WORKING OUT THE KINKS: AN UPDATE ON COLUMBUS' REFUSE AND COAL-FIRED MUNICIPAL ELECTRIC PLANT

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ABSTRACT

In August 1983, the City of Columbus, Ohio fired refuse derived fuel in the first boiler in its new Refuse and Coal-Fired Municipal Electric Plant. As with any innovative technology, some fine tuning was required. A summary of the steps taken to fine tune the Columbus Refuse/Coal-Fired Municipal Electric Plant is presented.

INTRODUCTION

The City of Columbus constructed a refuse/coal-fired municipal electric plant to consume solid waste and generate electricity. The plant is owned and operated by the City. The plant is designed to produce refuse derived fuel (RDF) on site with two shredders as well as accept RDF from three satellite shredding plants located around the City. It was intended that the plant burn RDF in combination with coal as fuel in the ratio of 80% RDF/20% coal by heat input. It was not intended that RDF be burned by itself. The use of some coal was expected to stabilize boiler performance and help minimize superheater corrosion due to the presence of sulfur in the coal. The plant has a nameplate capacity of 90 MW. The peak RDF throughput for the electric generating plant was intended to be about 3000 tons/day (2724 t/d) with all six boilers in operation.

EARLY PLANT HISTORY AND PERFORMANCE

Construction of the plant began in 1979. Initial firing of the boilers on coal took place in December, 1982. Startup activities continued with the circuit breakers being closed on the generators for the first time in June, 1983. RDF was introduced to the boilers in August, 1983, at which time severe operating difficulties were experienced, primarily with the systems handling RDS and ash. RDF continued to be fired sporadically with the first stable operation on RDF occuring in October of 1983. A summary of plant performance from October, 1983 through August, 1984 is shown in Table 1. The difficulties with processing, handling and burning RDF continued, resulting in a plant performance plateau with RDF consumption averaging about 830 tons/day (754 t/d) and coal consumption averaging about 380 tons/day (345 t/d).

The on-site shredder plant began producing RDF in June, 1983. The three satellite shredding plants have been in operation since July, 1975 with the shredded product being landfilled prior to the construction of the steam electric plant.

TABLE 1
SUMMARY OF PLANT PERFORMANCE
OCTOBER, 1983 TO AUGUST, 1984

Month	Generation MWH	Refuse Tons	(tons)	Coal Tons	(tons)	Number of Outage and Non-Outage Events Outages	No [illegible] es	Total
1983								
October	*	*		*		30	98	128
November	*	*		*		45	82	127
December	*	*		*		57	84	141
1984								
January	*	*		*		74	71	145
February	29,568	14,269	(12965)	10,421	(9462)	47	87	134
March	32,880	23,159	(21028)	10,984	(9973)	67	127	194
April	32,064	25,668	(23306)	9,372	(8509)	56	131	187
May	34,656	30,342	(27550)	10,313	(9364)	50	100	150
June	35,060	22,380	(20321)	13,017	(11819)	71	100	171
July	35,856	24,850	(22564)	12,447	(11301)	48	63	111
August	34,795	24,851	(22564)	12,633	(11471)	52	120	172
TOTALS	234,879	165,520	(150,298)	79,187	(71,899)			1,660

* Data not available

PLANT DESCRIPTION

The Columbus plant is situated on a 52 acre (21 ha) site on the south side of the City. Figure 1 shows a photograph of the plant.

A schematic of the overall plant is presented in Fig. 2.

The numbers referenced in the following paragraphs are keyed to the schematic.

Coal is delivered by truck (1) to a coal storage pile (5). The coal is transferred to the pile by the coal stacking conveyor (4) and then from the pile by the coal reclaim conveyor (6) to the coal conveyor (9) which loads the coal bunker (14) for each boiler.

