AKRON RECYCLE ENERGY SYSTEM IS ON THE LINE

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ABSTRACT

The Akron Recycle Energy System, a project designed for the production and sale of steam from 1000 tons/day (907 t/d) of municipal solid waste, was placed in service on July 19, 1979, supplying steam to B. F. Goodrich and the City of Akron. The process consists of single stage shredding and air classification of municipal solid waste to provide fuel to three steam generating units for the production of steam, and recovery of ferrous metals.

This plant was completed within the financial framework developed at the time of completion of financing at the end of 1976.

Although little operating and maintenance data is available to date, information is being developed as personnel training and increased production continue.

INTRODUCTION

The Akron Recycle Energy Facility began officially with the awarding of contracts on December 7, 1976, and ground breaking on the following day.

Serious construction started in March 1977 with foundation construction in all four building areas:

1. Building A — Tipping
2. Building B — Shredding and Control
3. Building C — Boiler House
4. Building D — RDF Storage

CONSTRUCTION AND FINANCES

Structural steel erection of the building “C” began in mid-November 1977 and proceeded through the winter of 1977-1978. The west half of the structure was readied for start of boiler erection evidenced by the first drum raising on May 14, 1978.

Structural steel erection in the boiler building was completed in July 1978. Erection of building “D” started in June 1978 and building “A” multiram framing and dumping bin steel started in August 1978. Framing of building “A” started in late 1978 and continued through the winter. Roofing and siding for building “C” started in September and continued through the fall and winter of 1978-1979.

All structural work was complete by the spring of 1979. Interior and architectural finishing work continued during the remainder of the building construction which was complete about September 1979.

The first mechanical equipment installed was components of the Triple/S density separation system located in building “B” basement under the shredders, in early December 1977, followed by the shredder discharge metering surge bins, and ultimately by the setting of the shredders in January 1978.

As previously noted, the first boiler steam drum “raising” occurred on May 14, 1978, followed by the second drum 10 days later. The final steam drum raising occurred on June 30, 1978, and work on all three units, auxiliaries, and elec-
trostatic precipitators continued through the following 12 months.

Boiler No. 2 (the first drum raised) was “lit-off” on April 23, 1979 as a prelude to boil-out, on May 2, 1979. Boil-out of boiler No. 1 was started on June 12, 1979. Boil-out of No. 3 unit began July 17.

The first shredding of refuse occurred on June 22, 1979 and boiler No. 1 was fired on RDF on July 3, 1979.

Steam was supplied to B. F. Goodrich on July 19, 1979 and subsequently to the Akron Central Business District on August 2, 1979.

Electrical and mechanical construction proceeded as determined by the structural schedule and progress. Work on the steam distribution system proceeded concurrently with the plant activities.

The distribution system construction, of pre-insulated pipe, consisted of an underground and above ground pipeline connecting to the existing Ohio Edison system at an offsite pressure reducing station approximately one-half mile (0.8 km) north of the plant. The service system was expanded by a new distribution line to the B. F. Goodrich Company, immediately adjacent to the plant, to the University of Akron, and to the Akron City Hospital. The latter two users served by an entirely new and independent system, are approximately 1.5-2.0 miles (2.4-3.2 km) distance from the plant (Fig. 1). All new steam service included piping for condensate return.

Contract awards made in December 1976 consisted of the following:

1. General Construction $12,582,068
2. Mechanical Construction 2,627,178
3. Plumbing and HVAC 173,990
4. Electrical Construction 1,969,141
5. Steam Generators 7,980,000

Total $25,332,377

In addition, awards for the distribution system extensions were made in May 1978 and consisted of the following:

6. Steam Distribution Phase I & II $ 539,653
7. Steam Distribution Phase III 2,285,900
8. Akron University Tie-In 291,000
9. City Hospital Tie-In 79,500

Total $3,196,053

Of the $25,332,377 initially awarded, $24,627,929 was for plant related construction with the remainder of $704,448 for distribution systems. Consequently, a total of $28,528,430 in contract awards was made to nine prime contractors, of which $3,900,501 was for the distribution system.

