ABSTRACT

During the first three years of operation, almost every major plant system in the 300-ton-per-day Northeast Incinerator has been modified or, as in some cases, completely redesigned.

The scope of this paper includes: a rationale for each of the major modifications, a cost analysis of the changes, and a description of the resulting improvements in overall plant operation. Extensive modifications to the controls and instrumentation system, the plant hydraulic system, the electrostatic precipitator control system and the fly ash handling system are among the things discussed.

INTRODUCTION

During a random tour of incinerator plants in the United States, it would become apparent to even the casual observer that municipal incinerators are not, for the most part, successful operations and well deserve public censure. While poor housekeeping, lack of proper preventive maintenance, operating over design limitations and an unfilled need for qualified professionals in the operating phase of municipal incineration significantly contribute to unsightly and inefficient operations, another significant factor is the lack of on-going in-plant engineering programs to improve plant efficiency thereby controlling or reducing the cost of the overall operation.

The best plant design can be improved upon, but seldom is there a municipal budget appropriation, after initial plant acceptance, to cover outside consultants and contractors fees. The responsibility for an on-going design improvement program falls upon the plant superintendent and his staff.

This paper is based upon our experience during the last three years at the Metropolitan Dade County Northeast Incinerator. Our 300-ton-per-day conventional incinerator plant equipped with an electrostatic precipitator was initially started up for full-time operation in October of 1970. All of the modifications outlined in this article have been engineered, designed, and implemented by the incinerator staff.

INSTRUMENTATION AND CONTROL SYSTEM

As originally set up, the incineration process (exclusive of the precipitator controls) was controlled by three major automatic control loops, the Induced Draft Fan speed control loop, the Precipitator Inlet Temperature loop, and the Primary Combustion Chamber control loop. It was apparent, soon after start-up, that none of the control loops were reliable enough to operate the process in automatic, although the instruments and controllers were in good working order.

Manual operation required the plant operator to remain within the close proximity of the instrument panel to monitor plant parameters and to make constant adjustments to the various process variables. Plant mechanics worked overtime to monitor running equipment external to the instrument panel.

The most apparent instrument and control problems were as follows:

1) Severe oscillations of all the electric instruments.
2) Inability to maintain speed control of the Induced Draft Fan resulting in loss of furnace draft and excessive furnace draft.
3) Individual oscillation of the precipitator inlet temperature recorder, spray water controller and Dilution Air Fan controller. (Figure 1.)
4) Frequent failure of the TC/I (thermocouple to current) transducer, the sensing element in the precipitator inlet temperature control loop.

5) Inability to operate at a stable primary combustion chamber temperature.

In observing the oscillations common to all instruments, it was noted that the oscillations were most severe when the telephone buzzer sounded, the instrument audible alarm sounded, or when one of the final control elements (120 VAC) valve motors were operated. This led to a check of the 120 VAC power supply. Line voltage variations were severe enough to be seen on a well dampened multimeter. The plant 120 VAC power supply source was a single 480 volt - 3 phase to 120 volt single phase - 45 KVA transformer.

A separate 480 volt to 120 volt transformer with an ungrounded secondary was installed by plant personnel. All of the auxiliary equipment, such as valve motors, audible alarms, and lighting remained on the main 120 volt transformer. The instrument electronics were supplied by the newly installed ungrounded transformer. After the separate 120 VAC power supply was established, the common oscillations were no longer present.

The purpose of the precipitator inlet temperature control loop is to reduce the temperature of the gasses exiting from the secondary combustion chamber from 1900°F to 400°F before they enter the electrostatic precipitator. A careful examination of this loop (Figure 1) showed it to be overly complex and to contain a basic design error.

Two process variables were being used to independently control a single process parameter. Both the amount of spray water and the amount of ambient (dilution) air pumped into the spray chamber was varied by miniature three mode automatic controllers. Each controller acted independently; no attempt had been made to interrelate the process variables by cascading. A change in the variable would change the precipitator inlet temperature and thereby affect the other variable, setting up a see-saw action.

The interaction between the spray water and the dilution air process variables was easily eliminated by operating the dilution air controller in manual, thereby, leaving the dilution air damper in a fixed position. We were, however, still faced with the problem of having an unreliable sensing element, the TC/I transducer.