Bulk refuse is trucked to a covered tipping floor area (2). Bulk refuse is transferred by front end loader to pan conveyors (7) which feed Heil 92B vertical shredders (8). The shredders reduce the size of the bulk refuse. The shredded refuse passes through a ferrous metal removal process, (Dings "Hockey-Stick" Magnets), (22) which removes some iron from the refuse. Shredded refuse is transported from the shredder station to the boiler house by the shredded refuse belt conveyor (10). Shredded refuse may go to Sprout Waldron surge bins (13) or to the storage pit which has a capacity of 7500 tons (6810 t).

The City operates three other shredder stations which produce shredded refuse which is trucked to this site (3) and dumped into the storage pit.

Two bridge cranes (11) are used to transfer the shredded refuse to the surge bins (13) from the pit. The surge bins discharge onto belt conveyors which

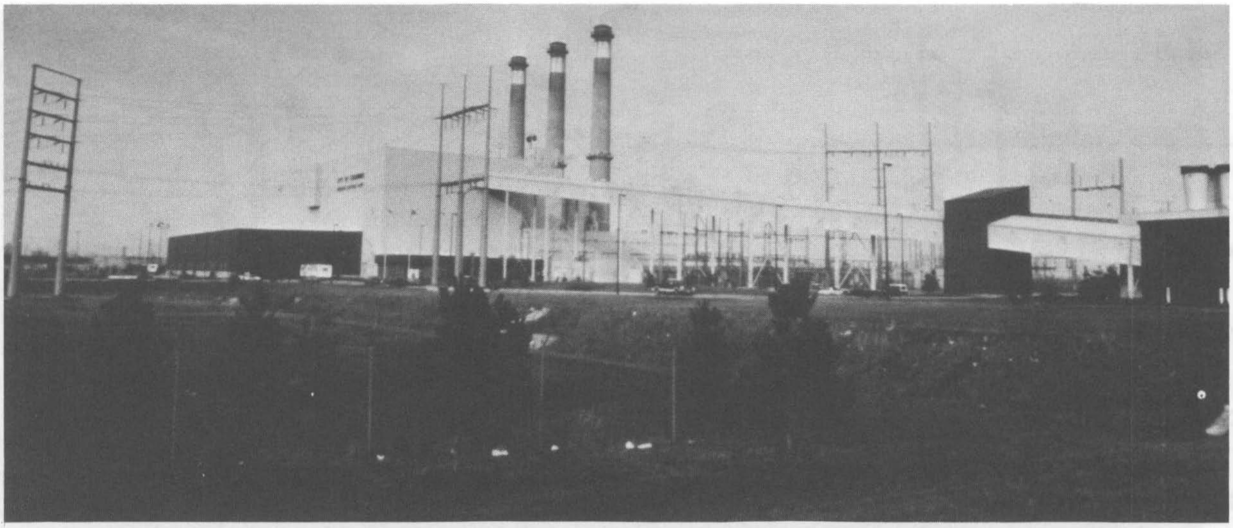

FIG. 1 COLUMBUS REFUSE/COAL-FIRED MUNICIPAL ELECTRIC PLANT

FIG. 2 SCHEMATIC OF THE COLUMBUS REFUSE/COAL-FIRED MUNICIPAL PLANT

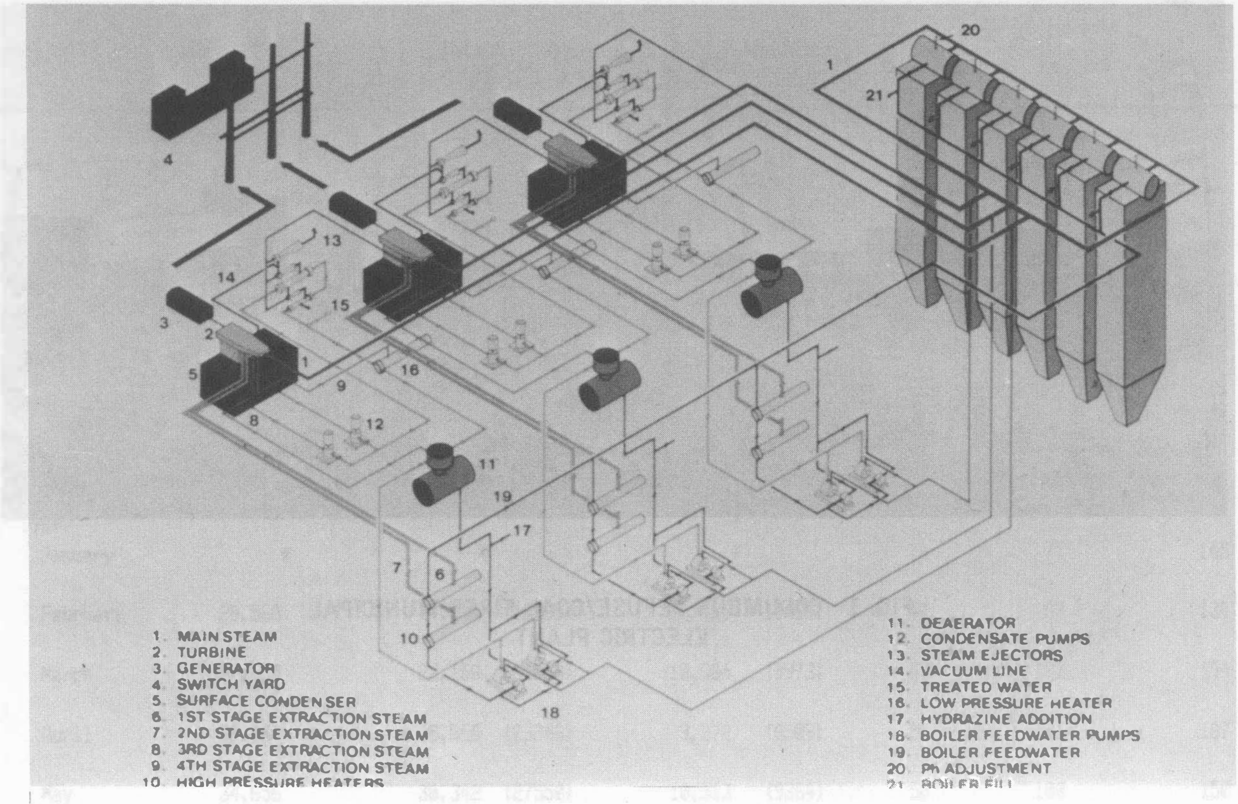

FIG. 3 STEAM, FEEDWATER AND CONDENSATE SCHEMATIC

discharge the RDF into feed chutes at the boiler front. The crane operator's pulpit (12) allows the operator to observe and manage the pit contents.

The six boilers (15) are capable of producing 165,000 lb/hr (74,844 kg/h) of steam each. The 700 psig (4823 kPa), 725°F (388°C) steam is used to drive three 30 MW steam turbine generators (19). The power produced is distributed to the existing customer base through the switchyard (20).

Mechanical dust collectors and high efficiency electrostatic precipitators (16) are used to reduce particulate emissions to acceptable levels. The clean flue gas is discharged to the atmosphere through three 272 ft (83 m) tall stacks (17).

The bottom ash is quenched with water in two basins located under each boiler and then transferred by conveyor (18) to an ash storage bunker. Fly ash is conditioned with water and combined with the bottom ash on the conveyor (18). Ash from the boiler hoppers and economizer are reinjected into the furnace.

A schematic of the steam, feedwater and condensate systems is shown in Fig. 3 and is self explanatory. Cooling water for the condenser is supplied from a small lake, adjacent to the plant site.

THE PROBLEMS AND PROPOSED SOLUTIONS

By late 1983, it became apparent that resolution of the operating problems would not be forthcoming without a concerted effort to identify the exact nature of the problems and to implement remedies as required. Thus, a series of investigations was initiated which culminated in a report in September, 1984 which identified the problems and outlined a plan of attack to solve them. As a guide in evaluating problems and solutions, three principal performance criteria were established for the plant as follows:

(a) Process an average of 2000 tons/day (1816 t/d) of solid waste and generate electricity using an RDF/Coal ratio of 90/10 by weight.

