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ABSTRACT

The papers in this proceedings were presented at an EPRI-sponsored seminar on Municipal Solid Waste As a Utility Fuel on May 13, 1982 in Miami Beach, Florida. The purpose of the seminar was to update the status of municipal and regional refuse-to-energy projects involving utilities. Recent experience is described with cofiring refuse-derived fuel with coal in tangential, wall, and cyclone-fired boilers at Ames, Iowa, Rochester, New York, Madison, Wisconsin and Baltimore, Maryland. Other topics addressed include the new coal/RDF cofired power plant in Lakeland, Florida, startup experience with the dedicated refuse-fired facility in Gallatin, Tennessee, and recent results of EPRI-sponsored projects.

FOREWORD

The EPRI seminar, Municipal Solid Waste as a Utility Fuel, was held May 13, 1982, in Miami Beach, Florida, and was attended by electric utility representatives. The purpose was to update recent utility experience with energy recovery from refuse and to discuss results of EPRI-sponsored projects.

The papers address both cofiring of refuse-derived fuel (RDF) in utility boilers and energy recovery from refuse in dedicated boilers. Recent RDF cofiring experience confirms that the ash-handling and boiler slagging problems reported at the last EPRI seminar on municipal solid waste in January 1980 (EPRI Seminar Proceedings WS 79-225) can be reduced or eliminated by producing and cofiring a low-ash-content RDF and by installing bottom dump grates in the boiler (except cyclone-fired boilers). Also of interest is the satisfactory initial start-up of the dedicated refuse-fired facility in Gallatin, Tennessee, which uses a rotary water-wall combustor. It appears that the utility preference is continuing to shift toward dedicated refuse-fired facilities due to the economic uncertainties of RDF cofiring.

On behalf of EPRI's Coal Combustion Systems Division, I would like to thank the speakers and attendees for their participation in the seminar.

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Section 1

THE AMES SOLID WASTE RECOVERY SYSTEM-UPDATE

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THE AMES SOLID WASTE RECOVERY SYSTEM - UPDATE

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INTRODUCTION

The Ames Solid Waste Recovery System became operational in November 1975. During the time period 1976-1979, this system was subjected to a detailed and systematic evaluation that was sponsored by the Industrial Environmental Research Laboratory of the Environmental Proection Agency and the Department of Energy.

Extensive data results of this research program and a detailed description of the system have been published [1-5].

This paper provides an update on operational activities and performance data since completion of the systematic study.

PROCESS PLANT

Many significant changes to the original plant design have been incorporated since the 1975 plant startup. The problems encountered and the modifications are discussed below.

The initial operation of the process flow line did not result in the removal of glass fines and grit as anticipated. This caused excessive erosion wear in all equipment, including the pneumatic pipeline to the Atlas Bin and the power plant steam generators, and slagging within the boiler furnace itself.

In October--December 1978, two rotary disc screens and associated conveyors were installed between the primary and secondary shredder. The primary shredder discharge passes beneath the electro-magnet and on to a scalping disc screen. The oversized (+1½ inch) material is delivered to the secondary shredder for further size reduction to -1½ inch. The screen bottoms (-1½ inch) are conveyed to the second disc screens for fines separation. The bottoms from this screen (-3/8 inch), consisting of glass, grit and direct, are transported to a waste storage bin and ultimately to a landfill. The oversized material from this second disc screen (+3/8 inch to -1½ inch) are mixed with the secondary shredder discharge and then conveyed to the surge bin and to the air density separator. The improvement in RDF quality has been reported in [6]. See Figure 1.