The TC/I transducer was, from several aspects, a source of recurring trouble. The input to the TC/I is a conven-

![Fig. 1 Precipitator Inlet Temperature Control Loop]
tional thermocouple. The output is a 4 to 20 milliamp signal directly proportioned to the measured temperature. These devices are not field repairable and are very costly. The required 400 feet of 4-20 milliamp transmission line was subject to induced rf frequencies from a nearby television station and induced voltage from power transmission lines and running motors.

The precipitator inlet temperature control system was modified as in Figure 2. Automation of the dilution air was eliminated; the expensive miniature three mode spray water controller was eliminated along with its necessary interface devices. A field repairable two mode controller was installed using a conventional thermocouple sensing element. An existing multipoint recorder was used to record the precipitator inlet temperature eliminating the need for a separate recorder. No operating problems have been experienced with this system since the modification was completed.

The problem of the induced draft fan speed fluctuations had been eased somewhat by operating the dilution air fan damper in a fixed position, thereby eliminating large variations in positive air pressure. I.D. Fan speed variations, however, remained a troublesome operational problem. Rapid changes in furnace draft, utilization of a high gain controller and mechanical delays experienced in changing the position of the speed control scoop tube and fan inertia had made the control system too sensitive to change on the input and too insensitive to change on the output to be effective in maintaining furnace draft at a specific setpoint in the instrument's narrow (0 to .6 in. H2O) range. (See Figure 3).

A mechanical restriction was placed in the furnace draft sensing line to reduce the violent input signals to more of an average level. The sensing instrument was also dampened electronically. The controller was tuned to the maximum proportional band, 300% (a gain of 1/3) and a
small amount of rate and reset were used (.05 min. and .3 repeats per minute respectively.)

The result was a stable furnace draft with no backfires or unusually high drafts during normal operation. The stabilization of furnace draft allowed the primary combustion chamber temperature controller to be accurately tuned to the process. A variation in upper overfire air is used to maintain primary temperature. A 24 hour period with variations of no more than ±100°F is not unusual during the dry season. No auxiliary fuel is used during operation.

A temperature instrument with an audible alarm was installed to monitor the induced draft fan fluid drive oil temperature to warn the operator of the loss of fluid drive cooling water and the furnace grate hydraulic flow control valves were removed from the instrument panel to eliminate the possibility of a hydraulic leak in the proximity of the electronic hardware as part of the instrument system modifications.

With a total cost of less than $1,500.00 in hardware and supplies, it was possible to achieve a reliable degree of automatic operation while eliminating more than $4,000.00 worth of instrumentation hardware.

**RELOCATION OF THE ELECTROSTATIC PRECIPITATOR CONTROLS**

The control panel and the 145 KW saturable reactor associated with the electrostatic precipitator were located in a small corrugated metal shed directly under the electrostatic precipitator. This location posed several operational problems.

With the combined effects of the intense Florida summer heat and the heat given off by the 145 kw saturable reactor, the ambient temperature would reach levels high enough to cause malfunctions in the solid state control circuitry. During frequent summer electrical storms and accompanying power failures, the plant operator would have to leave the plant operating station to reset the electrostatic precipitator. The remote location of the controls also made frequent checks of the precipitator parameters difficult.

The precipitator controls, saturable reactor and rapper control panel were relocated in the forced draft fan room directly adjacent to the plant instrument panel. Ambient air moving into the forced draft fan suction cools the solid state control circuitry and the saturable reactor. The panel is easily accessible to the plant operator. No further problems have been experienced with the precipitator controls since relocation.

The total cost of relocating the precipitator control panel, saturable reactor, and rapper control panel was approximately $2,500.00. Electrical conduit, raceways, wire and connectors were the most costly materials used in the modification.

**EVOLUTION OF THE ASH HANDLING SYSTEM**

One of the major problem areas in all incinerator operations equipped with anti-pollution equipment is what to do with the fly ash that has been removed from the gas stream. Our plant was no exception.

Originally, our ash handling system consisted of an enclosed screw conveyor located directly below and attached to the two ash hoppers that are an integral part of the electrostatic precipitator. From the discharge end of the screw conveyor, the ash dropped through a spring-loaded 10” valve, into a pug mill (double screw conveyor) where a fine water spray was added to reduce the effects of wind and gravity when the ash was further transferred by belt conveyor to the residue truck.

