THE USE OF ELECTROSTATIC PRECIPITATORS ON MUNICIPAL INCINERATORS IN RECENT YEARS

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ABSTRACT

It has been approximately ten (10) years since the first electrostatic precipitator was applied to an incinerator in the United States by the City of New York. Since that time, numerous installations have been made on various types of incinerators. This paper gives a brief description of the majority of the installations as well as actual performance data as compared to manufacturers' guarantees. It is noted that performance guarantees on operating installations have been met in all cases. Operating and maintenance experiences are also cited. The majority of the problems reported had to do with dust removal from the precipitator hoppers. Corrosion has also been experienced where the plant operation is intermittent. It is concluded that precipitators are a viable solution to air pollution resulting from the burning of waste.

INTRODUCTION

Although the commercial application of electrostatic precipitators to industrial and public utility process gases goes back more than half a century, this has not been the case with incinerators. Approximately ten years ago at this same session, a paper was given describing the use of precipitators on incinerators in Europe and suggested that this was a proven, viable solution to the problem. There was, of course, a reasonable amount of skepticism and curiosity which led to a veritable procession of visitors to the better known installations abroad such as Munich, Paris and Düsseldorf. It is the intention here to review briefly what has transpired in the ensuing period.

The theory of electrostatic precipitation is undoubtedly familiar to most of you. An electrode configuration consisting of positive grounded collecting plates and thin section negative discharge wires spaced approximately 127-152 mm (5-6 inches) apart is employed. A high voltage (approximately 30 KV) unidirectional charge is imposed on the negative element and an electrical field is set up between the two electrodes. The dust particles pass between the elements and are charged and transported to the electrode of opposite polarity. Periodically, the precipitated material must be removed from the electrodes and this is accomplished by applying a vibratory or impact force to dislodge the dust. Figure 1 portrays the basic components involved and Figure 2 gives an idea of the arrangement of a typical full size precipitator.

The first full scale installation of a precipitator on a municipal incinerator in the United States was made by the City of New York. Units were installed almost concurrently on two (2) 250 ton refractory type furnaces; one at the South Shore plant and the other at Southwest Brooklyn. Figures 3 and 4 show diagrammatically and actually what
the South Shore installation comprised. Details of these and other subsequent installations are as follows:

**CITY OF MONTREAL, QUEBEC**

**Des Carriers Incinerators**

This was the first large European type installation on the North American continent. Installed in 1970, it consists of four (4) incinerators, each rated at 300 TPD followed by waste heat boilers.

The precipitators are 21 gas passages in width and consist of two (2) electrical fields in series, each 7.32 meters (24 feet) high. The pyramidal dust hoppers discharge into a hydraulic dust removal scheme. The units are rated at 190,400 m³/h (112,000 acfm) at 280°C (536°F) and removal efficiency was guaranteed to be 95 percent of the inlet loading or a maximum of 0.20 grams/N m³ (0.0875 gr/scf).

Actual tests conducted in 1970 indicated, at a gas flow of 140,250 m³/h (82,500 acfm), an average collection efficiency of 99.45 percent, on an inlet loading of 5.59 grams/N m³ (2.43 gr/scf) resulting in a residual of 0.030 grams/N m³ (0.0133 gr/scf or 0.0203 #/1000 # gas). The average of eleven tests made in 1971 indicated an inlet loading of 2.85 grams/N m³ (1.24 gr/scf), an outlet of 0.0183 grams/N m³ (0.0799 gr/scf) or (0.1266 #/1000 # gas) with an efficiency of 93.5 percent. Deterioration of performance based on more recent tests was determined to be the result of required maintenance. Due to prolonged outages, corrosion of the internals had resulted in sub-par performance.
CITY OF NEW YORK

South Shore Incinerator, Unit #4

This installation consists of a 250 TPD refractory furnace installed in 1952 burning typical municipal waste. The gases are discharged at approximately 871°C (1600°F) and pass to an evaporation cooling tower of the upflow type where cooling to 260°C (500°F) takes place prior to entering the precipitator. The tower was 4.58 meters (15' - 0") inside diameter and 18 meters (59' - 0") high. An ID fan was installed between the precipitator and existing stack.

The precipitator installed in 1970 consists of a single unit with 23 gas passages, 7.32 meters (24 foot) high field height, and two (2) electrical fields in series. The casing is of Cor-ten steel and the internals are mild steel. Dust removal consisted of a drag scraper arrangement discharging into a screw conveyor.