Changes dictated by revised or modified equipment selections altering structural, mechanical, and electrical systems precipitated cost/contract revisions on the order of $5,200,000, an increase of 18 percent in direct construction expenditures. These increases were distributed as follows:

1. General Construction $2,300,000 (18.3%)
2. Mechanical Construction 1,000,000 (43.7%)
3. Plumbing and HVAC 42,000 (24.1%)
4. Electrical 1,200,000 (60.9%)
5. Steam Generators 508,000 (6.4%)
6. Steam Distribution I & II 26,000 (4.8%)
7. Steam Distribution III 120,000 (5.2%)
8. Akron University 6,000 (2.0%)
9. City Hospital 2,000 (2.5%)

It is readily seen that the greatest impact in changes was in the mechanical and electrical power and control systems which underwent, in some cases, drastic revisions to accommodate final equipment selections, and state-of-the-art systems upgrading.

Final direct construction costs then are in the order of $33,700,000. The Project financial status as of October 15, 1979 is shown in Tables 1 and 2. The indirect construction costs which include engineering design, construction management supervision, bonding fees, legal fees, other administrative expenses, spare parts, and start-up were in the order of $16,800,000 or almost exactly 50 percent of direct costs.

The project was funded by $46,000,000 in revenue bonds through the Ohio Water Development Authority (in cooperative agreement with the City of Akron and Summit County) and $5,000,000 in general obligation bonds each issued by the City of Akron and the County of Summit, making a total of $56,000,000 available.

The project was completed within the financial framework as developed in 1976 prior to initial contract awards.

**SYSTEM DESCRIPTION AND START-UP**

All solid waste vehicles enter by way of the ramp on the south side of the receiving floor. The driver gives his scale card to the scale operator. The scale card is obtained on an earlier visit when the truck is weighed empty. The card reader and computer sends the weight to the teletype printer which in turn computes and prints the following information in duplicate:
FIG. 1. DOWNTOWN AKRON LOCATION OF RECYCLE ENERGY SYSTEM PROJECT

1. Time of day  
2. Date  
3. Gross weight  
4. Tare weight  
5. Net weight  
6. Customer identification number  
7. Vehicle number  
8. Billing code

The card and a copy of the printout are given to the driver. The truck moves onto the receiving floor to a dumping station designated by the receiving floor attendant. There are eight holes in the center of the receiving floor and the trucks can dump from both sides of the holes. The solid waste drops into the pit onto both sides of the center cone. The driver exits from the receiving floor by way of the ramp. The entire dumping time is an average of five minutes including the weigh-in time.
TABLE 1. CITY OF AKRON - RECYCLE ENERGY SYSTEM PROJECT STATUS - DIRECT CONSTRUCTION EXPENDITURES

Month Ending October 15, 1979

<table>
<thead>
<tr>
<th></th>
<th>Budget</th>
<th>Siegfert Div. VII</th>
<th>Ruhlin Div. V</th>
<th>Siegfert Div. VI</th>
<th>Novatny Div. IX</th>
<th>B &amp; W Div. X</th>
<th>Others</th>
<th>(a) Total Payments</th>
<th>(b) Total Work Done</th>
<th>(c) Total Encumbrance</th>
<th>% Comp.</th>
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<tbody>
<tr>
<td><strong>1 - ORIGINAL CONTRACT DATA</strong></td>
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<td>Incinerator/Boilers, Etc.</td>
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**TOTAL ORIGINAL CONTRACT ENCUMBRANCES**: $25,332,377
### TABLE 2. CITY OF AKRON – RECYCLE ENERGY SYSTEM PROJECT STATUS –

**DIRECT CONSTRUCTION EXPENDITURES**

<table>
<thead>
<tr>
<th>Month Ending October 15, 1979</th>
<th>Budget</th>
<th>Ruhlin Div. V</th>
<th>Siegfeth Div. VI</th>
<th>Siegfeth Div. VII</th>
<th>Novatny Div. IX</th>
<th>B &amp; W Div. X</th>
<th>Others</th>
<th>(a) Total Payments</th>
<th>(b) Total Work Done</th>
<th>(c) Total Encumbrance/b/c</th>
<th>Notes</th>
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<tr>
<td><strong>2 - CHANGES AND ADDITIONS</strong></td>
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<td>Steam Distribution and Condensate Extensions 4,755,000</td>
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<td>Expended to date</td>
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<td>Misc. Modifications and Additions to Plant Design</td>
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<td>Escalation of Major Equip.</td>
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<tr>
<td>Expended to date</td>
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<td>Possible Add'l Features (Steam blow-off condensers, Inst. Air Compressors, Maintenance &amp; Machine Shop, Oil Spill Equipment)</td>
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<td>Expended to date</td>
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<td>Contingency &amp; Start-up</td>
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<td>(417,592)</td>
<td>(463,992)</td>
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**Notes:**
- (a) Total Payments
- (b) Total Work Done
- (c) Total Encumbrance/b/c
- % of Commitment
- $ Amounts

