

THE HAMILTON SWARU RETROFIT

HECTOR A. FRANCO

Mississauga
Ontario, Canada

ABSTRACT

The overall objective of the Hamilton SWARU retrofit program is to improve air emission control and to increase plant efficiency by means of an improved refuse feed system and boiler combustion controls. The air pollution control system will be upgraded by replacing each of the two existing electrostatic precipitators with a spray cooler for flue gas temperature conditioning and a baghouse filter.

INTRODUCTION

Background. The Hamilton Solid Waste Reduction Unit (SWARU), built in 1970 to 1972, was designed as an incinerator to reduce the volume of waste in order to extend the life of the existing landfills. To accomplish this objective in an environmentally safe manner, air emission control equipment was needed. Electrostatic precipitators were considered the most appropriate gas cleaning equipment for this application. This choice required that steam be produced to reduce gas temperatures below 600°F (316°C). To achieve this, two waterwall furnaces with conventional steam generation systems and air-cooled condensers were used.

Original Process. Weighed collection vehicles discharged their loads into a receiving pit with a capacity

of 600 TPD (545 tpd). Four pan conveyors, forming a live bottom in the pit, transported the refuse to four pulverizers. Undesirable material was removed from the waste stream by "pickers" positioned on a bridge over the infeed pan conveyors.

Following shredding by vertical shaft pulverizers and ferrous metal removal by a magnetic separator, the waste was transported, via belt conveyor, to an Atlas Storage Bin of similar capacity to the receiving pit. A rotating scraper and drag conveyor carried the Refuse Derived Fuel (RDF) stream to the feed system serving both boilers. The feed system for each boiler consisted of a weigh conveyor and a swinging spout to distribute the fuel to three air swept distributor spouts [1]. Fuel feed control was located in the receiving area, while the boiler controls were located in the boiler building open to the environment.

Fly ash was initially conveyed pneumatically to a cyclone/storage bin system for direct discharge into a truck.

Exhaust gases were cleaned by a two-stage electrostatic precipitator, one for each boiler.

Initial Plant Modifications. Many problems plagued the facility after start-up; some were resolved while others persisted. The following paragraphs will highlight the major problems and the attempts at their resolution.

The receiving pit was susceptible to bridging when

large volumes were being stored. Various attempts were made to resolve this problem, but no solution was found. In addition, retrieval from the pit with the pan conveyors was erratic.

The feed to and from the Atlas Bin was both unreliable and inconsistent due to bridging and plugging problems. To alleviate the problems associated with the Atlas Bin, it was bypassed entirely by installing a series of belt conveyors. Feed control was still accomplished manually from the control room in the receiving building. This meant that the boiler operator had to control feed indirectly through communication with the receiving area. The boiler controls were enclosed in a small room inside the boiler building for protection and ease of operation.

The pneumatic fly ash system was abandoned due to severe maintenance problems associated with abrasion and plugging. The use of the cyclone and storage bin was also discontinued as a result of severe dust and unloading problems. The modified grate residue handling system consisted of manually raking residue from a hopper onto a vibratory pan, where the residue was quenched with a water spray. The cooled residue was subsequently transported by a belt conveyor to a discharge area outside of the building. This process required that two men per shift work in a hot and dusty environment.

The fly ash was transported from the precipitators by screw conveyor into a wet tank. The resulting fly ash slurry was removed from the tank with a drag conveyor and transported by belt conveyor to a loadout at the rear of the boiler building.

Both the grate residue and fly ash were used as fill adjacent to SWARU.

Tricil's Experience. In February, 1978, Tricil and the Region of Hamilton-Wentworth entered into a 10 year Full Service Contract, which included the modification and operation of the Hamilton SWARU Plant.

Various modifications of SWARU were undertaken during 1978 to 1979. The following paragraphs give a brief account of the operational and technical improvements.

To minimize bridging and retrieval problems associated with the receiving pit, refuse is stored on the floor to keep volumes in the pit at low levels. This technique changed the function of the pit from a storage bin to a feed hopper.

In order to more closely control waste entering the plant, a program was implemented to restrict waste being processed to residential and light commercial types.

Bridging and plugging in the fuel transport system was minimized by replacing original chutes and trans-

fer points by ones which incorporated improved design features.

Improved boiler stability was achieved by providing the boiler operator with direct control of the feed system. The boiler operator was located in an upgraded control room in which he could visually monitor burden depth on the inclined pan conveyors with remote cameras. This allowed the operator to control feed by both manual and automatic speed variation in response to steam demand or furnace temperature.