Rated gas volume was 231,200 m³/h (136,000 acfm) at 315°C (600°F). Inlet loading was specified to be 4.27 grams/N m³ (3.5 #:/1000 #: gas) at 50 percent excess air with a removal efficiency of 95 percent or 0.213 grams/N m³ (0.175 #:/1000 #: gas) at 50 percent excess air. The average of ten tests indicated a gas volume of 163,291 m³/h (96,054 acfm), inlet loading of 2.04 grams/N m³ (1.67 #:/1000 #: gas) and an outlet of 0.129 grams/N m³ (0.106 #:/1000 #: gas).

An electrical fire in the early days of operation resulted in an extended outage which caused severe internal corrosion of the precipitator. After repairs and return to service, the unit performed satisfactorily until corrosion of the cooling tower resulted in system outage in 1973.
CITY OF NEW YORK

Southwest Brooklyn Incinerator

There are four (4) 250 TPD refractory type furnaces at this location with inclined travelling grates installed in about 1952. About six years ago, one of the furnaces was equipped with a downflow evaporation cooling tower and precipitator. The gases emanating from the furnaces are at approximately 370,600 m³/h (218,000 acfm) at 898°C (1650°F) and are cooled by high pressure water sprays to about 287°C (550°F) before entering the precipitators. After treatment in the precipitators, the gas passes through an induced draft fan installed at the time the precipitator was installed. At present, the three (3) additional units are being installed.

The original precipitator placed in service in 1970 consisted of 27 gas passages with a single electrical field 7.5 meters (25 feet) high. The unit was constructed of A-36 carbon steel throughout and two (2) trough hoppers discharged the collected material through motorized double flap valves into screw conveyors.

Each of the four (4) precipitators was designed to handle approximately 246,500 m³/h (145,000 acfm) of gas at 287°C (550°F) and 15 percent moisture by volume. The inlet loading was specified to be 4.27 grams/N m³ (3.5 #/1000 # gas) at 50 percent excess air and the precipitators are to remove 95 percent of the entering particulate resulting in an outlet loading of 0.213 grams/N m³ (0.175 #/1000 # gas) at 50 percent excess air. The average of ten tests conducted three and a half
years after start-up by the EPA dry method on the
first unit indicated 210,800 m$^3$/h (124,000 acfm),
an inlet loading of 49.9 kg/hr (110 #:/hr) and an
outlet of 3.19 kg/hr (7.03 #:/hr) resulting in an
average efficiency of 93.6 percent. The emission
level is well below allowable.

The first precipitator operated well for the first
several years although there were some initial prob­
lems with corrosion of spray nozzles in the cooling
tower which were corrected by a change in ma­
terial. Corrosion of the collecting surfaces, undoubt­
edly accelerated by weekend outages, necessitated
replacement of those in 1975.

DADE COUNTY, MIAMI, FLORIDA

Northeast Incinerator

This 300 TPD furnace was installed with reci­
procating grates in 1970. At the onset, there had
been considerable public resistance to the plant
which subsequently subsided.

The precipitator has 48 gas passages and a single
electrical field, 9.15 meters (30 feet) high. It is rated
to handle 486,200 m$^3$/h (286,000 acfm) of gas at
299°C with an inlet loading of 4.27-4.89 grams/N
m$^3$ (3.5-4.0 #: per 1000#) of gas at 50 percent ex­
cess air. An outlet of 0.5 #:/minute was required
resulting in an efficiency of 95.6 percent. Gas cool­
ing is somewhat unique in that it is accomplished
partially by air dilution 870°C to 482°C (1600°F
to about 900°F) and the balance by water evapora­
tion consisting of four (4) high pressure multiple
spray heads located in a refractory lined section of
the inlet flue. This was due to the need for optical
clarity at the stack at all times and fear of a steam
plume with 100 percent water cooling. Actual tests
indicated a gas volume of 338,300 m$^3$/h (199,000
acfm), an inlet loading of 0.445 grams/N m$^3$ (0.1935
gr/scf) and an outlet of 0.0623 grams/N m$^3$ (0.0272
gr/scf). This was well within guarantee level.

The unit performed well after correction of
some initial problems with faulty construction re-
resulting from improperly fabricated collecting plates and wire frames. The only problem experienced with the unit subsequently was with dust removal which was corrected by the provision of larger dust discharge valve and elimination of a pug mill type dust wetting and conveying system.