*Table adapted from [source]*
The pit is capable of holding 1,785 tons (1619 t) of raw solid waste. The solid waste is moved from the receiving pit to the infeed conveyor by hydraulic rams. In sequence, the material is pushed from one ram to another. There are eight of these rams on each side of the storage pit, with each ram able to stroke 18 ft (5.5 m) and designed to push raw solid waste at a 28 ft (8.5 m) head. The operating sequence will vary depending on the load depth. The municipal solid waste process is illustrated by the flow diagram shown in Fig. 2.

There are dual process lines which begin with the shredder infeed conveyor which is 8 ft (2.4 m) wide. The solid waste is pushed by the rams to a surge area, onto an infeed conveyor, and then to a shredder. The shredder infeed conveyor is a double-beaded steel pan with a variable speed drive. The conveyor speed varies from 0-30 ft/min (0.15 m/s) and is controlled by the operator in the control room. The speed of the infeed conveyor depends on the solid waste load depth. The conveyors are designed to convey 70 tons/hr (63.5 t/h) maximum for each line to the shredders.

Each shredder is powered by 1500 hp (1118 kW) squirrel cage fan-cooled 4160 V motors. The shredders are single direction and rotate at approximately 690 rpm. There are 52 manganese alloy hammers in each shredder, four rows of thirteen each. The hammers weigh 160 lb (72.6 kg) each and have a bow-tie shaped head. The hammers can be flipped to wear on both sides. On the basis of 20,000 tons (18,140 t) shredded to date by one shredder, an estimated 40,000 ton (36,280 t) life is expected on a set of hammers.

The specified particle size was 100 percent minus 6 in. (152 mm). The grates furnished with the shredder had holes of $8\frac{7}{8}$ in. x $8\frac{7}{8}$ in. (225 mm x 225 mm). The particle size was too large, so partitions were welded in the grate holes so the grate size would be $2\frac{1}{8}$ in. x $8\frac{7}{8}$ in. (54 mm x 225 mm). The particle size has since averaged to be 100 percent minus 5 in. (127 mm).

The reduction in grate size has not affected the rated 60 tph (54.5 t/h) minimum shredder capacity and the electrical usage has not increased more than 7 percent. The shredder can reduce a refrigerator into small pieces in less than 90 sec. The experience of other shredders in resource recovery plants that have had explosions prompted a grapple crane to be installed between the two infeed conveyors. From the control room an operator can remove articles that are hazardous to shred. Fire and explosion safety features installed in the shredder are:
1. Fenwal explosion suppression system.
2. Vent on one side of each shredder to the outside.
3. Flue gas inerting to each shredder to reduce the oxygen content inside the shredder. The gas temperature will be about 320°F (160°C).

The noise level of the shredder is well within standards except when a heavy steel object is fed into the shredder.

To transport the shredded solid waste from the shredder to the air density separation system, a flight conveyor is used. To control surges from the shredder, a chute below the shredder having 1000 ft² (305 m²) of holding area retains enough material to give the flight conveyor an even, constant feed. The flight conveyor was originally underpowered, but was changed from a 15 hp (11.2 kW) variable speed drive to a 30 hp (22.4 kW) variable speed drive.