A magnetic head pulley was installed downstream of the primary magnet in order to catch heavy ferrous, wire, and miscellaneous pieces prior to entering the boilers.

The manual grate residue system was replaced by a quench tank with integral drag conveyors to automatically quench, remove, and dewater the residue prior to being transported by belt conveyor to its load-out area. The fly ash system was upgraded with the installation of new wet tanks.

In 1982 a turbine generator was installed to commercially utilize the steam generated at the plant, hence the plant was changed from strictly an incinerator to an energy producing facility.

Another factor influencing feed control is the characteristics of the pulverizers. These units inherently produce slugging and allow oversized pieces to bypass the units. This affects the feed in that the slugging causes unstable feed rates, and the large pieces can plug the transport system.

Due to the nature of the infeed equipment, consistent feed rate control is difficult. In addition, the transport and boiler feed systems have limited provision for controlling feed rate to the boilers. Since refuse is extremely heterogeneous in its composition and, therefore, in its heat release, the feedrate response is slow, and good combustion control is difficult.

The electrostatic precipitators were not only undersized but also operating below the performance for which they were designed [2]. Even after modifications to the front field of the precipitators, occasional problems still occurred. Presently, the plant controls opacity within regulations by limiting through-put, but a nuisance is still created periodically by the fallout of soot particles in the immediate neighborhood.

Through this program of significant plant improvements, Tricil succeeded in meeting and exceeding all its contractual obligations and maintaining emissions within environmental standards. However, certain shortcomings still remain at the plant, necessitating a major retrofit. These fall into three main categories; refuse feed, combustion control, and gas emission control.

SWARU RETROFIT: PROCESS DESCRIPTION SUMMARY

Municipal solid waste is received 5 days/week, 8 hr/day, and prepared for semisuspension burning in the furnaces. The preparation is in the form of shredding and ferrous metal removal. The RDF is transported via a series of conveyors and fuel proportioners to two independent process lines rated at 300 TPD (273 tpd) each.

The existing furnaces are of the waterwall type and the travelling grates are designed for spreader stoker firing. Once combustion is completed, the flue gases exit the furnace and travel through a two-drum, single gas pass boiler, a tubular air heater, a coarse particulate drop out chamber, and a water spray cooler for temperature control.

The cooled flue gases will then flow through a baghouse filter for final particulate removal. The filtered flue gases exit the baghouse and are discharged up the stack to the atmosphere via an induced draft fan.

Particulates captured in the baghouse are transferred, along with that from the spray cooler, drop out chamber, and boiler hoppers, to a pugmill, by a series of transfer augers. The grate residues from the boiler discharge into the quench tank. The wet residue is then transferred to the residue storage area by drag and belt conveyors. In the storage area the residue is loaded into trucks and transported to a landfill.

FUEL TRANSPORT AND FEED CONTROL SYSTEM MODIFICATIONS

Refuse Preparation and Conveying Systems

Municipal solid waste is unloaded into the existing pit as well as the receiving floor in the receiving building. Four adjacent pan conveyors comprising the pit floor transfer the solid waste from the pit to four existing vertical shaft pulverizers. The waste is shredded to a size less than 4 in. \times 4 in. (25 mm \times 25 mm) and then discharged onto a belt No. 5 conveyor (see Fig. 1).

At the head pulley of No. 5 conveyor the magnetic belt extracts ferrous metal depositing onto the "primary metal take away" belt conveyor. This conveyor discharges the metal into the ferrous storage bin.

Conveyor No. 5 discharges onto the new No. 6 conveyor. Another magnetic head pulley has been relocated to the discharge end of No. 6 conveyor to further extract metals from the refuse. This extracted material is discharged onto a new "secondary metal take away" conveyor by means of a new transfer chute. All of

the separated metal is transferred to the relocated compactor.

The RFD (most ferrous metal removed) from No. 6 conveyor is divided into two streams by the primary fuel proportioner.

The primary fuel proportioner discharges the two streams onto new conveyors, No. 8 and No. 7, which in turn transfer RFD to the centerline of boiler No. 2 and No. 1 respectively.

A secondary fuel proportioner is provided for each boiler. The fuel proportioners receive the RFD from their feed conveyor (either No. 7 or No. 8) and split the feed between the boiler and a recycle conveyor.

The new recycle conveyor No. 9 transfers RDF, which will bypass the furnace back to the receiving pit.

Refuse Feed Control

The refuse feed control signal from the steam demand controller goes to three places: the secondary fuel proportioner, the primary fuel proportioner and the pan conveyors in the receiving pit.

