# SEWAGE SLUDGE INCINERATION AT THE MANCHESTER, NEW HAMPSHIRE WATER POLLUTION CONTROL FACILITY

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**Discussion by:**

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This paper is an excellent documentation of the operational problems associated with the Multiple Hearth Furnaces (MHFs) at the Manchester WPCF. Further, the paper provides convincing arguments that the use of the new Fluid Bed Incineration System (FBIS) will solve most (if not all) of the problems that were experienced. Presumably the authors did not yet have sufficient test information available at the time of the writing of this paper to discuss the performance of the new FBIS, because this would have been quite an interesting addition to the paper. In particular, some performance questions would be as follows.

(a) Is it possible to operate satisfactorily with less than 30% excess air?

(b) Is the temperature increase in the freeboard above the bed as expected?

(c) What emissions resulted from the operation

(d) Have any bed agglomerations been observed?

Comments on the text are the following:

(e) It is not clear by the description of the fluidizing tuyeres how backsifting of sand into the tuyeres during shutdown will be eliminated.

(f) It is clear that the dome water spray will provide a method of controlling the freeboard exit temperature with a rapid response time. It is not as clear why the water spray nozzles are required in the bed itself. Couldn't the bed temperature be reduced by reducing fuel oil feed, or perhaps by bypassing air around the air preheater? What is the limiting bed temperature?

## AUTHORS' REPLY

Data from the Acceptance Testing of the Fluid Bed Incineration System (FBIS) are now available and are presented in Tables 1, 2, and 3. In general, the FBIS performed quite well and easily passed its design criteria. Emissions of particulate, carbon monoxide, total hydrocarbons, nitrogen oxides, and sulfur dioxide were all very low. The FBIS has been in intermittent operation (dependent on sludge availability) since April 1994, and it has proven to be a much more stable and easily operable system than the MHFs. It should be emphasized that most of the operating problems encountered with the Manchester MHFs (i.e.. smoky and odorous emissions) were attributable to the variability of the sludge feed. The variability was due to poor mixing and blending of the primary and secondary sludges prior to dewatering. The FBIS was readily able to handle the variability in the sludge feed and still achieve stable and essentially complete combustion.

(a) Fluid bed incinerators combusting sewage sludge generally are designed for 30–45% excess air. Operation at less than 30% excess air may result in incomplete combustion and may adversely affect emissions. The Manchester FBIS has always been operated at approximately 40% excess air. Operation at 30% or less excess air has not been attempted.

(b) The difference in temperature between the bed and freeboard represents the amount of freeboard burning. A certain amount of freeboard burning is inevitable. Generally, less than 200°F of freeboard burning is desirable, and 250–300°F of freeboard burning is considered excessive. The Manchester FBIS had bed to freeboard temperature differentials of 234–250°F, indicating a significant but not excessive amount of freeboard burning.

(c) Air emissions data are presented in Table 3.

(d) Through June 16, 1994 the FBIS had over 600 hr of

**TABLE 1**
**OPERATING CONDITIONS — ACCEPTANCE TESTING OF FBIS**

| *Parameter* | *Test 1* | *Test 2* | *Test 3* |
|---|---|---|---|
| 1. Date | 14-Jun-94 | 15-Jun-94 | 16-Jun-94 |
| 2. Time | 0930 - 2230 | 1100 - 2100 | 1100 - 1930 |
| 3. Duration (hour) | 13 | 10 | 8.5 |
| 4. Filter Cake | --- | --- | --- |
| a. Loading (wet lbs/hr) | 17600 | 17934 | 18017 |
| b. Total Solids (% wet) | 15.31 | 15.16 | 14.12 |
| c. Volatile Solids (% dry) | 78.58 | 80.47 | 80.57 |
| d. Loading (dry lbs/hr) | 2695 | 2719 | 2544 |
| e. Higher Heating Value (Btu/lb V.S.) | 12634 | 12159 | 12536 |
| 5. Scum | --- | --- | --- |
| a. Loading (wet lbs/hr) | 414 | 404 | 414 |
| b. Total Solids (% wet) | 57.73 | 58.83 | 45.97 |
| c. Volatile Solids (% dry) | 97.00 | 97.06 | 96.23 |
| d. Loading (dry lbs/hr) | 239 | 238 | 190 |
| e. Higher heating Value (Btu/lb V.S.) | 16968 | 16809 | 16555 |
| 6. Bed Temperature (°F) | 1345 | 1345 | 1345 |
| 7. Reactor Exhaust Gas Temperature (°F) | 1596 | 1589 | 1579 |