The shredded solid waste is then fed to the air density separation system. The air density separation system operates by getting the shredded solid waste in motion as a result of air blowing through slots in a vibrating pan conveyor. The air velocity can be controlled by the operator from the control room. The shredded solid waste moves on the vibrating conveyor to the main air suction stream generated by the material handling fan located four stories up. The light fraction is drawn up through the material handling fan and is blown into a cyclone separator at the storage bin. To balance the air at the cyclone, a return air fan is used. The return air fan returns the air to the process, with one-third, or approximately 20,000 cfm (9.4 m³/s) going to the vibrating conveyor and two-thirds, or 40,000 cfm (18.9 m³/s) going to the boilers to be used as combustion air. The proportions can be changed by moving the position of the return air diverter. The quality of the air classifier light fraction split can be controlled by opening an air bleed on the material handling fan duct. The desired split is 70% by weight light fraction and 30% heavy fraction which will vary depending on the moisture content. A good separation is when fine filler particles begin to drop onto the heavy fraction belt. Adjustments must be made daily to insure the best separation. Heavy fraction material consists of:

1. Sand
2. Glass
3. Rocks and dirt
4. Ferrous metals
5. Nonferrous metals

This material drops onto the heavy fraction take-away belt which transports it to the magnetic separator. The magnetic separator is a rotating drum magnet. The ferrous metal is dropped onto a separate belt conveyor which carries it out of the building. The metals are discharged to a swing chute that distributes it in a truck for transportation to the market. The remaining heavy fraction is conveyed to a swing spout and distributed into a semitrailer for transport to the landfill. The heavy fraction will vary, but is presently estimated at 23%.

When the light fraction reaches the cyclone separator at the storage bin, it drops onto a shuttle conveyor. At this point the material is designated Refuse Derived Fuel (RDF). The shuttle conveyor distributes the RDF evenly over the length of the storage bin, which is 170 ft (51.8 m) in length. The RDF drops from the shutter conveyor onto the storage bin wedge section that splits the bin lengthwise. The storage bin has dual screw augers that move the material to the center of the bin and then onto one of two belt conveyors. The storage bin has a capacity of 2,100 tons (1906 t) of RDF. Each belt conveyor conveys the RDF from the center of the storage bin to a metering bin. The metering bin has three separate flight conveyors.

The design of one 2 ton (1.8 t) metering bin to feed the three boiler units has resulted in some flow problems with less than three boilers in service at one time. The installation of an air cannon to break up and aerate the RDF has helped to reduce this problem. However, further modification will be required to obtain desired flow of the RDF from the metering bin.

The shredded refuse is fed from the metering bin into the airlock. The mixture of air and refuse is conveyed through approximately 300 ft (69.6 m) of 8 in. (203 mm) pipe to a cyclone separator located at the top front of each boiler. These pneumatic conveying lines have experienced considerable plugging problems prior to the modifications to the shredder grates as mentioned earlier.

The steam generation section of the plant consists of three Babcock & Wilcox Stirling units having a capacity of 126,000 lb/hr (57,142 kg/h) each. A section through these units is shown on Fig. 3. A summary of expected boiler performance is as follows:
Early samples of as fired RDF indicate the higher heating value to be between 5900 and 6300 Btu/lb (13,700 and 14,600 kJ/kg).

The cyclone separators de-entrain the RDF from the air stream and drop it by gravity into a double swing spout. The swinging spout distributes the RDF to the four air swept spouts mounted on the front of the boiler.

The bed distribution on the traveling grate stoker is controlled by the amount of air being injected into the rotary air dampers and an individual damper at each refuse chute (see Fig. 4). These damper controls not only give side to side distribution, but front to back distribution as well. If, for instance, the refuse is not being thrown to the back of the stoker, more air can be introduced through the rotary air damper duct.

Under each of the air swept spouts are five high-pressure jets placed in such a manner as to fan the flow of air and fuel from the spout to assist in uniform side to side distribution.

At this time, the grate distribution appears to be reasonable, but adjustments to the air pressures and dampers are continuing.
The bed depth is approximately 8 in. (0.2 m) at a steam rate of 100,000 lb/hr (45350 kg/h). Burnout is good, with no noticeable unburned combustible leaving the grate. As operation continues and more uniform fuel feed is accomplished, grate speed adjustments will be made to reduce bed thickness.

The amount of suspension burning at these early periods of operation is significant, as indicated by the amount of "lights" introduced into the combustion zone. Some carryover to the generating bank is occurring but reinjection of ash from the economizer hoppers is used to reduce carbon loss.

