AIR POLLUTION CONTROL RETROFIT SIX YEARS LATER— ELECTROSTATIC PRECIPITATORS ON ROTARY KILN INCINERATORS

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ABSTRACT

Update on status and repair history of retrofitted incinerator with new electrostatic precipitator systems. Author revisits the previous subject of 1984 ASME paper titled, "Modern Air Pollution Control Retrofits: The Potential for Recovery of the Incinerator Itself."

At the 11th Biennial Conference in 1984 in Orlando, Florida, a paper titled "Modern Air Pollution Control Retrofits; The Potential for Recovery of the Incinerator Itself" was jointly presented by Ed Brabham and John Norton. That paper dealt with a technical search which had been conducted by Montgomery County to find air pollution control equipment that would allow its North Incinerator Plant to continue operating, and also with the technical requirements that had been established for a turn key installation of the air pollution equipment. This paper is intended to review and document the operating abilities, circumstances, and problems which have taken place since the time of start up—November 27, 1982.

The systems installed have operated well during the intervening years—causing no more than 10% of total facility downtime. Total downtime for the last 6 years has been typically about 5 weeks per year. Given the fact that the systems are working well at this time, it is easy to say that every author who delivers a paper on a system just started (or just about to start) should be required to deliver a follow-up paper on how well the subject system is working 4 years or more after start-up.

A commitment to this follow up presentation was made when the first system was started in 1982 and the first paper given in 1984. There are too many papers about systems which appear to have promise, but which fail miserably and are never heard of again. The professional literature documents their promise, but not their failure and reasons therefore. This causes many new plants to be built with flawed design concepts. It is excusable to fail, but to repeat such failures casts disgrace on this profession and widens the credibility gap between us and the general public, and between us and the environmental agencies.

The precipitators retrofitted on existing rotary kiln incinerators at Montgomery County's North Incinerator Plant are working well. The North Plant installation has worked so well, in fact, that it was virtually duplicated for installation at Montgomery County's South Incinerator Plant. The South Plant's two rotary kiln incinerators were re-started in November of 1984. There were some slight modifications, however, for the South Plant as a result of experience gained with the retrofitted electrostatic precipitators at the North Plant. These will be explained herein.

The 1984 paper described the three field units installed at the County's North Plant and detailed several items of merit in their specifications.

AIR COMPRESSOR

Ninety percent of the early problems for the North Incinerator Retrofit were due to one of its least likely components—a small air compressor. As part of the turn-key project, a 5 horsepower (5 hp = 3.7 kW) air compressor was included to drive the rapper hammers for field cleaning. Unfortunately, an off brand unit with a glossy brochure was selected and installed as part of the original installation. The price of the air compressor itself was probably not more than $1500.00. It failed repeatedly and finally had to be replaced.

During the first 6 months of operation this problem took at least 90% of the service and maintenance attention of the operating staff and the equipment manufacturer. For a few hundred extra dollars at the time of equipment selection, all of those problems could have been avoided. Note that this is a problem frequently identified with low bid work. Critical equipment should be specified by the engineer with guarantees.

At first it was thought that the unit was getting unclean air from the plant environs, and the air intake was reconfigured. After a second failure, it was suspected that the unit was sucking in too much moisture and overwhelming the air dryer. Then it was assumed that the unit was located in a position that was "just too hot" (perhaps 110°F, or 43°C) and the entire air compressor system was moved from the fourth floor down to the first floor. At that point the unit overheated, welding the piston and cylinder solid. It was replaced with a known brand, and then the air compressor problems stopped. Needless to say, for the South Incinerator installation a known brand was selected. There have been no such problems on the South Plant air compressor.

Fortunately, during the early months of operation it was fairly easy to interconnect the plant air system with the precipitator's so that the precipitator could continue to operate even though its air compressor was out of service. It is heartily recommended that such air pressure systems within plants be interconnected (perhaps with an isolation valve if that is deemed necessary) to provide back-up service in order to keep systems operating.

THIRD FIELD RAPPING PROBLEM

A larger problem was identified after approximately ten months of operation. This problem proved to be much more serious. It was successfully corrected with approximately $100,000 worth of additional duct work.