(b) Clean reliable plant without undue operating or maintenance constraints.

(c) Plant features consistent with good utility practice for facilities of this type.

THE PROBLEMS

A statistical analysis was performed showing outage/non-outage events for the various components of the plant to determine which areas were most troublesome. This analysis is summarized in Table 2. An outage event is defined as an event where a boiler which was burning RDF or RDF plus coal was shut down or converted to coal firing only, as a result of an unscheduled condition. A non-outage event is one where a significant problem was reported for a boiler burning RDF or RDF plus coal but it was possible to correct the problem while continuing to burn RDF or at least with a relatively short interruption. The analysis shows that the major contributors to outage/non-outage events within the steam–electric generation portion of the system were as follows:

Fuel Feed (Surge Bin to Boiler Chutes)	23%
Grates/Grate Weights	26%
Bottom Ash Quench Basins	32%
Total	81%

To complement the preceding analysis, a descriptive tabulation of approximately 100 identified problems was prepared. The nature of the problems ranged from the kind one would expect during the startup of any power plant to those requiring state of the art solutions and peculiar to RDF based resource recovery projects.

The major problem areas were as follows:

(a) The feed to the on-site shredders was subject to frequent plugs, and material was frequently carried back via the underside of the infeed conveyor to the infeed conveyor pit.

(b) RDF product from on-site shredders contained excessive oversize materials.

(c) Magnetic separators were not removing enough ferrous product, particularly large heavy items.

(d) The RDF product from the satellite plants was inconsistent with respect to ferrous removal, quality and quantity delivered.

(e) RDF Surge bins were subject to bridging, collecting stringers rapidly.

(f) The RDF infeed belts from the surge bins to the boilers filled with material, with frequent jams and fires occuring.

(g) The RDF feed to the boilers was inconsistent with respect to quantity and distribution.

(h) The RDF Crane grapples were slightly undersized.

TABLE 2
SUMMARY OF OUTAGE/NON-OUTAGE EVENTS BY CATEGORY
OCTOBER, 1983 TO AUGUST, 1984

CATEGORY	OUTAGE	NON-OUTAGE	TOTAL
RDF SURGE BIN VERTICAL AUGERS	63	23	86
RDF SURGE BIN HORIZONTAL AUGERS	69	80	149
RDF BELT INFEED CONVEYOR	13	20	33
RDF BOILER CHUTES	19	113	132
BOILER GRATES / GRATE WEIGHTS	256	164	420
BOTTOM ASH QUENCH BASINS	128	388	516
ELECTROSTATIC PRECIPITATOR HOPPERS	3	94	97
ELECTROSTATIC PRECIPITATOR FIELDS	1	14	15
FLYASH DUSTLESS UNLOADERS	33	71	104
EAST - WEST ASH BELT	1	40	41
RDF CRANE	11	56	67
TOTAL			1660

(i) The boiler furnace draft was unstable.

(j) The boilers formed clinkers and had frequent jams at the front of the grates.

(k) The boiler grates warped and plugged frequently.

(l) The grate weights broke off frequently.

(m) The grate area temperatures appeared high. The fuel bed was matted.

(n) Aluminum melted onto the grates causing jams.

(o) Ferrous material deposited on the grate bars causing jams.

(p) The boiler grate drive shafts and bearings failed frequently.

(q) Frequent bridging of boiler hoppers occurred.

(r) The precipitator hoppers bridged, frequently catching fire.

(s) The bottom ash quench basins jammed and failed frequently.

(t) Excessive steam was generated in the bottom ash quench basins.

(u) Excessive spillage occurred from the ash conveyors.

(v) The fly ash collection and conditioning system was inadequate, generating a highly variable ash consistency and excessive dust to the atmosphere.

(w) The siftings conveyor system was inoperative.

