lt. Governor Mark Singel's Office and RUST Engineering, Wheelabrator was able to use 5,015 cubic yards of this recycled glass cullet as structural fill beneath the MRF. The cullet was a by-product of recycling operations in the Philadelphia area; the three principal suppliers were Waste Management, Anheuser Busch Recycling, and Otter Recycling. The MRF project demonstrates that glass cullet can be successfully used in this application. It serves as a model of creative engineering, reflecting an environmental and social awareness of the need to conserve resources and to promote recycling by establishing practical and economically viable markets for recycled material.

All of the 5,015 cubic yards of cullet was destined to be landfilled at disposal costs ranging from \$40-\$60 per yard; the project actually paid \$8 per yard for the cullet. This turned an estimated total disposal cost of approximately \$250,000 into a positive revenue stream of over \$40,000.

Once permits were obtained, over 250 trucks delivered the glass cullet to the site. The glass was placed in the excavated area and compacted to the proper specifications. The concrete foundation was then poured and the 33,000 square foot MRF was constructed.

This project has demonstrated that compacted cullet is a suitable structural fill material meeting all specification requirements. The building has now been standing for two years with absolutely no signs of any adverse settling.

Because of this project, Wheelabrator was awarded the Pennsylvania Resources Council Annual Recycling Award and the *Philadelphia Business Journal's* 1995 ECO Award for the "Creative Use of Recycled Materials." The Company was also awarded the Pennsylvania Business for a Green America Annual Recycling Award and was a finalist in the "Keep America Beautiful" Annual National Award Program.

Millionth Ton of Ferrous Recovered: "Automatic Recycling"

Wheelabrator's 16 trash-to-energy facilities routinely recover ferrous metal, post-combustion, through a variety of

screening and magnetic processes. This process, named by the Steel Recycling Institute ("SRI"), is called "Automatic Recycling." Most of the ferrous metal, which is recovered, would not normally be recovered by traditional recycling programs. It includes metals from containers, furniture, appliances, tools, toys, building materials, etc. The combustion process burns off attached plastic, wood, rubber, textiles, etc., allowing the remaining metals to be successfully recovered from the ash stream.

In April of 1994, the same month as the opening of the Wheelabrator Falls Trash-to-Energy Facility, Wheelabrator recovered its millionth ton of ferrous metal. To commemorate this corporate milestone, a 12 foot high sculpture — a replica of the Wheelabrator logo, was erected at the entrance to the facility. What is truly unique about this sculpture is that it contains a part of the millionth ton.

The first ton of ferrous material recovered at the Falls Facility was that "millionth ton." This ton of metal was transported to Bethlehem Steel's Steelton Mill in Harrisburg, Pennsylvania, where it was formed into rail. The rail was then shipped back to Bucks County where an artist, John Matthews, and Sears Iron Works fabricated the rail into the "Renewal" sculpture. The sculpture was unveiled at the grand opening of the plant on September 22, 1994. At that event, Bill Heenan, the President of the Steel Recycling Institute, presented John Kehoe, the President of Wheelabrator Technologies, Inc., an achievement award for recovering the millionth ton of ferrous.

In calendar year 1995, the Falls Facility recovered 5,825 tons of ferrous scrap from the ash stream. This metal was beneficiated and processed, remanufacture, and returned to commerce.

CONCLUSIONS

The Wheelabrator Falls Recycling and Energy Recovery Facility has cut the template for innovative privately initiated projects in both the United States and abroad. A private entity is now operating a major recycling facility, waste-to-energy facility, leachate treatment system, wastewater treatment plant operation, innovative use of cullet, and potentially a composting facility next to two major landfills. It was the private sector's "free reign" for innovation and design again. Two years later, this has panned out well. In addition, a combined operation of a number of related public service type facilities will provide the best, most environmentally sound, and complete processing system ever assembled to service the public.