This problem became known as the "Third Field Rapping Problem". At first, even the Regional Air Pollution Control Agency was confused about the source of little black flakes ($<\frac{1}{16}$ in. or <1.0 mm) that were discovered on an irregular basis in isolated areas perhaps one-half to three-quarters of a mile (800–1200 m) from the North Plant. Oddly enough, the Regional Air Pollution Control Agency first suggested that these little black flakes "could not possibly" have emanated from the incinerator. The Plant Manager, however, was able to note certain patterns with regard to the disposition and location of these particles. With the assistance of a windsock installed at the Plant and a review of operating records, he was able to ascertain that the particles appeared down wind from the incinerator following rare combustion problems at the Plant. The particles seemed to form during infrequent periods of bad combustion and were released during rappings of the third field of the electrostatic precipitators. This theory was tested by "bottling up" the precipitator during rappings of the third field. The occurrences of these little black flakes in locations around the Plant stopped.

This problem only appeared after infrequent rapping of the third fields. It appears that the third field would catch the emissions from the first and second fields during their rappings, but when the third field rapped, there was nothing to prevent loss of the flakes (if they were present on the third field plates.) During normal times—with "good" combustion—this problem did not occur even when rapping the third field.

As a matter of public relations, a policy of only rapping third fields during daylight hours was adopted so that all "sins" were visible. Prior to that, the County had been accused of rapping during the wee morning hours in order to hide puffs of black smoke.

Before a final permanent solution could be instituted, staff continued to "bottle up" the precipitator during each rapping of the third field. The electrostatic precipitator was "bottled up" by banking the fires in the refractory lined rotary kiln incinerators, opening the emergency stack, and closing slide gates before and after the precipitator itself. Then all of the fields would be thoroughly rapped down and time allowed for all dust to settle to the bottom of the precipitator—into the collection hoppers. Then the slide gates would be reopened, the induced draft fan restarted, the emergency stack closed, and the fire restoked.

This procedure was unsatisfactory to the Regional Air Pollution Control Agency as they deemed the unit to be operating in an "uncontrolled mode" during the period when the emergency stack was open. Staff continued to do it, however, until a permanent correction could be instituted. There were no complaints from the neighbors while the unit was banked with the emergency stack open.

In order to solve the third field rapping problem, it was necessary to install "a crossover duct." This is a 60 in. × 60 in. (1.5 m × 1.5 m) duct joining the two incinerator trains after the wet conditioning tower. See Fig. 1. Slide gates allow use of the duct during third field rapping. The slide gate in the crossover duct allows isolation of the two systems during normal operation.

In order to maintain a 350°F (177°C) temperature in the crossover duct to prevent acid condensation, the crossover duct included a 12 in. × 12 in. (0.3 m × 0.3 m) duct which by-passes the slide gate in the crossover duct. While there is a small slide gate in this bypass duct, it is kept open at all times. The slight difference in pressure between the two incinerators causes a flow of gases through the crossover duct (and its little bypass duct) continuously—thus ensuring that the gas temperature within the duct is maintained at a relatively high temperature.

As with all of the other ducting between the conditioning tower and the outlet transition cone of the electrostatic precipitators, the crossover duct is heavily insulated with 6 in. (15 cm) of mineral wool fiber insulation (8 lb/ft^3 = 0.13 g/mm^3) and embossed aluminum corrugated lagging. Through the difference in duct pressure between unit #1 and unit #2 is slight—from 0.01 to 0.3 in. (0.2 to 7 mm) of water column—it is sufficient to ensure adequate gas temperature within the crossover duct. Virtually no corrosion has been observed in the duct during down times.

With the new crossover duct in place, plant staff are able to "bottle up" each precipitator individually while the incinerators are crossconnected (through the crossover duct) to the other precipitator. In order that the total gas volume does not overwhelm the one precipitator unit, the fires are first cut back to provide approximately one half of their normal gas flow (60,000 acfm at 500°F or 1700 m^3 at 260°C). Thus, the gas flow during crossover operation is maintained at approximately the normal operational level in the one ESP in service.

