Control of Air and Water Pollution from Municipal Incinerators with the Wet-Approach Venturi Scrubber

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DISCUSSION by John H. Fernandes, Combustion Engineering, Inc., Windsor, Conn.

This is an excellent paper, and Mr. Ellison and his company are to be commended for the timely release of such valuable engineering data. Scrubbers have been applied to incinerators in the past, but this proven operation based on the Chemical Construction Co.'s experience with scrubbers is most valuable. They should be commended for their very forward-looking approach to this matter.

I have only a few brief comments to make with respect to this paper.

1. I note that a minimum of slurry blowdown is used and blowdown is presented in such a way that the reader is led to believe that in the future an incinerator plant of this type would require no liquid blowdown. All the material except the dry residue would be recycled within the system itself. I question this, since my experience has been that a certain amount of blowdown is required or the concentration of very fine particulate matter increases in the water slurry leading to re-evaporation and re-entrainment in the effluent gases. This increase in fine particulate loading can reduce the overall gas cleaning efficiency.

2. Regarding the ceramic coating applied to the scrubber on the 73rd Street Incinerator, where does the brick lining end? It would appear that it is continued to the Venturi inlet, and from the Venturi through the moisture separation area a fiberglass reinforced polyester is used wherever the gas or liquid contact the surface. I am not certain of this because the paper did not illustrate a lining. I would appreciate some further discussion.

3. Polyester fiberglass reinforced coating is very susceptible to deterioration by excursions of temperature above 300 F. What assurance is there that there will not be a temperature excursion above the 300 F permissible with this type of lining? The non-homogeneous nature of the refuse indicates that there will be temperature peaks coming from the incinerator. How is this accommodated? What redundancy is built into the spray and control system that assures against temperature excursions in the scrubber?

4. Would the author care to be a little more explicit as to the coatings used? Was any consideration given to some of the new paint-on type coatings or enamel coatings suggested by other researchers in this field?

In closing, once again I would like to compliment the author and his company for a very timely release of engineering data. I would appreciate answers to the foregoing questions, since I too believe that a scrubber is one of the most compact and potentially one of the best solutions to incinerator gas cleaning available to the designer today.

DISCUSSION by William T. Clark, Day and Zimmerman, Inc.

This paper presents the interesting features of a difficult installation of a wet scrubber on an existing municipal incinerator. It is unfortunate that the details of the materials of construction are not presented, as their application to incinerator facilities is unique. The opportunity to evaluate the performance of the specific materials of construction over a long period of time (more than one year) would aid the industry in establishing the basic requirements of a good design. Misinterpretation of the general description – "internal linings of fiberglass reinforced polyester and acid brick" – may result in a misapplication of these materials by others.

The statement regarding elimination of tempering air, combined with a later reference to – "a higher weight flow of flue gas through the original dry collectors than through the wet scrubber" – must be interpreted to indicate that large quantities of tempering air were induced in the original installation. An analysis of flue gas conditions indicates that the
moisture in the refuse, the moisture in the combustion air and the moisture from gas cooling adds to the original weight of dry flue gas for a given refuse analysis.

<table>
<thead>
<tr>
<th>Per Cent CO₂ in Flue Gas</th>
<th>Leaving the Furnace</th>
<th>Gas Cooled For Dry Collector</th>
<th>Saturated Gas Leaving Wet Scrubber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>Pounds DFG/lb Refuse</td>
<td>19.1</td>
<td>12.8</td>
<td>9.7</td>
</tr>
<tr>
<td>Pounds H₂O/lb DFG</td>
<td>0.048</td>
<td>0.067</td>
<td>0.079</td>
</tr>
<tr>
<td>Average Flue Gas Temp. °F</td>
<td>970</td>
<td>1360</td>
<td>1710</td>
</tr>
<tr>
<td>Pounds Wet Flue Gas/lb Refuse</td>
<td>20.0</td>
<td>13.6</td>
<td>10.5</td>
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<td></td>
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</table>

These figures indicate that the weight of gas passing through a wet scrubber may increase in weight by as much as 40 percent depending upon the operating conditions. The total weight appears more dependent upon the excess air requirements than upon moisture evaporation. The equipment sizes and fan horsepower must be selected for the most critical condition. In general, the induced draft fan horsepower will be quite significant because of the high weight of gas and the high static pressure requirements of a wet scrubber of this type.

It is interesting to note that the calculated average furnace exit temperatures are significantly lower than normally recorded for these CO₂ levels. Thermocouple locations and gas stratification in existing facilities appear to be responsible for this discrepancy.

The energy requirements for subcooling of the scrubber effluent gases must be considered if this method of plume control is being evaluated. The exit gas temperature must be above the highest wet bulb temperature for the area in order to obtain reasonable operation of the scrubber column and cooling tower. A stack plume can be anticipated except on very hot dry days.

Consider a 250 ton-per-day incinerator operating at 200 percent excess air (6 percent CO₂) with saturated gases leaving the scrubber at 165 °F and then cooled to 100 °F by means of a scrubber. This lowering of the saturation temperature requires the removal of 0.31 lb of water per pound of dry flue gas. The associated enthalpy reduction is 372 Btu's per pound of dry flue gas. Assuming a 20 °F rise in the cooling water temperature requires a flow of 10,000 gpm of cooling water for this 250 ton-per-day incinerator. The flow will vary inversely with the temperature rise. This flow of water with the associated pumping horsepower, cooling tower fan horsepower, and capital expense for equipment would tend to indicate that the plume transfer from a stack to a cooling tower is not a realistic approach where nothing else is gained.

Consideration must also be given to gas absorption in the high volume of quench liquid, the need for chemical control of the circulating water, and the possibility of thermal pollution if the water is returned directly to a river, lake or stream.