THE PROPOSED SOLUTIONS

Following an evaluation of the problems combined with a review of performance at similar plants, a modifications program was formulated which consisted of the following major features:

(a) Main Plant

(1) Install dribble chutes on the underside of the shredder infeed conveyors.

(2) Change the shredder hammer configuration to obtain performance similar to that at other plants.

(3) Install disc screens or trommels after the shredders and magnetic separators to obtain oversize control. A single disc screen will be tested initially.

(4) Replace existing Dings hockey stick magnets with stronger constant field magnets. Add secondary magnets.

(5) Increase crane grapple capacity.

(6) Replace RDF surge bin discharge conveyors with a new system. A vibrating conveyor system will be tested on a single boiler initially.

(7) Institute procedures to burn RDF or coal separately in boilers, but not simultaneously.

(8) Refurbish grate drive systems, install high temperature grease bearings, accommodate boiler expansion.

(9) Install TV surveillance to monitor boiler combustion.

(10) Remove the entire ash system and replace with:

(a) Bottom Ash. Submerged drag chain conveyor, quench basins, and an enlarged belt conveyor.

(b) Siftings. Dry drag conveyors to quench basins.

(c) Reinjection Ash. Dry drag conveyors to quench basins.

(d) Fly Ash. Dry drag conveyors to a separate fly ash conditioning building, and enlarged belt conveyors.

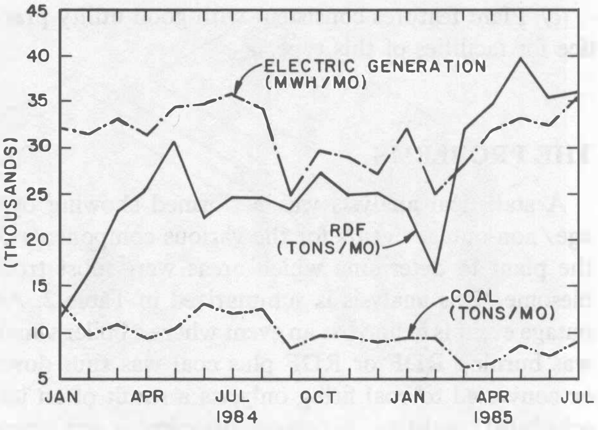

FIG. 4 PLANT PERFORMANCE

(e) Ash Storage. Reversible mixing discharge conveyor over enlarged storage area.

(b) Satellite Shredder Stations

(1) Install disc screens or trommels after the shredder and magnetic separators to obtain oversize control.

(2) Add secondary magnets.

It should be noted that while the preceding discussion has focused on the problems at the plant, the plant has many excellent features which will serve the City well and are likely to be emulated in other RDF based plants.

INTERIM PERFORMANCE

The modifications program was authorized in February, 1985. The entire program is not expected to be completed until the third quarter of 1986. In the meantime, plant operating and maintenance personnel have made changes which have resulted in a significant improvement in plant performance as shown in Fig. 4. The RDF consumption for the months April through July, 1985 averaged 1200 tons/day (1090 t/d) [with a daily high of 1950 tons/day (1771 t/d)] and coal consumption averaging 261 tons/day (237 t/d). In general, coal consumption varied to meet the electric generation requirements beyond that which could be generated with RDF.

The increased RDF throughput resulted in occasional shortages of RDF which also contributed to coal consumption.

The dribble chutes (Item 1a) were installed immediately and resulted in a dramatic increase in shredder throughput due to the ability to run at higher loads without the risk of carryback.

The oversize control system on the Heil 92B shredders will require substantial time to complete. In the meantime, the shredder hammer pattern was changed to reduce particle size. While this resulted in a somewhat smaller average particle size than desired and lower throughput, it resulted in the near elimination of problems with the RDF surge bin ragging. Since no changes were made to the satellite station shredders, this suggests that the oversize material causing the ragging was being produced mainly by the Heil shredders.

