THE IMPORTANCE OF PROPER LOADING OF REFUSE FIRED BOILERS

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Discussion by

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The authors of this paper must be congratulated for handling a very sensitive subject in a factual and forthright manner. It is good that they have taken the time to tell the technical community “the rest of the story.”

The Nashville Thermal facility was the first plant in the United States to use modern water wall mass burning boilers to supply, on an uninterrupted basis, both steam and chilled water to a major city, and it has been accomplishing this feat ever since it went into commercial operation over ten years ago. The authors have reported on the cooperative spirit between the owners, operators, consulting engineers and equipment suppliers that has made this possible. In the process, about a million and a quarter tons of refuse have been consumed.

This paper provides a good summary overview of the Nashville Thermal operation and performance. The authors have recognized the dilemma of every resource recovery facility in attempts to keep costs down, revenues up and at high assured reliability. Their sharing of financial information should help other resource recovery planners better evaluate their own plans. In this view, we would be interested in the authors’ comments on the feasibility of electrical cogeneration at Nashville under today’s PURPA environment.

The Nashville Thermal operators should be complimented for their contribution to the state-of-the-art of U.S. resource recovery technology. Their plant, including the boiler and stoker, used U.S. technology throughout. Because of the critical role it played, much has been written about the plant in the media and technical press. Maintenance is now at a manageable level and equipment availability appears good as a result of the shared loading between the boilers, an improved overfire air system, and a modified stoker system. The industry must, however, strive for ever better performance recognizing that the severity of service in handling and burning refuse and trash will always be a challenge. The heterogeneity of the fuel cannot entirely be economically overcome to make it burn like good clean fossil fuels. Thus, continuing improvements in technology must be sought. The Nashville Thermal experience provides an excellent springboard for this endeavor.

Discussion by

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As one who has observed the experience at Nashville unfold and as one who tried to assist in an ad hoc research committee, it is indeed a pleasure to hear this success story, especially because of the near brink-of-disaster in the past. It always seemed to me that the design was sound except, of course, for the initial selection of the particulate control equipment.

I believe the authors and the Nashville management are to be complimented for bringing this story to this conference. It is particularly gratifying that the authors cited Discussions to a paper on Nashville Thermal at the
1980 ASME National Waste Processing Conference. This conference is unique in that the papers are preprinted and various discussors like myself have a change to preview the papers to make comments like mine and my colleagues and also for the dialogue that will continue from the audience. What the Discussions did was provide a written documentation, which they apparently read. They not only heard but they listened.

I had the good fortune to review this paper when initially submitted and I revelled in encouraging it for publication. As a manufacturer, I'm pleased to see that a user listened and implemented the manufacturer's recommendation. I applaud the authors and Nashville Thermal for their courage in coming before the waste-to-energy community and telling us this story. However, in again reviewing the waste feed rate and steam capacity derating as reported in the paper, there is some confusion about the level at which they presently operate the plant. Perhaps a summary chart would help clear up this issue. It would also be of value to hear from the manufacturers about the new ratings.

Discussion by

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The experiences at Nashville Thermal are of particular interest to everyone because it was the first large refuse fired district heating/cooling utility plant in the U.S.A. associated with a major inner city renewal program and incorporated an imaginative quasi-public ownership management arrangement.

This comprehensive overview by the authors of the Nashville Thermal experience with their two municipal refuse fired boilers is a desirable contribution to the understanding of cause and effect relationships of equipment and their operations.

It is also recognized that the authors could not include all the events in their recapitulation and analysis.

However, there are several events which should be mentioned: the significance expense encountered to remedy frequent waste avalanching from the charging chute discharge with its consequent major upset to the furnace conditions. This unpredictable avalanching problem could have been a major contributor to the referred to "temperature and flame excursions" and their subsequent consequences.

If sufficient air is present for the fuel and sufficient draft is available for the combustion gases, steaming at higher capacity (within the stack opacity limits) results in higher air flow through the grates and, therefore, the grates may be cooler and less thermally stressed than they might be at say 50-75% capacity. Suitably located thermocouples should be indicative of this cause and effect. Of significance is the fact that the original grate metallurgy left much to be desired. After higher alloy castings were employed at considerable expense, stoker maintenance was reported to have dropped dramatically. Then the predominant cause for failure was reported to be mechanical—abrasion and wear of most of the moving components of the grate and its mechanism.

The basic functions of a stoker is to convey controlled quantities of fuel into the furnace to satisfy the design heat release, provide undergrate combustion air uniformly and in the proper quantities to suit each stage of combustion, and to convey inorganic residue out of the furnace. Apparently, the original stoker mechanisms and grate plates had great difficulty in bearing up under the 24 hr day-in-day-out continuous duty required.

A well mixed, highly turbulent furnace environment must be provided in the high temperature flame basket of the furnace to insure burnout of the gases and avoid long lazy flame (lapping) impingement on the pressure parts. The concept of additional strategically placed overfire air jets is not a radically new approach for completing combustion of the volatile gases and arresting flame excursions. This was introduced as a remedial approach when the furnace problems were first encountered, but was only partially embraced until the recent renovation.