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4. Municipal Solid Waste Task Force, Office of Solid Waste; The Solid Waste Dilemma, An Agenda for Action, EPA-530-SW-88-052; U. S. Environmental Protection Agency, 1988; pp. 18.
5. J. Kiser, Integrated Waste Services Association, Washington, D.C., personal communication, 1995.

Table 1. Energy Comparison

Plant	On-Line	Plant Capacity (tons/day)	Pressure (psig)	Temperature	Generator Nameplate Rating	Energy Production Net kWh/ton
Saugus ¹	1975	1500	650	850°F	40 MW	530
North Andover	1985	1500	600	750°F	42.2 MW	540
Millbury	1987	1500	850	850°F	45.6 MW	640
Falls Township	1994	1500	1300	930°F	53.1 MW	700

¹ Saugus numbers reported after the turbine addition of 1985.



US005423294A

United States Patent [19]

[11] Patent Number: 5,423,294

Cole et al.

[45] Date of Patent: Jun. 13, 1995

[54] FURNACE TILE AND EXPANSION JOINT

5,220,957 6/1993 Hance 122/DIG. 13

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[57] ABSTRACT

[21] Appl. No.: 160,875

[22] Filed: Dec. 3, 1993

[51] Int. Cl.⁶ F22B 17/02; F28F 19/00

[52] U.S. Cl. 122/512; 122/DIG. 13;
165/134.1

[58] Field of Search 122/6 A, 512, 235 A,
122/DIG. 13, DIG. 14; 165/134.1

A protective wall structure for protecting boiler tubing in facilities using refuse as a fuel source to produce steam for electrical power generation. The protective wall structure includes an array of shielding tiles, heat transfer bonding material, and elongated compressible material. The shielding tiles include a front surface facing the interior combustion zone of the facility, a rear surface facing the boiler tubes, and a plurality of sidewall surfaces. The heat transfer bonding material is positioned between the boiler tubes and the rear surfaces of the shielding tiles to permit heat transfer and create a bond between the boiler tubes and the shielding tiles. The elongated compressible material is positioned between the sidewall perimeter surfaces of adjacent shielding tiles to provide an expansion joint. This permits relative expansion between adjacent shielding tiles without cracking upon an increase in temperature in the interior combustion zone.