In October-December 1978, a dust removal system and a baghouse system were installed to counter the extreme dust experienced in the previous two years. Dust

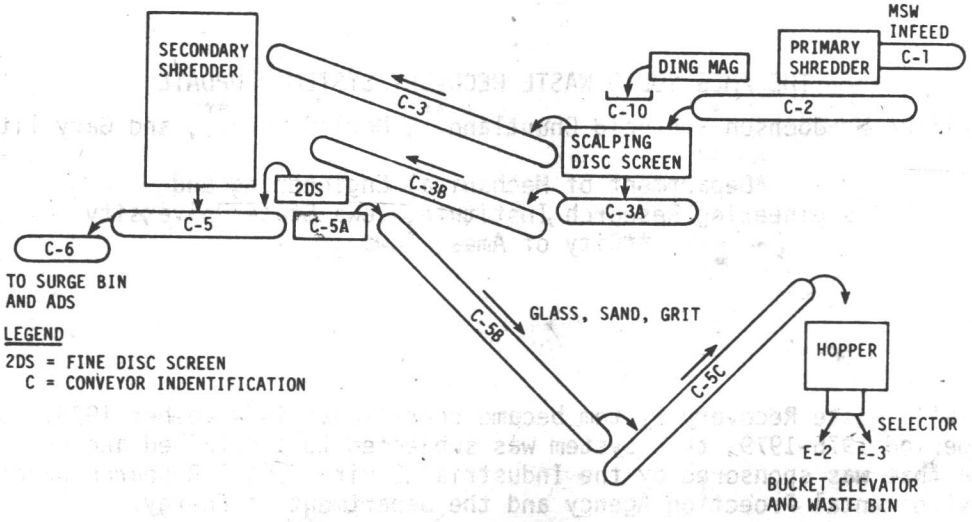

Fig. 1. Disc screen system retrofit.

pick-up hoods were positioned at strategic locations, including the discharge from the induced draft fan used in the operation of the air classifier. The baghouse filter material is recovered by injection into the screw feeder receiving RDF from the cyclone separator.

The surge bin receiving the C-6 conveyor discharge from the secondary shredder would periodically experience bridging, which required extended unplugging time. An air cannon was installed near the bin bottom and the unplugging difficulty has been reduced.

All air lock feeders were replaced with new units containing replaceable liners, as well as replaceable and adjustable vanes in each rotor. In addition, two-ply belts with molded cleats and a 3/16 inch top rubber cover have been installed.

A twin screw feeder delivers RDF from the cyclone discharge to the air lock for pneumatic transport to the Atlas Bin. Both screw flights rotated in the same direction and delivered RDF off-center to the air-lock feeder. One screw flight experienced extreme wear. The simple solution was to reverse flight and shaft rotation.

The two 1000 horsepower shredder motors contributed to a low plant power factor. Capacitors were installed at each motor switch gear.

Large conveyors such as the flight conveyor required excessive starting currents and power, resulting in some equipment damage. Current-sensing relays were used that permitted sufficient starting current but reduced maximum allowable current so as to provide for trip-out before equipment damage.

Stopping the process line resulted in pluggage of the pan conveyor (from flight conveyor). The interlock sequence was altered to allow continuous operation of the pan conveyor and air lock feeding RDF to the air classifier if another portion of the conveyor process system was shut down. However, if the air lock feeder failed, system shutdown would occur.

ATLAS BIN

From 1975-1978, only two infeed conveyors at the Atlas Bin were used to deliver RDF to the airlock feeders for subsequent pneumatic injection to the appropriate boiler. In December 1978, two screw conveyors were installed at the discharge of the North and South infeed conveyors just above the airlock feeders. Thus, four infeed conveyors now supplied RDF to two airlock feeders. This, in turn, allowed the drag sweep buckets and pull-ring to operate at lower speeds, and lowered the corresponding wear.

In June 1978, the Atlas Bin floor was resurfaced with Dresser, Wisconsin hard trap rock and epoxy binder. Again, extreme wear resulted in floor deterioration. Further experimentation with floor surface material resulted in the use of asphalt street mix.

In June 1981, the pull ring assembly was replaced. Rubber gaskets were installed around the rim sealing the four gusset plate attachments to the four sets of sweep buckets. In addition, a floor was installed above the pull-ring assembly around the periphery of the bin.