Secondary Fuel Proportioner. The secondary fuel proportioner receives a signal which is compensated for time delays in the material feed system. This signal is further modified to allow the fuel proportioner to:

(a) Change its position during the time it takes the refuse to travel from the pit pan conveyors.

(b) Return the proportioner to its original position once the changed fuel quantities arrive.

As the fuel requirements are changed, the pan conveyor speed, and secondary fuel proportioner position, change immediately.

In addition to the individual refuse feed control signals, two other signals are generated to control the primary fuel proportioner and the variable speed pan conveyors.

Primary Fuel Proportioner. The primary fuel proportioner position is maintained at the ratio of the fuel signals for boiler No. 1 and boiler No. 2. When fuel requirements are changed, the pan conveyor's speed immediately changes. Two signal modifiers are part of the control to maintain the position of the primary fuel proportioner until required fuel feed changes arrive from the pan conveyors.

Pan Conveyors. The control of the pit pan conveyors depends on total refuse requirements. To control the pan conveyor speed for total refuse flow, the two signals for fuel to boiler No. 1 and boiler No. 2 are summed.

Recycle Conveyor No. 9. In this feed system a recycle conveyor is used to allow the individual secondary proportioners to control the feed, both increasing and

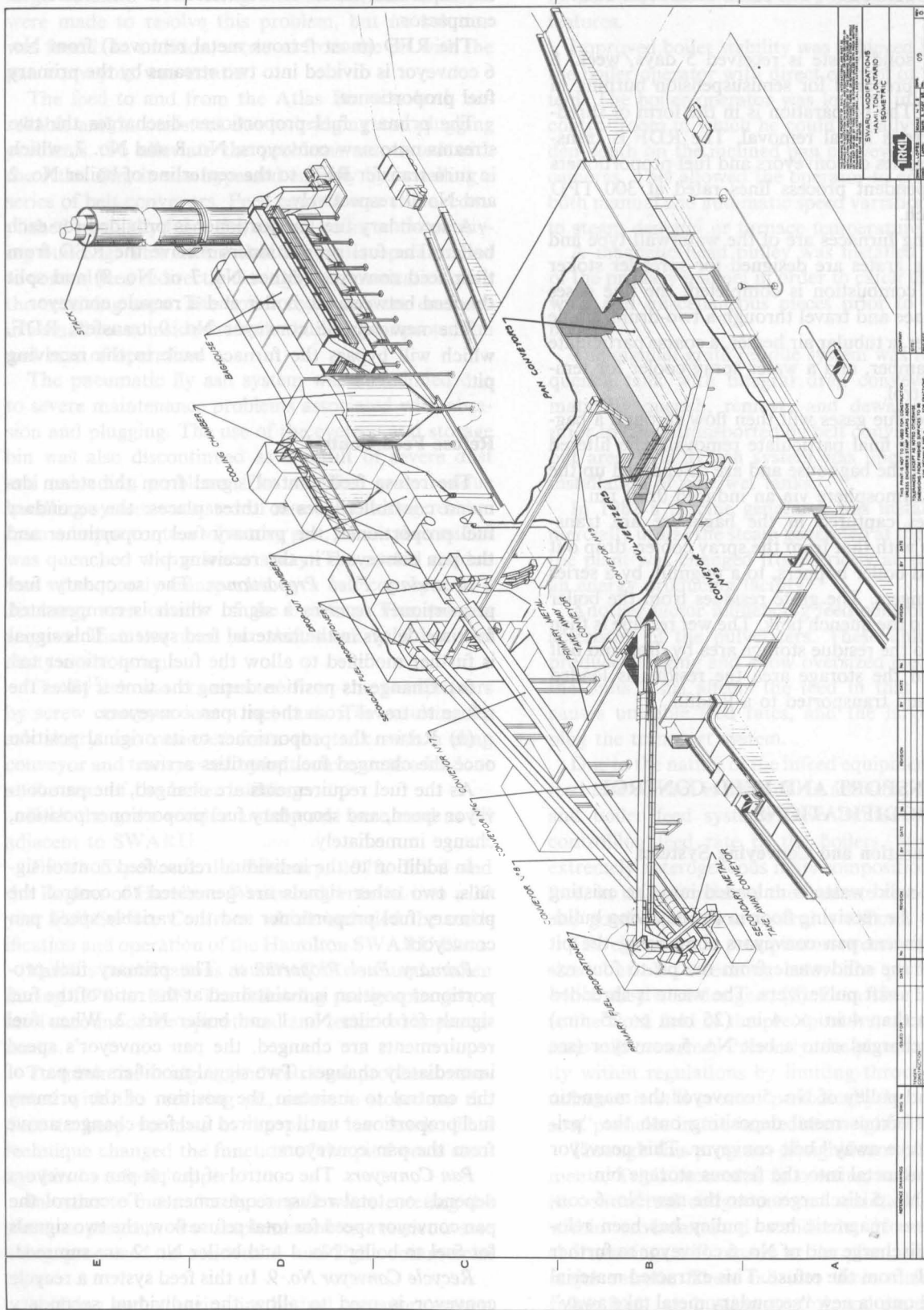


FIGURE 1

decreasing. To accomplish this, each secondary fuel proportioner recycles approximately 10% back to the pit via the recycle conveyor. The system accommodates immediate changes of +10% to -100% RDF flow. In order to cope with upward changes in excess of 10% RDF flow, an up-ramp limiter is used such that the fuel flow increases cannot exceed 10% every time increment. The effect of this is to prevent the use of all the recycled fuel and hence a loss of fuel feed control.

COMBUSTION CONTROL MODIFICATIONS

Modifications include a micro-processor based control system. This system monitors and controls boiler parameters to accommodate changes in refuse quality and excess air requirements in order to achieve optimum combustion efficiency and minimize emissions.

Combustion Air System

The plant combustion air system consists of a series of fans and ducts designed to provide both preheated overfire/underfire air and tempering air.

The overall air flow control is accomplished by the underfire air controller. This flow controller receives a set point from the overall steam flow master and is checked against the measured air flows to the boiler. The overall air flow control is compensated for temperature and pressure to effect good overall control of the air system.

Fuel Feed Modifier. The signal from the main steam flow controller is delayed by a dead time compensator. This compensator is used to delay the set point to the underfire air controller by the time it takes the fuel to travel from the secondary fuel proportioner to the boiler grate. The object of this is to ensure that the air/fuel ratio is maintained in the boiler.