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12 Claims, 8 Drawing Sheets

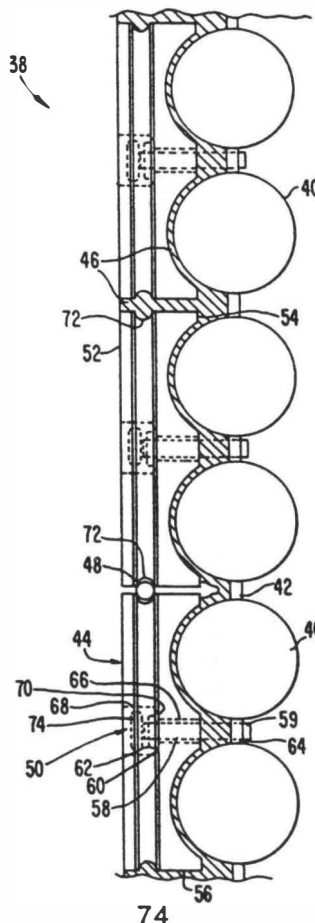


FIG. 5

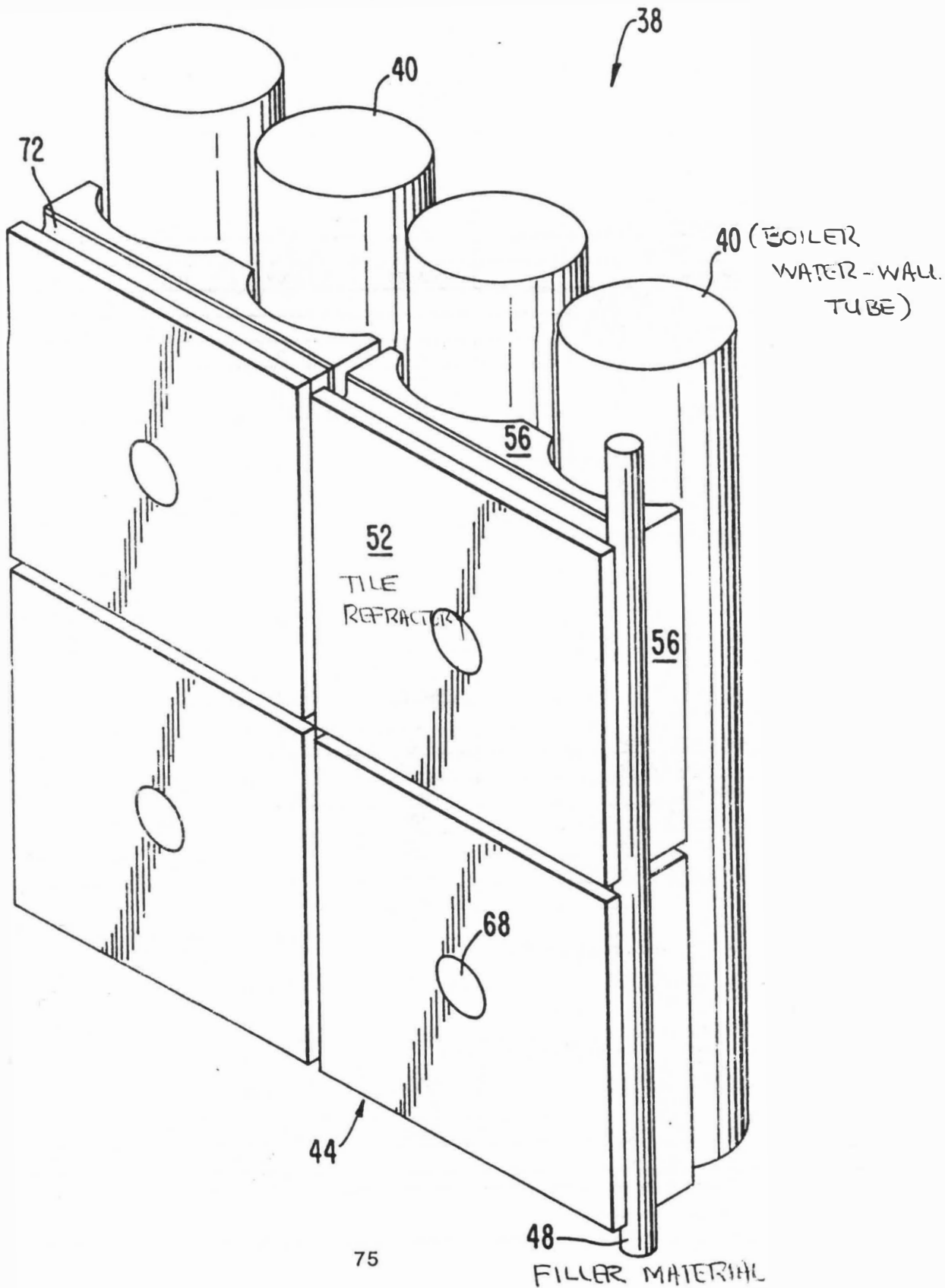


TABLE 2-1
 TEST RESULTS VERSUS PERMIT LIMITS
 WHEELABRATOR FALLS RESOURCE RECOVERY FACILITY
 AUGUST 1994
 UNIT NO. 1

	Rep 1	Rep 2	Rep 3	Average	Permit Limit
UNIT NO. 1 SDA INLET					
Concentration, ppmvd @ 7% O₂					
Hydrogen Chloride	679	617	630	642	- -
Sulfur Dioxide	146	161	171	159	- -
Concentration, µg/DSCM @ 7% O₂					
Mercury	179	299	329	269	- -
Emission Rate, lb/hr					
Hydrogen Chloride	344	326	309	326	- -
Sulfur Dioxide	129	145	153	142	- -
Mercury	0.0575	0.0902	0.103	0.0836	- -
UNIT NO. 1 FF OUTLET					
Concentration, ppmvd @ 7% O₂					
Carbon Monoxide	9.87	11.3	15.1	12.1	200
Hydrogen Chloride	4.13	4.07	5.59	4.60	30
Nitrogen Oxides as NO ₂	161	147	136	148	180
Sulfur Dioxide	6.11	7.24	18.1	10.5	30
Concentration, ng/DSCM @ 7% O₂					
2,3,7,8 TCDD (PA TEF)	1.17 E-02	5.11 E-03	1.85 E-02	1.18E-02	1
Total PCDD/PCDF	1.52	1.50	2.88	1.97	30
Concentration, µg/DSCM @ 7% O₂					
Mercury	20.6	10.9	23.4	18.3	120
Concentration, gr/DSCF @ 7% O₂					
Filterable Particulate	0.00176	0.00157	0.000806	0.00138	0.010