Mr. Ellison's discussion of the significance of the test procedure in determining the presence of condensable materials in the flue gas stream should not be taken lightly. The present definition of Particulate Matter in the City of New York - Local Law No. 14 - reads as follows:

Particulate Matter; Any liquid, other than water, or any solid which is so finely divided as to be capable of becoming wind-blown or being suspended in air.

This type of definition is becoming quite prevalent and unfortunately is being applied to codes that were established using test procedures that measured only dry filterable material at the gas sampling conditions. The presence of condensable material cannot be ignored, but certainly the allowable emissions standards should be based upon test data that properly considers the potential presence of this material.

DISCUSSION by R. Kopita, Peabody Engineering Corp.

Mr. Ellison has given a very interesting preliminary study of the results of a Venturi type wet scrubber operating on a Municipal Incinerator. The data presented in this paper coupled with the data available from the installation of other high efficiency low pressure drop units, can perhaps answer some of the questions that have been raised on the use of high efficiency wet scrubbers.

In examining the data, we have attempted to correlate CO₂ with residual loading with the thought that high CO₂ would produce an off gas containing more sub-micron particulate. We have been able to establish such a correlation on scrubbers of the Peabody type operating on various municipal incinerators. Using the data from Table No. 2, we have not been
able to make this correlation; however, if we strike up the high and low results, we then can make this correlation.

We would like to have Mr. Ellison indicate if he has temperature data to go along with the CO₂ data. That is, the higher the operating temperature, the higher the CO₂. We also would like Mr. Ellison’s opinion as to what increase of energy input would result in residual loading of 0.1 lb per thousand lb of flue gas corrected to 12 percent CO₂, with CO₂ readings of 7 percent or a furnace temperature of 2200 to 2400 F.

We concur with Mr. Ellison, that if gas phase pollutants and condensables are to be considered as particulate matter, then the use of a wet scrubber is almost mandatory. It should be pointed out, that any dry type of collector would not have the capability of removing condensables or gas phase pollutants.

In regard to water pollution, several papers are being presented at this session, and we concur with Figure No. 5, that such a system is now being used on several incinerator scrubbers of our design. One particular job on a 300 ton per day incinerator has a total water discharge of 50 gpm.

The question of steam plume has been raised many times and we do not feel that any regulation should be considered which would cause the rejection of a wet scrubbing system, solely on the basis of steam plume. If this line of thinking is followed then every atmospheric cooling tower in the country should be shut down. Also many in the audience have seen large utility boilers firing gas, and emitting steam, from their stacks on a cold day.

If we were to sub-cool the gases as indicated by Mr. Ellison, and such systems have been proposed and designed, water rates approaching 2,500 gpm would be required for a 250 ton per day furnace. A previous discusser has indicated that a 20 deg rise in the water temperature would be a good design point; however, we would like to point out that a well designed gas cooling tower would raise the water temperature within 10 deg of the saturation temperature of the water or to about 160 F. The 250 gpm rate is predicated on this type of cooling tower.

The recuperative stack approach would be more desirable and preliminary studies have indicated that an additional capital expenditure of approximately $50,000.00 to $75,000.00 would be required for a 250 ton per day furnace.

**AUTHOR'S CLOSURE**

Blowdown of scrubbing slurry liquor is essential in that it provides a means of disposing of collected gaseous and solid contaminants and of limiting the concentration of dissolved and suspended solids in the closed-loop recirculating scrubbing liquor. Because of the unique design of the Wet-Approach Venturi Scrubber, uniform liquor homogeneity is achieved by effective control of liquor line/carrier velocity throughout the system. Therefore, the approximately 20 gal of scrubbing liquid that can be taken up in the cooling and wetting of the residue from one ton of refuse is a sufficient rate of liquor blowdown to maintain slurry concentration within practical design limits for this type of liquid handling system.

Fiberglass-reinforced polyester linings should be overlain with acid brick wherever the gas cleaning system designer’s good engineering judgement indicated potential for erosion by suspended solids in the scrubbing liquor. Use of this plastic scrubber construction places a strong emphasis on availability of emergency water to protect the system against loss of scrubbing liquor flow. The New York City East 73 Street Municipal Incinerator Venturi scrubber system installation incorporates such an emergency water system, totally independent of the scrubbing liquor circuitry, designed for automatic activation if and when the scrubber outlet temperature exceeds 190 F.

The reduction of saturated gas temperature at the scrubber outlet from approximately 165 F to 100 F offers means of reducing both steam plume emission and scrubber I.D. fan operating horsepower. This energy saving is accomplished by condensing 0.31 lb of water per lb of dry gas and by lowering of the gas temperature. The specific volume is reduced from, 27.7 to 15.1 cu ft per lb dry gas. This volume reduction of approximately 46 percent will contribute directly to fan operating horsepower savings. In addition, gas density is increased from 0.055 to 0.069 lb per cu ft, which is advantageous in the selection of the I.D. fan, generally permitting a reduction in fan size and in capital cost. Packed tower gas cooling sections are usually designed for a cooling water temperature rise of 40 F or greater, the principal objective being a maximum cooling water design temperature of approximately 95 F from the induced draft cooling tower. It should also be noted that the water vapor condensed from the 165 F saturated gas stream will significantly reduce total fresh water make up requirements of the system.

The CO₂ concentration of the scrubber outlet gas at 73 Street does not provide a consistent basis for correlation of gas cleaning performance in view of the variable quantity of air introduced by the air-
bleed damper in the automatic control of furnace draft. It is anticipated that New York City's comprehensive program for testing of venturi-scrubber performance during 1970 will provide comprehensive emission data and correlation of operating conditions with gas cleaning efficiency.