Operating procedures were instituted to stop the cofiring of coal and RDF in the same boiler. The burning of RDF by itself resulted in:

(a) low instance of clinkers
(b) cooler grate temperatures (as measured in the rail)
(c) loose burned out ash at grate discharge
(d) near elimination of ferrous deposits
(e) aluminum melting reduced to approximately one-quarter of the previous level
(f) near elimination of grate weight loss
(g) reduced steam generation in quench basin
(h) significant reduction in grate bar warpage and plugging

Boiler No. 1 was inspected after 6 months of operation using the new procedures. The boiler was in excellent condition. Holes in the grate bars were approximately 60% open. The only observed significant boiler tube metal loss was to the lower side walls (believed to be due to erosion from reinjection) and selected areas around the reinjection nozzles and fuel feed chutes (again due to erosion). Superheater tubes have been measured and appear to be in excellent shape with the only superheater tube losses to date being due to a condensate problem with one soot blower.

Boiler grate drive systems are being refurbished one at a time, including installation of grease lubricated bearings. Shaft and bearing failure have been nearly eliminated.

Plant personnel have significantly reduced problems with the boiler, economizer and precipitator hoppers by improving performance of the vibrators, with plugs and fires being relatively rare. Improved combustion and resultant reduced combustibles in the ash are also believed to be contributing factors. Boiler excess air is presently targeted at 60–65% as opposed to 80% and above during the early operation.

The entire ash system and RDF fuel feed conveyors and chutes continue to plague the plant and are estimated to cause 90% of the current outage/non-outage events.

Beginning in January 1985, records are being kept to show the daily amount of RDF and coal consumed and the amounts of steam produced for each boiler.

For boilers scheduled to burn RDF, the ratio of RDF to total fuel burned by weight has been as follows:

		JAN.	FEB.	MARCH
RDF Burned	tons/month	19,115.20	16,614.00	32,063.30
	(t/month)	(17,356)	(15,085)	(29,113)
Coal Burned	tons/month	3707.67	3865.79	3172.51
	(t/month)	(3366)	(3510)	(2880)
Ratio RDF/Total		80.60%	76.73%	90.11%

		APRIL	MAY	JUNE
RDF Burned	tons/month	34,987.69	39,619.96	35,678.11
	(t/month)	(31,768)	(35,974)	(32,395)
Coal Burned	tons/month	2909.88	4598.68	4147.03
	(t/month)	(2641)	(4175)	(3765)
Ratio RDF/Total		91.68%	88.39%	88.38%

		JULY	AUG.
RDF Burned	tons/month	35,808.17	34,453.23
	(t/month)	(32,513)	(31,283)
Coal Burned	tons/month	3825.33	6438.79
	(t/month)	(3473)	(5845)
Ratio RDF/Total		89.32%	81.31%

In addition, data is being collected to determine the amount of steam and electricity generated per ton of RDF for each boiler. A summary of the data for the first 8 months is as follows:

	JAN.	FEB.	MARCH	APRIL
lb steam/tons RDF	6800.15	7584.41	6075.32	6403.56
(kg/t)	(3400)	(3792)	(3037)	(3201)
kW·h/tons RDF	617.47	727.51	566.32	622.67
(kW·h/t)	(679)	(800)	(623)	(685)

	MAY	JUNE	JULY	AUG.
lb steam/tons RDF	5354.74	5865.03	5785.53	5979.22
(kg/t)	(2677)	(2932)	(2892)	(2989)
kW·h/tons RDF	508.93	558.81	526.92	549.50
(kW·h/t)	(559)	(614)	(579)	(605)

The plant data also shows an increasing number of boiler-days where the RDF throughput exceeds 500 tons/day (454 t/d) with no apparent adverse results indicating the maximum capacity of the plant may be slightly greater than 3000 tons/day (2724 t/d).

DESIGN PERSPECTIVES

From time to time the question is asked if RDF based resource recovery plants represent a viable technical option for processing solid waste. The data being generated at the Columbus facility, as well as other plants, would indicate that plants of this type can perform successfully. It is predicted that the Columbus plant will be capable of sustained runs at 2000 (1816) to 2400 tons/day (2179 t/d) of solid waste once the hardware problems are corrected.