Fortunately, the loading on the third fields has been so slight that there is need to clean them only approximately every 3–5 days, depending on the opacity readings and the ability to maintain necessary field voltages. Since the crossover duct was installed in approximately September of 1983, the department has received only one complaint for suspicious appearing flakes within a 1 mile distance of the North Incinerator. Fortunately, that apparently came from a different

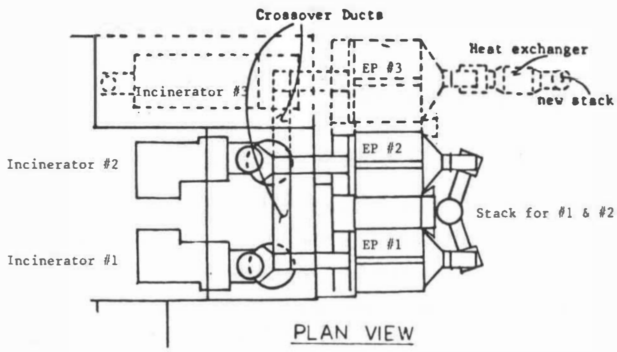

FIG. 1 PLAN VIEW SHOWING CROSSOVER DUCTS BETWEEN EXISTING INCINERATOR EQUIPMENT TRAINS AND PROPOSED NEW THIRD INCINERATOR EQUIPMENT TRAINS

source. No other such complaints have been recorded with the incinerator or the Regional Air Pollution Control Agency.

The crossover duct was included in the South Incinerator retrofit at the beginning. No such complaints have been registered about flakes in the vicinity of the South Plant. New third incinerator lines under construction at each plant, include crossover ducts which will allow interconnection of the third unit to the existing units. See Fig. 1.

HOPPER PLUGGING

Hopper Plugging with the captured fly ash has been a nuisance problem despite steep (60 deg.) sidewall slopes and bin heaters and vibrators which were included in the original retrofit. Its solution has been one of checking the hoppers shortly after start-up. Hopper plugging has been most severe within 24 hr of a cold start-up.

New precipitators for the third units at each plant include steepened hopper side slopes (from 63 deg. to at least 70 deg.) and double screw conveyers at the bottom as shown in Fig. 2. End slopes in the hoppers have been increased to 90 deg. for the new hoppers, thus avoiding the shallower slope which results at the compound joint between end walls and side walls.

The hoppers have not experienced rusting. This is attributed to hopper heaters designed to maintain a temperature of at least 350°F on the insulated hopper skin, and a skirt of sheet metal around the base of the enclosure of each precipitator which keeps frigid winter

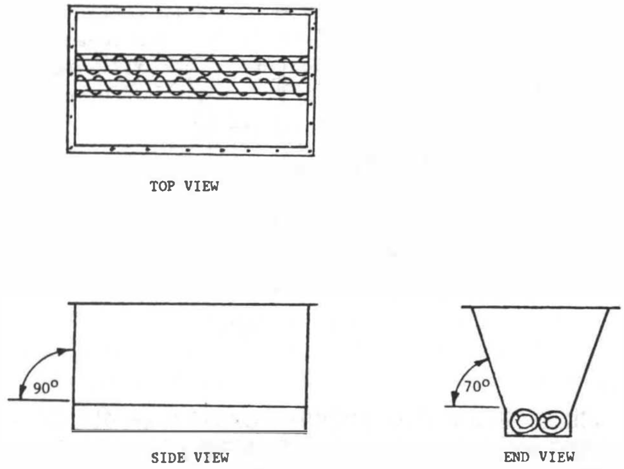

FIG. 2 DOUBLE SCREW HOPPER BOTTOMS
(Note: Increased Side Wall Angles of Repose to Reduce Plugging by Fly Ash)

winds from coming in contact with the hopper insulation and cladding.

CORROSION

A frequent problem experienced with electrostatic precipitators has been corrosion. This has been observed at many major incinerator installations. During the design of this retrofit, the use of a wet conditioning chamber to control temperatures (the unit does not have a boiler for lowering temperatures of the gas stream) was cause for concern. There were suggestions that conditioning water would automatically manufacture acids. However, the maintenance of hot, dry water vapor has prevented the formation of acid on the interior of the precipitator. In particular, "Cor-10" steel collection plates have been essentially unaffected by 5½ years of continuous operation. The light patina of rust which occurred as the modules sat in the field waiting installation is unchanged today.

Careful control of the temperature of the gas stream entering the precipitators at approximately 500°F (260°C), occasionally adjusting up to 560°F (290°C), have also avoided condensing situations within the electrostatic precipitator itself.