## TABLE 2
## PROCESSING OPERATING PARAMETERS — ACCEPTANCE TESTING OF FBIS

| Parameter | Test 1 | Test 2 | Test 3 | Average | Design |
|---|---|---|---|---|---|
| 1. Date | 14-Jun-94 | 15-Jun-94 | 16-Jun-94 | --- | --- |
| 2. Flue Gas Flow Rate (dscfm) | 8568 | 8634 | 9130 | 8777 | > 7066 |
| 3. Flue Gas Oxygen Content (% dry) | 6.1 | 6.8 | 6.8 | 6.6 | 4.5 - 7.5 |
| 4. Fuel Oil Consumption | --- | --- | --- | --- | --- |
| a. Actual (gph) | 45.6 | 47.7 | 45.4 | 46.2 | --- |
| b. Design (gph) - based on actual conditions | 50.6 | 58.0 | 70.2 | 59.6 | --- |
| 5. System Process Temperatures | --- | --- | --- | --- | --- |
| a. Recuperator Outlet Air Temperature (°F) | 1221 | 1203 | 1193 | 1206 | > 1200 |
| b. Windbox Inlet Temperature (°F) | 1210 | 1194 | 1184 | 1196 | > 1180 |
| c. Windbox Temperature (°F) | 1187 | 1170 | 1160 | 1172 | > 1150 |
| d. Average Bed Temperature (°F) | 1345 | 1345 | 1345 | 1345 | --- |
| e. Reactor Exhaust Temperature (°F) | 1596 | 1589 | 1579 | 1588 | 1500 - 1600 |
| 6. Scrubber Exit Temperature (°F) | 70 | 72 | 71 | 71 | < 110 |
| 7. Ash Volatile Content (% dry) | 0.43 | 0.46 | 0.30 | 0.40 | < 2 |
| 8. Impingement Tray Water Suspended Solids (mg/l) | 4.4 | 0.0 | 0.0 | 1.5 | < 50 |
| 9. System Heat Release (mm Btu/hr) | 36.64 | 37.11 | 34.45 | 36.07 | > 32.0 |
| 10. Average Sand Consumption (lbs/hr) | --- | --- | --- | 21 | < 60 |

## TABLE 3
## EMISSIONS TEST RESULTS — ACCEPTANCE TESTING OF FBIS

| *Offgas Analysis* | | | | | |
|---|---|---|---|---|---|
| 1. Date | 14-Jun-94 | 14-Jun-94 | 14-Jun-94 | Average | Design |
| 2. Particulate (lbs/dry ton) | 0.12 | 0.16 | 0.34 | 0.21 | < 0.75 |
| 3. Particulate (grains/scfd) | 0.0027 | 0.0036 | 0.0065 | 0.0043 | < 0.0143 |
| 4. Carbon Monoxide (ppm corrected to 7% O2) | ND (1) | 8.8 | ND | 2.9 | < 100 |
| 5. Total Hydrocarbons (ppm corrected to 7% O2) | 0.8 | 0.9 | 0.9 | 0.9 | < 10 |
| 6. Nitrogen Oxide (ppm corrected to 7% O2) | 22.1 | 25.6 | 22.0 | 23.2 | < 300 |
| 7. Sulfur Dioxide (ppm corrected to 7% O2) | 11.1 | 16.4 | 17.60 | 15.00 | < 50 |
| 8. SO2 @ Scrubber Inlet (ppm corrected to 7% O2) | 124.9 | 123.3 | 91.5 | 113.2 | |
| 9. SO2 Removal Efficiency (%) | 91.1 | 86.7 | 80.8 | 86.8 | |
| 10. Opacity (%) | 0.0 | 0.0 | 0.0 | 0.0 | < 20 |

(1) ND - Not Detected

operation and no indication of bed agglomeration has been observed.