CITY OF BRAINTREE, MASSACHUSETTS

This location was equipped with two (2) 120 TPD water wall furnaces and waste heat boilers. Installed in 1970, the precipitators are 12 gas passages in width, with a single electrical field, 4.58 meters (15 feet) high. Each unit was rated at 54,400 m³/h (32,000 acfm) at 315°C (600°F) with a specified inlet loading of 6.10 grams/N m³ (5 #/1000 # gas.) The performance required was 93 percent removal or an outlet of 0.198 grams/N m³ (0.086 gr/scf.) Actual performance tests indicated 40,500 acfm of gas, an inlet loading of 44.2 kg/hr (97.5 #/hr). and an outlet of 7.93 kg/hr (17.5 #/hr.) This is equivalent to 0.108 gr/scf. The only problem reported was with hopper pluggage. This was corrected by a modification of the hopper baffles.

TOWN OF HEMPSTEAD, LONG ISLAND

Oceanside Incinerator

This installation consists of one (1) 300 TPD refractory furnace equipped with a waste heat boiler which delivers 241,060 m³/h (141,800 acfm) of gas to the precipitator at 315°C (600°F). The inlet loading was specified as 4.6 grams/N m³ (2.0 gr/scf) and a removal efficiency of 98 percent was required resulting in an outlet of 0.092 grams/N m³ (0.04 gr/scf). The precipitator installed and operating in 1974 comprises 28 gas passages and two (2) electrical fields in series, each 7.5 meters (25 feet) high and approximately 2.29 meters (7'-6") deep, with a dust hopper under each field. The shell is fabricated of Cor-ten whereas the internals are mild steel. The collected material discharges through rotary valves into screw conveyors. Actual performance tests in 1971 indicated inlet loadings of 2.55 and 2.33 grams/N m³ (1.11 and 1.015 gr/scf) and outlets of .069 and .053 grams/N m³ (0.03 and 0.0229 gr/scf) resulting in efficiencies of 97.3 and 97.74. As a matter of interest it was found that the paper char content of the ash represented approximately 55 percent of the total and that it was removed at an efficiency level of 97-98 percent. The majority of the Ringleman readings taken were 0.5. Additional tests conducted in 1975 indicated that the outlet loadings were somewhat higher than the original tests. Investigations involving maldistribution of gas due to pluggage of gas distribution plates, possible recirculation of collected ash, and general condition of equipment was being investigated.

COMMUNANTE URBAIN DE QUEBEC

Quebec City, P.Q.

This location comprises four (4) incinerators followed by waste heat boilers. Each unit is rated for 272,160 kg/hr (600,000 #/hr). steam production.

Each precipitator was installed to handle 170,000 m³/h (100,000 acfm) at a temperature of 260°C (500°F). Inlet burden was specified at 16.2 grams/N m³ (13.3 #/1000 # gas) at 50 percent excess air and removal requirement was stipulated to be 0.244 grams/N m³ (0.2 #/1000 # gas) at 50 percent excess air resulting in an efficiency of 98.5 percent. The precipitators are 23 gas passages in width with two (2) electrical fields in series, each 7.32 meters (24'-0") high. Operation has been reported to be satisfactory since startup in 1974 and efficiency tests indicated performance
to be within guarantee limits. Outlet loadings of 0.219 grams/N m³ (0.095 grlscfd) were reported.

**DISTRICT OF COLUMBIA, WASHINGTON, D.C.**

**Incinerator #5**

This plant, installed in 1972, comprises six (6) 250 TPD refractory type furnaces with grates. Gas cooling is accomplished in a spray chamber where a multiplicity of sprays in banks are timer controlled. Mechanical collectors were provided ahead of the precipitators.

Each precipitator has 25 gas passages, two (2) electrical fields in series, each 7.5 meters (25 feet) high. Pyramidal hoppers were provided. Rated gas volume was 222,360 m³/h (130,800 acfm) at 287°C (550°F). Inlet loading was specified at 4.27 grams/N m³ (3.5 # per 1000 # gas) at 6 percent CO₂ and required residual was 0.46 grams/N m³ (0.2 gr Iscfd) at 12 percent CO₂. Actual test data indicated 218,783 m³/hr (128,696 acfm) an inlet loading of 0.693 grams/N m³ (0.3010 gr/scfd) and an outlet of 0.133 grams/N m³ (0.0578 grlscfd).

The only problem stemmed from continual initial pluggage of the ash removal system. This was corrected by installing the wet type removal system similar to Montreal.