It is worth noting that the average startup time for RDF based resource recovery plants built to date has been on the order of 3 years, an unacceptably long period of time. Further, an informal poll taken among the Akron, Occidental, RFI, Albany and Columbus plants indicates that 70% or more of the problems which caused the lengthy startup and operating difficulties were solved at the plant by plant personnel. The obvious conclusion from this is that the data base which exists at the existing plants is crucial to future plants if startup times are to be shortened and if the technology is to advance.

The evidence at the Columbus plant clearly indicates that cofiring of RDF and coal in the manner originally envisioned is not feasible. The potential benefits of cofiring are more than offset by the negative results described previously. While a number of theories have been advanced as to the reasons for the negative results, at this writing it does not appear that this phenomenon is well understood.

The preparation of an acceptable RDF is critical to the successful operation of an RDF based plant. Directionally, it is expected that as the quality of RDF is improved, it should be easier to handle and burn, and operating and maintenance costs should decrease. On the other hand, the capital and operating costs associated with RDF preparation increase as the quality is improved. One additional adverse side effect is that as RDF quality improves, in most cases the combustible loss increases.

During the analysis of the problems at Columbus, it became evident that while a variety of opinions exist with respect to what constitutes the best approach to RDF preparation, there is little or no data which relates RDF preparation to the handling and combustion of RDF in a real boiler. Nearly all operating plants are still experimenting with this relationship in one fashion or another.

While tentative definitions have been developed by ASTM for a number of broad categories of RDF and some computer models exist which simulate RDF processing systems, a major effort remains before the relationship of RDF preparation to boiler and plant performance is well understood.

OPERATING PERSPECTIVES

In the final analysis, the people in the best position to reflect on the design of a resource recovery plant are those who operate and maintain the plant on a day-to-day basis. The following comments come from the Columbus plant staff:

(a) On balance, availability and reliability are more important than efficiency at a resource recovery plant. High steam pressures and temperatures, perhaps above 600 psig (4134 kPa), 700° F (371° C) should be critically evaluated. Fly ash reinjection was found at Columbus to be much more trouble in terms of waterwall tube erosion and combustion problems than could be justified by any improvement in efficiency.

(b) A greater number of smaller boilers are superior from an operating standpoint, to fewer larger boilers. The improvement in plant throughput to date has been due in part to the fact that the plant has six boilers. Conservative design of the boilers is essential, particularly with respect to heat available per square foot of absorbing surface in the furnace and heat release on the grate.

(c) Maintenance requirements are significantly higher than for a coal or wood waste fired plant. Costs will be higher and more on-site maintenance facilities are necessary to maintain high plant availability/reliability.

(d) Resource recovery plants seldom operate exactly at design conditions. A range of operating conditions must be allowed for. RDF feed and ash/residue disposal systems must be sized to accommodate the variations in quality and quantity which will occur. The ability to get RDF into the boilers and ash/residue out of them on a reliable basis with a highly variable fuel is essential. Heat release in the boiler furnace is quite variable, which will cause a fairly wide band of steam pressures/flows. The steam drum should be sized to

accommodate greater surges than with other fuels. Air flow and feedwater control systems will "swing" over a wider band.

(e) The underfire and overfire air systems must be highly adjustable to provide proper combustion and gas circulation within the boilers.

(f) Tubular (recuperative) air heat exchanges are preferred over the regenerative type.

(g) Extended training (6 months to 1 year) of key personnel at similar plants is necessary if a smooth startup is to be accomplished. At this point in time, equipment and system manufacturers may not be knowledgeable in starting up or optimizing the performance of their equipment due to a lack of experience.

SUMMARY

Early operating difficulties with the RDF and ash systems at the Columbus plant caused the facility to perform below original expectations. A modifications program is in progress designed to correct the difficulties. Interim performance data indicate that the plant will perform at or above design values once the modifications are completed.