(e) The tuyeres are cone shaped with flat, disc-shaped tops. The flat plate on top has numerous slits which have been punched into the plate. The opening of each slit is approximately the same diameter as the finer grain sand in the bed. The slits are oriented such that the fluidizing air must flow horizontal to the plate to pass through the slits. According to the manufacturer, it is the size and orientation of the slits which cause the sand to bridge and prevent back-sifting when the unit is shutdown.

(f) It was found during preliminary operations that the reactor-side-wall water spray nozzles and the water injection guns in the bed were not necessary, and they have been taken out of service. In general, the bed temperature is always very stable, varying approximately ±5°F, even though the sludge feed rate and feed characteristics vary significantly. The stability of the bed is undoubtedly due to its large thermal inventory, and hence large thermal inertia. Although the bed temperature is stable, the freeboard temperature can vary considerably from 1450 to 1600°F during transient feed conditions.

**Discussion by:**

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The paper was well written. I have only three comments:

(a) In the third paragraph following the heading "Short Term Improvements," I believe the word "off" should be changed to "from" to make the sentence read, "The clinkers would break from the rabble teeth and get rabble through the furnace."

(b) In the second paragraph following the heading "Particulate Emissions," it was mentioned that the feed rate dropped, corresponding to a hearth loading rate of 4.48 wet lb/hr–ft$^2$. The writer should go further and explain that a multiple hearth is roughly sized using 8–10 wet lb/hr-ft$^2$, thus showing that the capacity/loading is about one-half of what would be expected.

(c) Lastly, in the first, second, and fourth paragraphs following the heading "Fluid Bed Incineration System at Manchester, NH WPCF," the following design criteria are given:

| | |
|---|---|
| • Design feed rate: | 43 DTPD |
| • Percent solids of sludge feed: | 22% |
| • Reactor diameter at the bed: | 14 ft |

We would not expect a 14-ft diameter fluid bed incinerator to have this capacity.

## AUTHORS' REPLY

(a) Your rewording is correct.

(b) Multiple hearth incinerators are typically sized to handle 8+ wet lb/hr-ft$^2$ and thus the 4.48 wet/lb-ft$^2$ loading rate indicates that the capacity of the MHF had been reduced to about half of what would be expected.

(c) The 14-ft diameter is at the bottom of the bed. The top of the bed and the freeboard are 17 ft in diameter. During the Acceptance Testing, the solids content of the sludge feed averaged only 14.86%, significantly less than the design solids content (22%). However, as shown in Table 1 and 2, the FBIS was able to meet its capacity requirement in terms of total Btu input; namely, minimum of 32 MM Btu/hr.

**Discussion by:**

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(a) Gas spatial velocity in the freeboard is 3 ft/sec, which is very high. What is the sand loss (in terms of % bed inventory per 24 hr)?

(b) You have a very special hot wind box with a metallic distribution plate. What is the material used and what is the pressure loss across the plate?

## AUTHORS' REPLY

(a) During the Acceptance Testing, the FBIS was loaded above its design total Btu input of 32 MM Btu/hr. As a result, the freeboard superficial space velocities ranged from 3.6 to 3.8 ft/sec which are quite high. However, the sand loss was 21 lb/hr, which is not excessive. Since the total bed contains approximately 123,000 lb of sand, the sand loss in 24 hr is approximately 0.41% of the total bed inventory. Sand loss is also largely dependent on the type of sand used. At Manchester, the sand used is Olivine, sp. gr. 3.2–3.4.

(b) Yes, this is one of the first hot windbox fluid bed incinerators using a metallic distribution plate with such a high preheated air temperature (1200°F). The air distribution ducts are constructed of Type 310 stainless steel and the tuyeres are constructed of Type 330 stainless steel. The pressure drop across the tuyeres is 20–25 in. w.c. at design conditions.

## ERRATA

In the "Appendix — Design Criteria of Fluid Bed Incineration System," under the heading "WWTP Solids Loadings," change the third and sixth lines to read as follows:

| | U.S. Units | S.I. Units |
|---|---|---|
| Initial Year: | | |
| Scum (dry) (7 day basis | 7550 lb/week | 3420 kg/week |
| Design Year: | | |
| Scum (dry) (7 day basis) | 12,030 lb/week | 5460 kg/week |