However, some rust was experienced at points inside the units where "cold" conditions were allowed to develop. During the presentation of the original paper, it was indicated that double doors had been used throughout the precipitator installation. These were specified with the original construction. The purpose of the double doors was to keep the gas stream away from relatively cool door jambs which are in contact with the outside, ambient air. Inadvertently, however, double doors had not been installed on the outlet transitions of the precipitators at the North Plant. Although the doors were insulated (as were all other doors) the door jams rusted entirely through on both precipitators in this location. This happened within 9 months of start up. The door jambs were replaced, and a ⅛ in. (3 mm) interior steel door was added to keep the gas stream away from the cooler door jambs. Since that time, no additional rust has been experienced on these door jambs.

INSULATION AND CORROSION

As mentioned in the 1984 paper, the insulation of the system was felt to be critical in order to minimize corrosion. In all respects, the insulation has proved adequate—except for the outlet transition cone doors noted above. A thorough inspection of the interior of each electrostatic precipitator has demonstrated that original design theories on this system retrofit were correct. That is, good insulation (in combination with double doors) has kept corrosion from occurring—even in the corners of the unit.

Hopper heaters were included in the hoppers, where their remote location and distance from the active gas stream was thought to provide the opportunity for "cold spots." The hoppers appear to be in sound condition.

One location where manageable rust has occurred is the areas of the side walls through which the rapping mechanisms extend. In order to keep dust out of the pneumatic rapper housings, there are holes in the bottom of the pneumatic rapper housings to allow ambient air to be sucked into the unit (due to negative pressure within the unit.) This incoming air ("purge air") is intended to keep dust from the interior of the precipitator from traveling into the rapper boxes. As expected, the edges of the holes around the rapper are corroding as the incoming ambient air cools the interior gas stream and condenses the acids and water vapor. In the original design, however, this was anticipated, and it is now a matter of managing the deterioration. That is, these steel plates are replaced in a timely fashion as the corrosion eats away at the sacrificial steel material. This is a minor expense, and easily managed with a small amount of attention.

FIELD RAPPING CHANGES

In the original design of the precipitator, mechanisms were provided for the rapping of half of the first field of the unit at one time. In other words, the first field would be rapped on two separate occasions (upper and lower section) in order to provide for a complete rapping of the entire first field. This was true also for the second field and the third field.

As noted above, little black flakes were occasionally formed during poor combustion and collected on the precipitator plates.During rapping of the third field these rare flakes would be transported out the precipitator and up the stack where they posed a problem to the environment. Frankly, during the rapping of the first and second fields, there are short, visible puffs which are legal under the standards of the Ohio EPA. Though legal, even these small puffs are undesirable.

Various methods have been tried to minimize and eliminate puffs. First, the physical rapping arrangement was altered so that only positive plates would be rapped during each rapping of the plates in a specific field. Then, after a time, the negative plates would be rapped. With this change, the first field needed to be rapped on four different occasions in order to completely shake down all of the plates—upper positive, upper negative, lower positive, and lower negative. This reduced the puffs substantially. When the precipitators were installed at the South Incinerator site, in addition to including the crossover duct as part of the original construction, this new rapping system was included. The theory is that particles dislodged from a negative plate can actually become stuck to a positive plate after being reentrained in the gas stream. Most go to the bottom hoppers and very few are blown up the stack.

In addition, at the South Incinerator, a trial rapping mechanism was included on the third field of unit #1. This trial unit was installed at no cost to the County and the manufacturer was allowed to monitor and modify its operation as they felt appropriate. In this unit a hammer would rap each plate individually. Thus, during a full rapping cycle each plate would get one rap and over a programmed period the entire field would be completely rapped. This trial system has eliminated puffs.

The electrostatic precipitators on the new third incinerator lines at each plant include a similar single plate rapping method. It is hoped that with this system the precipitators will not require "bottling up" during rapping of the third fields. The theory here is that dislodged, reentrained flakes will be captured by the adjacent quiet plates of opposite charge instead of passing up the stack. Over a period of time, even light flakes will gradually descend to the hoppers.

DETERIORATION OF EMISSION RESULTS

Opacity has not deteriorated since start-up. In fact the opacity results are better today than they were during the period just after installation. The opacity has improved due to operational and maintenance changes at the plants. One of the biggest improvements was to minimize ash conveyor jambs which used to require breaking the air seal for correction. Staff has operationally determined a direct correlation between excess air leakage into the unit (through such things as temporarily broken air seals on the ash system) and increased opacity in the stack.