**CITY OF HARRISBURG, PENNSYLVANIA**

This plant consists of two (2) 360 ton per day systems, each equipped with a reverse reciprocating stoker. A water cooled inclined chute feeds the refuse to the stoker. The multi-pass boilers are of a welded membrane waterwall design with integral economizer. Steam production is 54,932 kg/hr (120,000 lbs/hr) per system based on a refuse heating value of 2,780 KcAL/KG (5000 btu/lb). Furnace exit temperature is approximately 870°C (1600°F) and economizer exit 260°C (500°F).

Each precipitator is designed to handle approximately 187,000 m³/hr (110,000 acfm) at 274°C (525°F) and to remove 95 percent of an inlet loading of 4.27 grams/N m³ (3.5 # per 1000 # gas) resulting in an outlet loading of 0.213 grams/N m³ (0.175 # per 1000 # dry flue gas) corrected to 50 percent excess air. Each precipitator comprises 29 gas passages and 2 electrical fields in series each 7.5 meters (25 feet) high and approximately 2.29 meters (7' - 6") deep with a dust hopper under each field. The shell is fabricated of Cor-ten whereas the internals are mild steel. The dust discharges directly into inclined screw conveyors. No dust valves are used.

Average of eight (8) tests conducted in May of 1973 indicated the following performance:

<table>
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<tr>
<th>Furnace #, #/1000</th>
<th>Inlet Loading</th>
<th>Outlet Loading</th>
<th>Efficiency</th>
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<tbody>
<tr>
<td># gas grams/N m³</td>
<td>1.98</td>
<td>0.075</td>
<td>96.2</td>
</tr>
<tr>
<td># gas grams/N m³</td>
<td>2.41</td>
<td>0.091</td>
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<tr>
<td></td>
<td>1.74</td>
<td>0.085</td>
<td>95.0</td>
</tr>
<tr>
<td></td>
<td>2.12</td>
<td>0.104</td>
<td></td>
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</tbody>
</table>

Additional tests in December, 1974, confirmed that the equipment is performing within guarantee and meeting applicable codes. The only operating problem reported had to do with some insulator failures in the early stages of operation. This was remedied and has not recurred.

**CITY OF PHILADELPHIA, PENNSYLVANIA**

**Northwest Incinerator**

Two (2) 325 ton refractory type furnaces at this location burn municipal refuse and each emits approximately 510,000 m³/h (300,000 acfm) at 676°C (1250°F). The gas is cooled in evaporative cooling and drying towers to the precipitator entry temperature of 287°C (550°F) and a gas volume of 372,810 m³/h (219,300 acfm). The dust loading was specified as 3.24 grams/N m³ (1.41 grains per standard cubic foot or 2.6 #/1000 # dry gas) with an efficiency requirement of 98.1 percent resulting in a residual of 0.023 grams/N m³ (0.01 grain per actual cubic foot).

The precipitator casing was specified as 4.76mm Mayari-R (3/16") with trough type dust hoppers with 305 mm (12") wide drag conveyors. Precipitator internals are of mild steel. Each precipitator has thirty-two (32) gas passages and two (2) electrical fields in series each 10 meters (33'- 0") high and approximately 3.36 meters (11'-0") deep.

Actual performance tests indicated outlet loadings 0.039 grams/N m³ (0.0168 grlscfd) and 0.057 grams/N m³ (0.0247 gr/scf). The installation has been in service for almost two years and no problems are reported.

The cooling towers are 3.84 meters (12'-8") I.D. with 178mm (7") of castable refractory and 25.4mm (1") insulating board. The outer shell is 6.35 mm (1/4") Mayari-R. The design air volume for the nozzles was 68 N m³/h (40 scfm) at 55 psig. Spray nozzles consist of eight (8) 10.3 GPM nozzles at 100 psig and two (2) 16.4 GPM at 60 psig.
HEMPSTEAD, LONG ISLAND

Merrick Incinerator

This installation consists of four (4) refractory furnaces followed by waste heat boilers.

The precipitators are 36 gas passages wide, one field deep 7.5 meters (25 feet) high. Rated gas volume for each unit is 251,600 m³/h (148,000 acfm) at 315°C (600°F) with an indicated dust loading of 1.15 grams/m³ (0.5 gr/acf). Actual performance tests averaged 0.223 grams/m³ (0.097) gr/acf at the inlet with 0.36 grams/m³ (0.0158 gr/acf) outlet loading. The units were guaranteed for 95 percent removal or an outlet burden of 0.0575 grams/m³ (0.025 gr/acf). The only problem reported by the supplier was broken suspension insulators. This can normally be corrected by an adequate purge air system to prevent fouling of the insulators.