Particulate ≤ 10 Microns	0.000827	0.00257	0.00257	0.00199	0.010
Emission Rate, lb/mmBtu					
Filterable Particulate	0.00361	0.00323	0.00166	0.00283	0.1***
Emission Rate, lb/hr					
Carbon Monoxide	3.73	4.31	5.54	4.52	69.3
Hydrogen Chloride	2.03	2.07	2.58	2.23	- -
Mercury	0.00591	0.00312	0.00696	0.00533	- -
Nitrogen Oxides as NO ₂	101	88.7	76.8	88.7	102.6
Filterable Particulate	1.25	1.11	0.567	0.976	8.0
Particulate ≤ 10 Microns	0.650	1.84	1.83	1.44	6.7
Sulfur Dioxide	5.28	6.30	15.2	8.93	64.9
THC as Carbon	0.0678	0.0713	0.0699	0.0697	3.6
Removal Efficiency, percent (lb/hr)					
Hydrogen Chloride	99.41	99.37	99.17	99.31	90
Sulfur Dioxide	95.91	95.66	90.07	93.88	80
Mercury	89.72	96.54	93.24	93.17	80
Removal Efficiency, percent (concentration)					
Hydrogen Chloride*	99.39	99.34	99.11	99.28	90
Sulfur Dioxide*	95.82	95.50	89.42	93.58	80
Mercury**	88.49	96.35	92.88	92.57	80
Percent Opacity	0	0	0	0	< 10

* HCl and SO₂ - % Removal Efficiency based on ppmvd @ 7% O₂ ** Hg - % Removal Efficiency based on µg/DSCM @ 7% O₂

*** Subpart Db standard.

HCl standard under Subpart Ea: 95% reduction (weight or volume) or 25 ppmvd @7% O₂, whichever is less stringent.