For the new incinerators, under construction, Montgomery County specified a larger cross sectional area on the electrostatic precipitators. The larger cross section will slow the gas stream within the precipitators and thereby ensure better particulate catch in line with today's permitting and environmental concerns. The larger cross section also provides some allowance for such undesirable air infiltration as may occur during future operations.

The original four incinerators in Montgomery County are regulated by Ohio EPA below 20% for opacity. Emissions are not visible to the naked eye until 10% opacity is reached. Emissions from both Montgomery County Plants are invisible to the naked eye unless there is some malfunction in the plant. Opacity on each stack is usually held below 10%—as low as 5% on the average.

MASS EMISSION RESULTS

Mass emissions have only been tested on two occasions at the North Incinerator Plant and once at the South Incinerator Plant since the retrofit of these new precipitators due to the excellent opacity conditions. Unfortunately, the Ohio Environmental Protection Agency required some changes in testing procedures during the second tests at the North Plant. Thus, the results are not 100% comparable. By eliminating the trial periods where rapping was required, however, it can be seen from Fig. 3 that emissions did not deteriorate substantially—not even when field rapping was required. The results appear to be substantially worse for precipitator No. 2 at the North Plant during the second set of mass emissions tests, but the poor read-

DATE	RUN#	GR/DSCF	GR/DSCF @ 12% CO_2
11-16-82	NI 1-1	0.0107	0.0237
11-16-82	NI 1-2	0.0108	0.0254
11-16-82	NI 1-3	0.0122	0.0282
	Avg.	0.0112	0.0261
11-19-82	NI 2-1	0.0106	0.0245
11-19-82	NI 2-2	0.0101	0.0233
11-19-82	NI 2-3	0.0120	0.0277
	Avg.	0.0109	0.0252
12-13-83	1-1	0.0130	0.0223
12-13-83	1-2	0.0113	0.0277
12-13-83	1-3*	0.0176	0.0297
12-13-83	1-4	0.0139	0.0238
	Avg.	0.0140	0.0259
	Avg. W/O Rap	0.0127	0.0246
12-15-83	2-1*	0.0260	0.0780 **
12-15-83	2-2	0.0312	0.0624 **
12-15-83	2-3	0.0167	0.0318
12-15-83	2-4	0.0272	0.0502 **
	Avg.	0.0253	0.0556
	Avg. W/O Rap	0.0250	0.0481

* Upper field rapped during test per EPA request.
** Combustion problems (tires and automobile hood).

FIG. 3 PARTICULATE CONCENTRATIONS

ings resulted from incinerator problems, not precipitator conditions.

During the second test periods (approximately one year after start up) on incinerator No. 2 at the North Plant, several refuse charging and combustion problems were encountered which adversely affected emissions.

One major problem was that the feed chute to the incinerator had deteriorated, thus causing erratic refuse charging rates. Large clumps of waste kept falling into the fire in an uncontrolled manner. In addition, at one point during the tests, an automobile hood became lodged between the ignition chamber and kiln. This resulted in over-fire air problems, loss of air lock in the feed chute, and a fire which backed up through the charging hopper. During run No. 2 several tires were inadvertently charged to the incinerator. Normal plant practice is to remove tires and car hoods from the refuse and use landfill disposal facilities, but the presence of an inexperienced crane operator between tests took its toll in errors.

During the second series, four tests were conducted on incinerator No. 1—three during normal operation and one while manually rapping the No. 1 upper field in the ESP. The average stack gas volumetric flow rate was 48,281 dry standard cubic feet per minute (dscfm) (22.8 m^3/s) or 125,565 actual cubic feet per minute (acfm)(59.3 m^3/s). The average stack gas temperature was 436°F (224°C) and contained 33.1% water vapor, 6.5% carbon dioxide, and 14.0% oxygen.

During the second series, four tests were conducted on incinerator No. 2, three during normal operation and one while manually rapping the No. 2 upper field in the ESP. The average stack gas volumetric flow rate was 42,174 dscfm (19.9 m^3/s) or 100,812 acfm (47.6 m^3/s). The average stack gas temperature was 424°F (218°C) and contained 28.1% water vapor, 5.7% carbon dioxide, and 15.0% oxygen.

Electrostatic Precipitators, when well maintained (as has been the case in Montgomery County, Ohio), will provide uniform, long term emission control for particulates.