POWER PLANT

As cited previously [5], bottom dropout of unburned material resulted in the installation of bottom dump grates in April 1978. In September 1978, two RDF ports, originally installed above the two coal ports in each corner of the C.E. unit No. 7 were relocated below the lower coal port. This was done to satisfy an emission level required for the new 60 MW unit No. 8.

In June 1981, the overgrate combustion air supply was modified to use the heated primary air discharge from the air heater to the coal mills.

In the original dump grate retrofit installation, no provision was made to introduce overfire air along the full length of the dump grate. In July 1981, approximately 22 tubes along the throat of water wall just above the dump grate experienced failure and were repaired using window patches. On January 1, 1981, a curtain of refractory insulation forming a box configuration around the throat and over the grate was installed.

OPERATIONAL PERFORMANCE

Process Plant

The summary of economic performance for 1976 through 1981 is shown in Table 1. A complete breakdown of capital costs and detailed financial analysis are given in [1,4,5]. Income from the sanitary landfill is primarily from disposal of demolition material. Expenses associated with disposal of rejects and bypassed municipal solid waste (MSW) are included in operational costs. Net costs per ton MSW are also shown. Extended scheduled shut-down for Atlas Bin floor resurfacing in June 1980 resulted in diversion of 4510 tons of MSW directly to a landfill. The total cost associated with this is $42,767 in lost revenue and $36,072 in landfill handling costs and represents a $1.97 per ton of MSW difference.

Replacement of the Atlas Bin pull ring in June 1981 resulted in a diversion of 969 tons of MSW to landfill. The lost revenue was $10,503 and landfill handling costs were $6374, which results in a total cost of $0.41 per ton of MSW.

The 1981 subsystem electrical energy consumption is shown in Table 2, and energy consumption per ton of MSW is shown in Table 3. The electrical energy consumption

for 1977-1980 on a percentage basis is shown in Table 4.

Process plant down times for 1980 and 1981 are shown in Table 5. Unscheduled down times for 1980 and 1981 are 20.3% and 14.9%, respectively. A log of items contributing to unscheduled down times of more than one hour for 1980 and 1981 is listed in Table 6.

Table 1. Economic Performance.

	1976	1977	1978	1979	1980	1981
Revenue						
Refuse Sale for Fuel	$ 319,453.00	$ 353,326.93	$ 322,344.03	$ 305,421.58	$ 380,002.66	$ 444,630.75
Sale of Metals	97,885.43	102,323.23	89,270.45	78,604.19	77,094.59	80,643.32
Public Fees	21,904.80	25,494.88	27,802.03	23,767.38	46,940.57	46,580.53
Wood Chips	2,262.40	2,792.23	962.24	727.87	1,598.67	1,254.08
Paper Recycling	2,112.34	7,416.00	2,225.34	472.60	910.80	190.78
Sanitary Landfill	10,281.68	24,124.74	33,590.00	29,879.02	40,513.10	23,182.64
Iowa State University	88,353.60	91,494.48	116,309.13	140,464.18	116,643.47	109,635.26
Miscellaneous	16,889.25	13,091.18	18,495.80	19,067.31	14,561.24	14,475.91
Other Gov't Revenues	--	113,218.56	75,001.85	157,326.50	213,795.64	8,992.74
Scrap Iron & Tires	--	--	--	--	--	6,111.35
Total Revenue	$ 559,142.56	$ 733,282.23	$ 686,000.87	$ 755,730.63	$ 892,060.74	$ 735,697.36
Expenditures:						
Operations	$ 572,287.51	$ 638,717.60	$ 637,345.87	$ 737,234.87	$1,002,570.41	$ 807,818.97
Startup Charges	54,383.77	52,183.45	52,183.45	52,183.44	--	--
Bond Interest	299,519.46	265,352.51	263,595.63	245,600.00	229,350.00	209,850.00
Bond Principal	183,333.69	200,000.00	200,000.00	200,000.00	300,000.00	300,000.00
Equipment Reserve	12,500.00	12,500.00	12,500.00	12,500.00	12,500.00	12,500.00
Total Expenditures	$1,122,024.43	$1,168,753.56	$1,165,624.95	$1,247,518.31	$1,544,420.41	$1,330,168.97
Net Cost	($562,881.87)	($435,471.33)	($479,624.08)	($491,787.68)	($652,359.67)	($594,471.61)
Tons	40,936	48,381	37,720	32,010	40,076	41,011
Cost/Ton	($13.75)	($ 9.00)	($12.72)	($15.36)	($16.28)	($14.50)
Tons RDF	34,464	40,890	28,488	23,059	26,797	26,818