CITY OF BALTIMORE, MARYLAND

Incinerator #4

Two (2) 300 TPD continuous feed, travelling grate refractory wall furnaces burning municipal refuse are involved. Gases are cooled by water sprays from 870°C (1600°F) to 287°C (550°F) resulting in approximately 30 percent by volume of water. Each precipitator handles 282,200 m³/h (166,000 actual cubic feet) of gas with an inlet loading of 3.45 grams/N m³ (1.5 grains per standard dry cubic foot) at 6 percent CO₂ and a required efficiency of 95 percent resulting in a residual of 0.069 grams/N m³ (0.03 gr/scf) at 12% CO₂.

The precipitators, installed in 1975, comprise two units each with 34 gas passages, 9 meters (30 foot) high collecting surfaces and four (4) electrical fields in series.

The precipitators are furnished with Cor-ten housings and mild steel internals. Trough hoppers with drag conveyor type dust removal were specified as well as hopper heating.

CITY OF HONOLULU, HAWAII

Waipahu Incinerator

Two (2) 300 TPD furnaces are installed at this location which burn municipal refuse and emit 323,000 m³/h (190,000 acfm) of gas at 232°C (450°F). Inlet dust loading was specified at 0.299 grams/m³ (0.13 gr/acf) with a required efficiency of 95.0 percent resulting in an outlet of 0.0138 grams/m³ (0.06 grains).

Each precipitator will comprise 23 gas passages, three (3) electrical fields in series, each 7.32 meters (24 feet) high.

The precipitator housings were specified to be fabricated of A-242 steel with A-36 internals. Two (2) trough type hoppers will be provided per unit with 229 mm (9") screw conveyors and rotary discharge valves. Hopper vibrators and high-low level probes will be provided as well as electric heaters to provide 70 watts per square foot.
CITY OF LEXINGTON, KENTUCKY

Two (2) 350 TPD water wall furnaces are to be installed at this location using municipal refuse, natural gas or #2 oil as fuel. The solid waste given as the design base was type 3, 3336 KcAL/Kg (6000 HHV Btu/#) with an analysis of 36 percent carbon, 4.9 percent hydrogen, 30 percent oxygen, 0.9 percent nitrogen, 0.1 percent sulfur, 15 percent ash and 13 percent moisture. The precipitators are each rated to handle 238,000 m³/h (140,000 acfm) of gas at 287°C (550°F) with 11.3 grams/N m³ (5.0 grains per standard cubic foot) inlet loading. Guaranteed efficiency is 99.0 percent resulting in an outlet of 0.115 grams/N m³ (0.05 gr/scf) with 12 percent CO₂ in the gas.

The precipitators will be fabricated of mild steel with pyramidal hoppers which are equipped with vibrators, ash level indicators, electric heaters and motorized double dump valves. Each unit will consist of 26 gas passages, with three (3) electrical fields in series, each 7.32 meters (24 feet) high.

The above descriptions do not comprise all of the American units. We are aware of additional installations in Ogden, Utah; Cape Fear, North Carolina; Stamford, Connecticut; Toronto, Ontario; Nashville, Tennessee; Saugus, Massachusetts; and Rochester, N.Y. Details of these were not available from the precipitator suppliers.

SUMMARY

There have been approximately 36 electrostatic precipitators installed at 15 locations in the past eight years. These have included application to a variety of incinerator designs and firing practices. New plants have been equipped and installations have been made to facilities which have been in use for many years. Both water wall and refractory type furnaces are included. To the best of our knowledge, none of the operating units have failed to meet guaranteed performance. In general operational problems have usually been associated with dust removal. Pluggage of dust conveying equipment is not an unusual situation on any precipitator application. Solutions usually involve provision of over-sized components such as dust valves and conveyors, heating and vibration of hoppers or conversion to a hydraulic type of conveying system. From a maintenance viewpoint, it becomes obvious, particularly with operations which are not continuous, that corrosion of the mild steel components may be expected after a few years of operation. The most practical solution to this is an auxiliary heating system to keep the precipitator above the dew point during periods of outage. When evaporative cooling towers are used, they should be fully, rather than partially, refractory lined to prevent corrosion.

CONCLUSION

In conclusion, there has been substantial successful experience in the application of electrostatic precipitators to municipal incinerators in recent years. The system designer and owner-operator can feel confident of success on future applications.