TABLE 2-2
TEST RESULTS VERSUS PERMIT LIMITS
WHEELABRATOR FALLS RESOURCE RECOVERY FACILITY
AUGUST 1994
UNIT NO. 2

	Rep 1	Rep 2	Rep 3	Average	Permit Limit
UNIT NO. 2 SDA INLET					
Concentration, ppmvd @ 7% O₂					
Hydrogen Chloride	731	740	578	683	- -
Sulfur Dioxide	115	176	168	153	- -
Concentration, µg/DSCM @ 7% O₂					
Mercury	428	309	336	358	- -
Emission Rate, lb/hr					
Hydrogen Chloride	404	382	322	369	- -
Sulfur Dioxide	109	171	157	145	- -
Mercury	0.145	0.105	0.113	0.121	- -
UNIT NO. 2 FF OUTLET					
Concentration, ppmvd @ 7% O₂					
Carbon Monoxide	15.0	19.9	22.7	19.2	200
Hydrogen Chloride	3.74	4.33	3.67	3.91	30
Nitrogen Oxides as NO ₂	143	149	149	147	180
Sulfur Dioxide	8.80	9.24	6.66	8.23	30
Concentration, ng/DSCM @ 7% O₂					
2,3,7,8 TCDD PA TEF, 2 run average	2.31 E-02	4.53 E-01	7.66 E-03	1.54 E-02	1
Total PCDD/PCDF, 2 run average	4.18	59.9	1.75	2.97	30
Concentration, µg/DSCM @ 7% O₂					
Mercury	42.8	30.1	32.8	35.2	120
Concentration, gr/DSCF @ 7% O₂					
Filterable Particulate	0.000269	0.000336	0.000432	0.000346	0.010
Particulate ≤ 10 Microns	0.00251	0.00362	0.00674	0.00429	0.010
Emission Rate, lb/mmBtu					
Filterable Particulate	0.000554	0.000691	0.000888	0.000711	0.1
Emission Rate, lb/hr					
Carbon Monoxide	6.07	7.81	8.85	7.58	69.3
Hydrogen Chloride	1.98	2.13	1.87	1.99	- -
Mercury	0.0143	0.00965	0.0105	0.0115	- -
Nitrogen Oxides as NO ₂	88.4	90.9	96.8	92.0	102.6
Filterable Particulate	0.199	0.256	0.317	0.257	8.0
Particulate ≤ 10 Microns	1.97	2.60	4.91	3.16	6.7
Sulfur Dioxide	7.88	8.23	6.01	7.37	64.9
THC as Carbon	0.207	0.425	0.289	0.307	3.6
Removal Efficiency, percent (lb/hr)					
Hydrogen Chloride	99.51	99.44	99.42	99.46	90
Sulfur Dioxide	92.77	95.19	96.17	94.71	80
Mercury	90.14	90.81	90.71	90.55	80
Removal Efficiency, percent (concentration)					
Hydrogen Chloride*	99.49	99.41	99.37	99.42	90
Sulfur Dioxide*					80
Mercury**	90.00	90.26	90.24	90.17	80
Percent Opacity	0	0	0	0	< 10

* HCl and SO₂ - % Removal Efficiency based on ppmvd @ 7% O₂ ** Hg - % Removal Efficiency based on µg/DSCM @ 7% O₂

*** Subpart Db standard.

HCl standard under Subpart Ea: 95% reduction (weight or volume) or 25 ppmvd @7% O₂, whichever is less stringent.

TABLE 2-3
 ADDITIONAL METALS CONCENTRATION, $\mu\text{g}/\text{DSCM}$ @ 7% O_2
 WHEELABRATOR FALLS RESOURCE RECOVERY FACILITY
 AUGUST 1994
 UNIT NOS. 1 AND 2

	Rep 1	Rep 2	Rep 3	Average
UNIT NO. 1 FF OUTLET				
Hexavalent Chromium	< 0.810	< 0.788	< 0.737	< 0.778
Metals				
Arsenic	< 0.484	< 0.499	< 0.486	< 0.490
Beryllium	< 0.0484	< 0.0499	< 0.0486	< 0.0490
Cadmium	0.677	0.405	1.47	0.851
Chromium	1.94	2.84	1.80	2.19
Lead	0.697	0.998	1.23	0.975
Nickel	2.36	1.67	2.97	2.33
Zinc	13.5	18.0	27.2	19.6
UNIT NO. 2 FF OUTLET				
Hexavalent Chromium	< 0.731	0.747	< 0.661	< 0.713
Metals				
Arsenic	< 0.514	< 0.452	< 0.471	< 0.479
Beryllium	< 0.0514	< 0.0452	< 0.0471	< 0.0479
Cadmium	0.483	0.570	0.251	0.435
Chromium	1.70	1.22	1.93	1.62
Lead	1.27	1.52	1.60	1.46
Nickel	1.52	2.14	1.19	1.62
Zinc	20.5	24.0	16.0	20.2