Table 2. Electrical Energy Consumption - 1981.

	Primary Shredder	Secondary Shredder	ADS System	PSI System	Atlas Bin	Indirect	Total Calculated	SWRS Total	Power Plant Total
January	28,300	40,200	26,640	17,030				285,600	
February	17,600	27,300	17,250	10,510	31,600	68,000	172,260	178,920	174,800
March	20,400	34,900	22,330	13,020	34,576	68,624	193,850	196,560	200,500
April	24,100	37,600	19,650	12,440	41,712	64,188	199,590	206,640	206,000
May	21,900	35,700	17,840	11,310	40,096	63,004	189,850	195,720	198,000
June	22,200	24,600	15,180	9,380	25,512	70,888	167,760	174,720	174,050
July	26,000	33,600	22,580	14,520	38,576	83,124	218,400	219,240	226,300
August	29,600	31,400	22,070	14,580	36,208	75,792	209,650	224,280	215,250
September	31,600	30,500	20,480	13,620	34,264	66,536	197,000	204,960	205,500
October	29,000	34,100	22,460	13,960	37,104	62,096	198,720	206,640	205,000
November	26,800	26,800	18,260	11,580	N/A	N/A	N/A	190,680	N/A
December	24,000	32,100	20,350	13,260	N/A	N/A	N/A	216,720	N/A

Table 3. 1981 Electrical Energy Consumption per Ton MSW.

	Total kw-hr / ton	Atlas Bin kw-hr / ton	Process Plant kw-hr / ton
January	94.13	N/A	N/A
February	67.27	11.88	55.39
March	57.50	10.11	47.39
April	56.11	11.32	44.79
May	60.78	12.45	48.33
June	55.88	8.16	47.72
July	59.16	9.77	49.39
August	52.34	8.45	43.89
September	53.06	8.87	44.19
October	56.85	10.02	46.83
November	57.66	N/A	N/A
December	70.47	N/A	N/A

Table 4. Historical Trend - Electrical Energy Consumption.

Sub-System	Percent of Consumption			
	1977	1978	1979	1980
Primary Shredder	11%	13%	11%	11%
Secondary Shredder	18%	15%	14%	16%
Air Density Separation Blower	8%	11%	10%	11%
Pneumatic Conveying Blower	6%	7%	8%	8%
Process Plant Indirect	57%	54%	57%	54%
Total Annual Process Plant Consumption (× 1000 kwh)	2325	2147	2070	2314

Note: RDF storage bin consumption excluded.

Table 5. Process-Plant Down Time, 1980-1981.