The following operational problems were experienced with the ash handling system:

1) The spring loaded valve would become overloaded and jammed.
2) The main screw conveyor would become jammed.
3) The wet ash in the pug mill would become dense and heavy enough to bend and often break the twin screw.
4) The amount of ash collected by the precipitator depends upon the type of material being burned, the rate of burning, the quality of combustion, and the changing dynamics of the gasses passing through the precipitator. All of these parameters are infinitely variable in municipal incinerators. Since the amount of ash collected was constantly changing, it was not possible to achieve an optimum pug mill water spray setting. One instant, the fly ash would be blown by the wind and the next instant, a water slurry would be dripping off of the belt conveyor.

The present ash removal system evolved through a series of experiments that continued for more than two years. The present system consists of two 16” double flapper cam-operated motorized discharge valves (one valve is located under each of the precipitator ash hoppers) with 60 feet of 8 inch PVC pipe to receive the fly ash and convey it hydraulically to the quench tank and a 100 G.P.M. trash pump to recycle the contents of the quench tank through the PVC collection and discharge pipe. The screw conveyor, pug mill and transfer conveyor were completely eliminated. The collected fly ash settles in the quench tank and is removed with the other noncombustibles by the drag conveyor.

In the course of changing the fly ash removal system, we eliminated several costly, high maintenance pieces of equipment. In their place, we are using two $1,400.00 flapper valves, $500.00 worth of piping and a $250.00...
pump. The total cost, including several interim and experimental measures, along the course of development, was less than $3,000.00.

Although overloading still occurs occasionally, when there is a drastic step change in precipitator operating temperature, the majority of over-loading and resulting mechanical failures have been corrected. Unusually heavy ash discharges can be flushed out by augmenting recycled quench tank water with clear water from a hose. The wind blown ash and dripping ash problem have been corrected by using enclosed PVC pipe for ash transport.

**RELOCATION AND SPACING OF THE HYDRAULIC SYSTEM**

The modification of the incinerator’s main hydraulic plant is typical of those changes that were made to improve the accessibility of equipment for maintenance and repair purposes.

The hydraulic supply tank, main hydraulic pumps, heat exchangers, accumulator, and the associated valves and piping were located in the lower level of the incinerator plant directly below the forced draft fan and associated duct work. The cramped location made hydraulic maintenance a time consuming and sometimes impossible task. Eight man hours were required for the routine-cleaning of one heat exchanger. Tightening of many of the threaded fittings was not possible without first draining the main hydraulic tank.

The hydraulic station was moved piece by piece to a cement slab adjacent to the plant and reassembled with enough room around each component for easy access. An existing fuel oil tank was used for a hydraulic supply tank. Valves were installed to allow tightening of any threaded fitting without loss of hydraulic oil from the tank.

The total cost of relocating the hydraulic system was less than $2,500.00. Since relocation, the routine maintenance costs have been drastically reduced. One-half man hour is required for cleaning a heat exchanger.

**OTHER MODIFICATIONS**

Other modifications to the plant include:

1) Remachining the electrostatic precipitator rapper hammers for additional clearance on the rapper shafts.
2) Replacing the overhead crane rail hold-down clips with J-bolts.
3) Replacing drip-proof motors with totally enclosed fan cooled motors throughout the plant.
4) Construction of a larger waste water sump for ease of cleaning.
5) Eliminating the draft reversal system and installation of an additional undergrate air fan.
6) Elimination of the underhearth positive air blowers.
7) Installation of larger well water pumps.
8) Installation of a cooling water distribution manifold on the operating level.
9) Installation of a self oiling system on the drag conveyor.
10) Replacing the furnace hearth refractory with steel plate on the wearing surface.
11) Elimination of the feeder cut off roll assembly.

**CONCLUSION**

To survive public scrutiny and ever tightening legislative restrictions, municipal incineration must pattern itself after other heavy industrial operations in having in-plant on-going engineering improvement programs. It is no longer possible for incinerator operators to excuse sub-standard operations on the basis of having to live with what the contractors gave them to operate. Our experience at the Northeast Incinerator shows that extensive modifications, necessitated by operational problems, and state-of-the-art upgrading can be accomplished economically by the incinerator operating staff.

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