Pre-heated Underfire Air. The existing forced draft fans draw ambient air from the plant basement and pass the air through the existing air heater. The air may exit the air heater between 347°F (175°C) and 428°F (220°C), depending on boiler load.

The force draft fan damper is controlled by a single pressure loop and is set up to maintain a desired duct pressure at the air heater outlet. The pressure set point is fixed at a value capable of providing sufficient air for full boiler load.

The main control on this system is by flow through the underfire air damper. Since the flow of overfire air is manually set, all automatic flow changes are accomplished by this damper.

The existing air damper located in the underfire duct is controlled by the steam flow and O₂ signals via the micro-processor. Tempering air for undergrate air temperature control may be introduced into the system through a bypass damper around the air heater.

Excess Air Control. The excess air is controlled by trimming the set point to the underfire air controller. The excess air controller transmits its output to a signal modifier that adjusts the underfire air controller's set point. This maintains a constant excess air and steam flow in spite of changes in fuel quality.

Overfire Air. Two new fans, one for each boiler, are used to provide the overfire air distribution to the boilers. The overfire air system receives hot air from the force draft fan system and it operates with minimal automatic functions. The system is designed to provide constant overfire air pressure of 15 in. (381 mm) with the capability to control the temperature.

The overfire air system operates under constant pressure by controlling the overfire fan inlet damper. If the overfire air flows need to be adjusted, it is necessary for the operator to move the manual dampers in the front and rear overfire air ducts.

Pressure Control

The furnace pressure is monitored and transmitted to the pressure controller, which in turn controls the damper upstream of the new induced draft fan. Adjustment of this damper maintains the negative boiler pressure around 0.1 in. (2.5 mm) water column at the top of the furnace.

AIR POLLUTION CONTROL EQUIPMENT

Drop-Out Chamber. As the gases exit the air heater, they enter a drop-out chamber, which is designed to remove heavier fly ash. This new settling chamber houses screens to aid in the removal of spark carryover. The bottom of the chamber discharges through a downpipe to the main ash gathering conveyor.

Spray Cooler. The spray cooler is equipped with a 60 deg. conical bottom and is provided with a penthouse for access to the spray nozzles. The spray cooler contains one set of three atomizing spray nozzles for normal operation and another set of spray nozzles for back-up.

The flue gas, entering the top of the spray cooler at about 600°F (316°C), is contacted with a fine water spray which is introduced into the chamber via the spray nozzles. The total flow-rate of water is automatically controlled by the outlet flue gas temperature.