	Month	Airlock Transport Meter Hours	Shredder Infeed C-1 Meter Hours	Loss Hours	% Down Time
1980					
	January	142.5	107.0	35.5	24.9
	February	174.6	143.6	31.0	17.7
	March	198.3	165.9	32.4	16.3
	April	169.7	125.5	44.2	26.0
	May	178.7	156.3	22.4	12.5
	June	85.2	31.3	53.9	63.3
	July	190.0	158.1	31.9	16.8
	August	187.1	151.2	35.9	19.2
	September	212.4	145.4	67.0	31.5
	October	204.4	169.7	34.7	16.9
	November	175.3	152.0	23.3	13.3
	December	215.1	195.0	20.1	9.3
Totals		2133.3	1701.0	432.3	20.3
1981					
	January	197.1	179.7	17.4	8.8
	February	176.8	152.0	24.8	14.0
	March	206.7	168.2	38.5	18.6
	April	178.3	164.2	14.1	7.9
	May	153.1	140.3	12.8	8.4
	June	147.2	132.5	14.7	9.9
	July	207.6	182.7	24.9	11.9
	August	205.9	157.5	48.4	23.5
	September	159.6	80.4	79.2	49.6
	October	194.9	183.9	11.0	5.6
	November	158.0	146.5	11.5	7.3
	December	175.9	151.5	24.4	13.8
Totals		2161.1	1839.4	321.7	14.9

Table 6. Process Plant Interruptions 1980-1981.

Date	Time (hrs)	Item
1980		
February 5	8.0	Change C-5A head pulley
March 18	4.0	Operator training test
March 19	3.5	Work on Atlas Bin
March 20	4.5	ADS pan conveyor bearing replaced
April 2,3,4	24.0	Primary shredder rotor replacement
April 7	4.0	E-1 motor burned out
April 30	11.17	Airlock feeder liner replaced after jamming
May 8	7.0	Broken chain and bent flights in flight conveyor
June 16	6.25	Secondary disc screen bolt failure
June 17	2.5	Airlock feeder blade pressure leakage and repair
June 20	3.42	C-3 rag pluggage
July 1	6.5	Broken flight
July 3	3.5	Primary shredder jammed
July 30	2.25	C-3A belt damage
August 1	6.5	Atlas Bin pull-ring drive assembly damage from fire
August 5	1.92	Primary shredder explosion
September 5	3.75	ADS pan conveyor sheared shaft key
	1.84	and vibratory linkage non-synchronized
October 17	2.17	Broken pin in Atlas Bin bucket sweeps
October 20	3.75	C-5A torn belt
October 31	2.0	Fire in secondary shredder
November 21	2.17	Fire at Atlas Bin
November 24	1.84	Fire at Atlas Bin
December 4	2.25	Grizzly bar repair at Atlas Bin
	1.5	C-3 jam and circuit breaker trip
December 12	2.0	ADS feeder motor replacement
December 17	1.5	Rebolt top cover on E-1
December 15	2.42	C-6 circuit breaker malfunction
1981		
January 12	4.42	Retainer off at transport line airlock feeder
January 15	4.92	C-5C shaft broken
January 23	1.17	Pluggage of screw feeder; clean out of ADS fan air filter trap
February 9	4.75	ADS feeder motor replacement
	3.5	C-1 jammed, and circuit breaker
March 19	5.08	C-1 motor bearing failure
April 13	4.75	Stoker grate over heat at power plant
April 17	11.0	Atlas Bin full; unable to process
April 21	4.5	Broken sweep drive in Atlas Bin
April 22	11.0	Atlas Bin sweep problem
April 23	10.25	Atlas Bin sweep problem
May 22	3.5	Lost south bearing on ADS pan conveyor
June 24	7.0	C-16 tail pulley repair
July 7	5.25	C-3B belt ripped
July 9	5.25	Variable speed drive belt on flight conveyor broken
July 13	4.67	C-5A plugged
August 24	3.0	Ding magnet motor inoperative

Atlas Bin

Bin operational costs for 1980 and 1981 are listed in Table 7. Resurfacing costs of the bin floor in June 1980 are shown in the July entry. Pull ring replacement in June 1981 is reflected in July costs.

Power Plant

Refuse derived fuel (RDF) is still being fired in the 35 MW unit No. 7 at the rate of approximately 15% by Btu input. Unit No. 7 operates with an efficiency as previously reported in [5].