Combustion air for RDF burning is introduced into the furnace through the stoker. This undergrate air is approximately 80 percent of the combustion air. This air is preheated by the regenerative air heater and is supplied to the stoker from the forced draft fan. The amount of air is controlled through a control damper in the control room. The remainder of the combustion air is introduced into the furnace through the overfire air system. A control damper on the overfire air (OFA) duct is used to control the amount of air delivered to the system. The OFA nozzles, or air jets, consist of four rows of nozzles on the front wall and three rows of nozzles on the rear wall of the unit; there are no side nozzles on the units as shown on Fig. 5. The OFA system also supplies air to the rotary air damper, which distributes the RDF across the grate and introduces RDF into the furnace. The amount of air supplied to each row of OFA jets is regulated by manual dampers. At the present time, pressure is approximately 25 in. of water (6.2 kPa) to the overfire air nozzles. The purpose of the OFA jets is to insure enough turbulence in the combustion zone of the furnace to achieve more complete burnout and to avoid areas of reducing atmosphere in the furnace.

The furnace appearance has generally been very good, with no appreciable slag accumulations on any part of the furnace. The only slag accumulations (small as they are) are located just below the refuse chutes, which introduce the refuse into the boilers.

The convection surfaces of the boiler bank and economizer are of the in-line arrangement. The single pass boiler bank is divided into three shallow sections to permit good cleanability with retractable soot blowers. The horizontal gas flow pattern in the high gas temperature region of the boiler reduces susceptibility to pluggage. Further, the boiler is designed without baffles or turns and with low gas velocities to minimize erosion tendency.

The economizer is similarly designed with cavities to permit the use of mass blowing retractable soot blowers. It should also be noted that flue gases do not pass over the horizontal surface of the economizer until their temperature has been lowered well below the fusion temperature of the ash by the boiler convection bank.

The unit is cleaned using steam soot blowers of which four are located in the generating bank of the unit (between the steam and lower drums) and four of which are located in the economizer section of the boiler. There has been no appreciable change in the tube temperature due to slag accumulation. The soot blowers are operated once a day to clean the generating bank surfaces and the economizer tubes.

The flue gases pass through an electrostatic precipitator to remove the particulate matter. The precipitator is designed with four fields to provide for predicted emissions of 0.11 lb/million Btu (0.047 g/MJ).

The precipitator operates at 525 F (274 C) at full load, a temperature that should protect it from high and low temperature corrosion under normal operating conditions.

No emission data has been taken to date and full load adjustments of the precipitator have not been made; however, stack appearance is good.

A regenerative air heater follows the precipitator reducing the flue gases to an uncorrected end temperature at full load of 325 F (163 C) while heating the combustion air to 340 F (171 C). Locating the air heater after the precipitator reduces the cleaning required in the air heater with the economy provided by the 325 F (163 C) exit gas temperature.

The air heater is cleaned every 2 hr on oil firing and every 6 hr during refuse firing. This insures a
clean air heater. The air heater is a Ljungstrom Regenerative type manufactured by Air Preheater Company.

Following the induced draft fan, a waste heat economizer has been installed to heat water for building heating and to reduce the temperature of the gas leaving the stack to approximately 250 F (121 C).

A steam coil air heater operating on 5 psig (34.5 kPa) saturated is installed in the duct at the outlet of the forced draft fan to maintain the regenerative air heater's metal temperatures at recommended levels when ambient air is cold.

It is realized that with the 325 F (163 C) exit temperature, conditions may be encountered where corrosion of the cold end of the air heater surface may be experienced. However, these are not anticipated to be frequent, and the economic benefits warrant the possibility of long term maintenance of the air heater surface.

Air taken for the RDF transport system is introduced to the forced draft fan inlet. This permits the air to be used as combustion air and eliminates discharging it with possible odors into the atmosphere. This, however, has created a problem with the steam coil air heater. Lint and dust, which are natural products of the shredding and air separation process, are entrained in this air and are deposited on the fins of the steam coil air heater. This has required frequent cleaning of the steam coil air heater.

The use of a bag filter to clean this air is being considered.

Each unit is also equipped with three auxiliary oil burners with steam atomization for operation to maintain steam production in the event of disruption of the refuse supply to the unit. These steam atomized oil burners are equipped with high energy spark igniters eliminating the need for natural gas or high oil pressures for mechanical atomization during light-off. The oil burners are also equipped with a burner safety system.