**TABLE 2-1
TEST EMISSIONS SUMMARY
UNIT NO. 1
January and February 1995**

	Run 1	Run 2	Run 3	Average	Permit Limit
UNIT NO. 1 SDA INLET					
Concentration, $\mu\text{g}/\text{DSCM}$ @ 7% O_2					
Mercury	229	246	203	226	--
Emission Rate, lb/hr					
Mercury	0.0606	0.0738	0.0607	0.0650	--
UNIT NO. 1 FF OUTLET					
Concentration, $\mu\text{g}/\text{DSCM}$ @ 7% O_2					
Mercury	41.1	37.8	40.5	39.8	120
Hexavalent Chromium	ND(0.673)	ND(0.784)	ND(0.806)	ND(0.754)	--
Metals					
Arsenic	ND(0.406)	ND(0.478)	ND(0.489)	ND(0.458)	--
Beryllium	ND(0.0406)	ND(0.0478)	ND(0.0489)	ND(0.0458)	--
Cadmium	0.642	0.722	0.364	0.576	--
Chromium	3.08	1.68	1.02	1.93	--
Lead	1.49	0.875	0.665	1.01	--
Nickel	1.86	1.29	1.54	1.56	--
Zinc	30.9	36.3	7.83	25.0	--
Concentration, gr/DSCF @ 7% O_2					
Filterable Particulate	9.05E-04	7.94E-04	9.19E-04	8.73E-04	0.010
Particulate \leq 10 Microns	0.00278	0.000480	0.00101	0.00142	0.010
Emission Rate, lb/hr					
Mercury	0.0116	0.0131	0.0125	0.0124	--
Filterable Particulate	0.736	0.532	0.631	0.633	8.0
Particulate \leq 10 Microns	1.73	0.371	0.737	0.946	6.7
Total Hydrocarbons as C	1.70	1.28	0.897	1.29	3.6
Removal Efficiency, percent (lb/hr)					
Mercury	80.86	82.25	79.41	80.84	80
Removal Efficiency, percent ($\mu\text{g}/\text{DSCM}$ @ 7% O_2)					
Mercury	82.05	84.63	80.05	82.25	80

TABLE 2-2
TEST EMISSIONS SUMMARY
UNIT NO. 2
January and February 1995

	Run 1	Run 2	Run 3	Average	Permit Limit
UNIT NO. 2 SDA INLET					
Concentration, $\mu\text{g}/\text{DSCM}$ @ 7% O_2					
Mercury	230	240	303	258	--
Emission Rate, lb/hr					
Mercury	0.0687	0.0690	0.0902	0.0760	--
UNIT NO. 2 FF OUTLET					
Concentration, $\mu\text{g}/\text{DSCM}$ @ 7% O_2					
Mercury	8.52	14.7	13.2	12.1	120
Hexavalent Chromium	ND(0.823)	ND(0.888)	ND(0.820)	ND(0.844)	--
Metals					
Arsenic	ND(0.451)	ND(0.477)	ND(0.428)	ND(0.452)	--
Beryllium	ND(0.0451)	ND(0.0477)	ND(0.0428)	ND(0.0452)	--
Cadmium	7.00	6.20	3.86	5.69	--
Chromium	0.939	0.978	0.620	0.846	--
Lead	1.28	0.525	0.920	0.908	--
Nickel	1.07	0.778	0.569	0.806	--
Zinc	21.7	7.64	12.8	14.0	--
Concentration, gr/DSCF @ 7% O_2					
Filterable Particulate	9.27E-04	3.55E-04	7.11E-04	6.64E-04	0.010
Particulate \leq 10 Microns	0.000142	0.00113	0.0	0.000423	0.010
Emission Rate, lb/hr					
Mercury	0.00245	0.00420	0.00381	0.00349	--
Filterable Particulate	0.656	0.251	0.527	0.478	8.0
Particulate \leq 10 Microns	0.0873	0.703	0.0	0.263	6.7
Total Hydrocarbons as C	0.704	0.660	0.923	0.762	3.6
Removal Efficiency, percent (lb/hr)					
Mercury	96.43	93.91	95.78	95.37	80
Removal Efficiency, percent ($\mu\text{g}/\text{DSCM}$ @ 7% O_2)					
Mercury	96.30	93.88	95.64	95.27	80