Operation of the new B&W 60 MW unit No. 8 has been delayed due to a series of constructional and instrumentation control delays. This unit utilizes a Detroit Stoker dump grate design including inter-tube orifices over the grate for overfire heated combustion.

A single monthly sample of RDF being pneumatically transported from the Atlas Bin to the power plant is analyzed for heating value and moisture. These values plus density are shown in Table 8.

SUMMARY

in summary, some update performance data has been presented for the Ames Solid Waste Recovery System. The assistance of Annette Thompson and John Eskrich in data preparation is gratefully appreciated.

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Table 7. Atlas Bin Operational Costs.

Month Ending	1/31/80	2/29/80	3/31/80	4/30/80	5/31/80	6/30/80	7/31/80	8/31/80	9/30/80	10/31/80	11/30/80	12/31/80
Personal Services	3,110.89	1,668.29	1,013.35	1,717.57	1,353.25	2,028.89	2,834.40	1,679.49	7,633.91	3,210.75	1,666.77	4,522.82
Contractual Services	240.69	429.40	0.00	12.41	35.44	1,961.15	--	--	741.27	23.10	180.25	22.17
Commodities and Parts	997.64	761.65	571.66	1,339.28	3,103.93	7,203.19	7,203.19	469.90	1,770.46	1,743.90	976.72	1,283.66
Total	4,349.22	2,859.34	1,585.01	3.069.26	4,492.62	11,194.00	10,037.59	2,149.39	10,145.64	4,977.75	2,823.74	5,828.65
Dollars Per Ton	1.71	0.96	0.47	0.78	1.47	5.54	2.62	0.54	2.55	1.30	0.85	1.82
Month Ending	**1/31/81**	**2/28/81**	**3/31/81**	**4/30/81**	**5/31/81**	**6/30/81**	**7/31/81**	**8/31/81**	**9/30/81**	**10/31/81**	**11/30/81**	**12/31/81**
Personal Services	3,128.18	1,663.79	2,220.89	5,126.89	4,002.99	4,611.23	2,074.94	1,650.41	2,069.15	3,042.76	2,527.39	1,993.19
Contractual Services	610.75	129.35	0.00	8.18	0.00	0.00	202.59	17.24	51.27	0.00	2,627.11	402.73
Commodities and Parts	1,011.20	1,062.34	3,881.12	4,512.17	338.78	1,605.63	50,169.07	2,442.21	837.94	1,642.66	1,469.25	7,857.40
Total	4,750.13	2,855.48	6,287.29	9,647.24	4,341.77	6,216.86	52,447.16	4,109.86	2,958.36	4,685.42	6,623.75	10,253.32
Dollars Per Ton	1.56	1.07	1.84	2.62	1.35	1.99	14.15	0.96	0.77	1.29	2.00	3.33

Table 8. RDF Heating Value - Atlas Bin Discharge.

		Heating Value Btu/lb	Moisture %	Density lb/ft^3	Standard Deviation
1980					
	January	6168	28.64	4.56	0.54
	February	6671	17.20	4.21	0.53
	March	7926	12.59	4.12	0.63
	April	7245	14.61	5.04	0.47
	May	6911	6.09	4.46	0.68
	June	6456	13.98	5.13	0.50
	July	5580	23.03	5.12	0.94
	August	7335	14.78	5.26	0.46
	September	6438	21.40	5.13	1.04
	October	7129	16.08	4.43	0.38
	November	6633	16.01	4.52	0.51
	December	6973	14.39	4.32	0.33
1981					
	January	6500	18.27	4.16	0.50
	February	8130	9.8	4.0	0.41
	March	7287	12.78	3.8	0.42
	April	7029	17.56	4.92	1.00
	May	--	--	5.24	0.87
	June	4969	--	4.42	0.61
	July	5716	--	4.98	0.78
	August	6317	22.01	5.10	0.63
	September	--	--	5.25	0.93
	October	5984	24.64	4.54	0.51
	November	--	--	--	--
	December	--	--	--	--