The boiler controls for this plant are Hagen (Westinghouse) controls of the pneumatic type. The units can be controlled in automatic sequence on either refuse or No. 2 oil. Both, however, cannot be controlled in automatic at the same time. The control system is normally flow controlled with pressure allowed to swing slightly; however, full steam pressure is required for some customers so the units control point will be full load pressure. The RDF feed to maintain flow is controlled by a variable speed drive connected to a metering conveyor at the surge bin. The conveyor speed can be increased or reduced depending upon fuel demand.

Two of the boiler units are equipped with test connections for measurement of air velocities, temperatures, pressures and dust loading where applicable. Also, chordal thermocouples have been installed in several furnace wall tubes to measure tube metal temperatures.

Although little performance data is available at the present time, operating data and performance test data are expected to be available in the early summer of 1980. Also, during 1980, it is planned that four superheater sections will be installed in one of the boiler units. These superheater sections will be made of several materials and designed for a range of superheat temperatures. Each section will have a steam control valve to control the steam flow through the section and thus the steam and metal temperatures. This will permit the evaluation of the materials for corrosion resistance. Also, a program to investigate the corrosion incidence of various metals in the lower and upper furnace by the use of air-cooled probes is being considered for 1980.

**OPERATION**

The Akron Recycle Energy System is operated by Teledyne National, which has been involved in operating resource recovery facilities for the past 5 years.

The main purpose of the Akron Recycle Energy System was to dispose of all solid waste generated within the Summit County Area. The dumping fee charged ($3.50/ton, $3.86/t) is competitive with that for landfill in the area. The steam generated from the solid waste replaces the steam which had been generated by Ohio Edison using conventional fuels. The City of Akron will take over the old steam plant, while the central business district steam distribution lines will be operated and maintained by Teledyne National.

The steam demand from the central business district was insufficient to consume all that could be generated by the three boilers, however, the city was successful in contracting with three additional large users of steam:

1. The University of Akron
2. City Hospital
3. B. F. Goodrich
4. B. F. Goodrich is an interruptible customer and
has agreed to purchase all steam in excess of that used by other customers. Because of the large amount of solid waste generated in the summer and a lack of heating needs at that time, some of the steam will be vented to the atmosphere. The Akron Recycle Energy System has the capability for producing 378,000 lb. of steam per hour (171,000 kg/h) which is 126,000 lb/hr (57,000 kg/h) from each boiler. To assist with the electrical power demand, two 2,000 kW turbine generators have been installed and will furnish one-third of the plant’s power needs. This permits operation of the boiler units, but not processing equipment with in-plant power.

To operate and maintain the complete Akron Recycle Energy System, the total personnel requirement is 58 employees including the office staff. A personnel chart is shown in Fig. 6. The staff requirement is based on 16 hr, 5 days per week processing solid waste and 24 hours per day, seven days a week producing steam and providing 8 hours a day, 5 days per week for steam distribution maintenance.

CONTROL ROOM

1. Boiler operations: one licensed engineer per shift; one helper per shift.

2. Process operations: one operator per shift.

The distribution of the remaining manpower requirements depend on the shifts for processing solid waste (see manpower chart). The receiving floor will remain constant with two full time and two part-time employees. Their jobs consist of weighing and directing haulers where to dump and to monitor the waste for hazardous and unprocessible materials. Preventative and general maintenance are done on a regular shift basis. Modifications are being completed by the maintenance personnel on an “as required” and “planned basis”.

There will be a regular distribution system maintenance schedule and a yearly meter change schedule. The total manpower for steam distribution will be four maintenance persons and one supervisor.

Billing for the steam and tipping fees will be done by Teledyne National on a monthly basis. The total financial report will not be available until the end of the year and at that time a written report will be submitted.

CONCLUSIONS

Financing of this project was completed in
December 1976. The construction of the system and initial operation, which included the supplying of steam to the central business district of Akron, were both completed on schedule and within budget.

The initial operation has demonstrated that the system can supply steam within the projected demand requirements, and initial operation problems are being addressed and appropriate solutions are being implemented.

**REFERENCE**


**Key Words**

- Boiler
- Combustion
- Energy
- Municipality
- Pneumatic
- Fuel
- Shredding