TABLE 1 AIR EMISSIONS

	Present		New Emissions Estimate	
	Emission Rate From Stack (10 ³ µg/m ³)	Emission Rate From Stack (10 ³ µg/m ³)	Half hour average maximum Ground Level Concentration (µg/m ³)	Ministry of Environment Standard (µg/m ³)
Particulate	475	14.9	2.65	100
Calcium	7.2	0.21	0.04	20
Iron	5.4	0.19	0.03	10
Lead	3.6	0.10	0.02	10
Mercury	0.2	0.004	0.001	5
Zinc	5.4	0.17	0.03	100
Hydrogen Chloride	138	138	24.8	100
Sulphur Dioxide	270	270	48.5	830
Nitrogen Oxides (as NO ₂)	48	48	8.7	500
	(PPM)	(PPM)		(PPM)
Unburned Hydrocarbons (as methane)	100	50		100
Carbon Monoxide	1000	800		2000

A hydropneumatic spray water head tank is also provided for emergencies (e.g., power failure) to allow enough time for the baghouse bypass damper to fully open.

The spray cooler has two outlets; a bottom discharge for dry particulate discharging through a motor operated tipping dust valve onto the spray cooler transfer conveyor and a side outlet for the treated flue gas.

Baghouse. Under normal conditions, the spray cooler exhaust gases enter the baghouse at about 392°F (200°C). The gases pass through five parallel compartments. A bypass is also provided for start-ups, shutdowns and emergencies that may be encountered as a result of temperatures in excess of 473°F (245°C).

The baghouse is a pulse-jet type comprising five identical compartments. Each compartment hopper is supplied with electric heaters and individual thermostats.

The baghouse can be operated in an on-line or off-line cleaning mode. Baghouse pressure drop will be monitored and transmitted back to the control room. The cleaning of the bags is initiated when the pressure drop across the baghouse reaches 6 in. (152 mm). All five compartments are then cleaned in sequence. Each baghouse hopper discharges fly ash to the baghouse screw conveyor through a motor operated tipping dust valve.

Bag-Precoating System. Filter bag blinding is minimized by precoating of filter bags with limestone once a week. A limestone silo complete with a pneumatic conveying system is provided.

Stack and I.D. Fan. A new 500 hp induced draft fan has been installed to provide the necessary draft on the boiler system. The fan exhausts the flue gases to the atmosphere via a new stack. The stack has two insulated flue liners and an outer structural shell.

RESIDUE/FLY ASH HANDLING SYSTEM

Residue/fly ash is gathered at five locations. Grate residue travels off the boiler grate and drops into the wet tank beneath the boiler. Fly ash from hoppers located before the air heater is transferred by a screw conveyor to the ash transfer conveyor. Drop out chamber and spray cooler fly ashes are dropped straight to the ash gathering screw conveyor while baghouse fly ash is transferred to the same gathering conveyor by

two screw conveyors. The ash gathering conveyor transfers all of the fly ash to a pugmill located in the basement. The pugmill then conveys the fly ash to the short ash drag conveyor.

The grate residue in the quench tank is removed by a drag conveyor. The drag conveyors from both boilers transfer the wet residue also onto the short ash conveyor which in turn transfers all the wet residue and fly ash onto a long ash conveyor. This material is temporarily received on a storage pad outside below the head pulley of the long ash conveyor.

PLANT EMISSIONS

The sole source of air emissions from the RDF fired boilers is the final stack. The emissions from the new emission control system have been estimated and are summarized in Table 1.

The figures presented in this table were developed in the following manner: The estimates for particulate and heavy metal emissions were based upon an emission test program performed on the existing facility [3]. Expected particulate removal efficiency of the drop out chamber, spray cooler and baghouse were then applied to give the stack emission rate. The emission rate from one stack flue was then used to calculate the half hour average maximum ground level concentration at the point of impingement. The same calculation procedure was used to account for hydrogen chloride, sulphur dioxide, and nitrogen oxide emissions. The figure for hydrocarbon and carbon monoxide emissions is based directly on present operating data; however, changes in combustion control as described above will all tend to reduce these levels even further.

REFERENCES

- [1] Finkelstein, A. "An Investigation of Burning Methods to Generate Steam from Solid Waste." Presented to Ontario Ministry of Environment Toronto, Ontario, January 15, 1979.
- [2] Cadotte, A. P. "Hamilton SWARU Air Emissions." Engineering Report for the Regional Municipality of Hamilton-Wentworth, December 18, 1981.
- [3] Ontario Research Foundation. "Boiler Performance and Stack Emission Test Program at SWARU." November 9, 1979.

Keywords: Baghouse; Boiler; Combustion; Control; Incineration; Refuse Derived Fuel; Retrofit.