The steam generator is a Btu conversion device and each of the refuse fired units at NTTC were reported to have been designed and rated for converting 180,000,000 Btu/hr from mixed municipal refuse (360 TPD, 15 TPH @ 6000 Btu/lb) into 109,000 lb of steam. Reverting the fuel quality to the more realistic value of 4500 Btu/lb would require 20 tons/hr or 480 TPD for generating steam at the rated continuous capacity. With either fuel quality basis, the heat release rates in the furnace and on the grates would be the same. Admittedly, 530 TPD would be a 10% increase in duty, but this additional energy conversion margin is not uncommon and certainly not exorbitant. . . . the waste "quantity" would be still greater for the same Btu input if the waste quality degenerates to 4000 Btu/lb or less. . . . the fans were apparently sized accordingly, and surely this extent of calorific variability of mixed municipal refuse must have been anticipated.

Derating these units from 109,000 lb steam/hr down to a normal continuous capacity of 50,000 lb steam/hr appears to be a radical remedial solution. Will adequate furnace temperatures be sustained at these light loads? Steam temperature? It was startling to learn that in spite of this 54% derating, the system availability was only 81% for the first 10 months at this modest duty. (From 480 TPD @ 4500 Btu/lb, 180,000,000 Btu/hr, to the new firm
rating of 200 TPD per unit and at 81% availability provided only 162 TPD of capacity; actual reduction in refuse processing capacity is then from 480 TPD to 162 TPD which is ± 66%). It would be interesting to learn the causes of the outages during this period and the steps taken to improve the availability to that currently enjoyed! Perhaps reliable operation will now be sustainable for longer periods! Can it be surmised from this experience that this type of firing and furnace should have been more than twice as large for the 180 million Btu input originally required albeit the glowing B&W-Bozeka 1975 performance tests?

Many owners would find any derating a burden and derating to this extent can be intolerable if alternate refuse disposal is just not available. If the derated capacity is tolerable in Nashville, why is adding another processing train being considered? Will the new equipment match that now installed?

Quoting out of context can be considered self-serving. It is unfortunate the authors did not refer at all to the original technical paper by the (former) plant manager, but selected only specific statements made by some of the discussers of his paper. The authors also didn’t mention that the general failure of the original installation could be attributed at least in part to the contingent engineering expediences resorted to by the facility designers and the compromised diligence by the underwriters engineers to permit the project to proceed within the underestimated funds from the Bond issue. It was only through the persistence and resourcefulness of plant management, the subsequent design engineers retained, and the confidence by the board who arranged for additional funds to permit the renovations and additions necessary for finally providing for a technically, operationally and environmentally viable district heat/cooling mixed municipal refuse burning steam generating plant.

These circumstances remind us once again not to compromise what we have learned through long experience regarding design, construction and operation for the sake of economic expediency. One way or another the piper eventually will be paid in operation encumbrance, money, recrimination and perhaps even total failure of the facility.

We may not always know what to do but surely we should have learned what not to do.

AUTHORS’ RESPONSE

To Herbert I. Hollander

We have several comments with regard to Mr. Hollander’s discussion paper, specifically with certain points raised on the second page.

The first deals with Mr. Hollander’s comments in the first paragraph on page 2 concerning the heating value of the solid waste where you state the desirability of “reverting the rating to the more realistic form at 4500 Btu/lb. . .” Nashville Thermal has conducted testing on the heating value of the solid waste and the results indicate an average heating value in the range of 4800-5000 Btu/lb.

There are several reasons that the assumed heating value in Nashville is higher than the “more realistic form at 4500 Btu/lb.” The first is due to the fact that Thermal receives relatively “select” waste at the plant. Most of the waste collected in the immediate adjacent commercial area, consisting largely of paper from office buildings, is delivered to the facility. Furthermore, Nashville is a major publishing center in the south, and as such there is a large percentage of paper in the waste stream. Further, since Thermal processes only approximately 450 tons of solid waste per day, and the Nashville Public Works Department estimates that approximately 1500 TPD is generated in the City, Thermal is in the relatively unique position of having to handle and incinerate only the most processable portion of the waste being generated in Nashville.

Regarding the “rerating” of the boilers, the original design of the stokers per the stoker manufacturer was a rating of 300 TPD based on typical refuse having a heating value of 4500-5000 Btu/lb. During the design and bidding stages, this rating was increased to 360 TPD based on 6000 Btu/lb refuse.

The final design of the stoker loading according to the boiler manufacturer’s performance sheet, was 30,000 lb of refuse per hour, which was equivalent to 360 TPD. The stoker manufacturer advised that this was the maximum design loading of the stoker regardless of the Btu content of the solid waste. Any shortfall in stoker-fire Btu’s to achieve rated steam output was to be made up by firing No. 2 fuel oil.

On the foregoing basis, the maximum steam output when firing 4500 Btu waste without supplementary fossil fuel would be approximately 80,000 lb/hr.

The boiler manufacturer’s performance summary showed the following:

<table>
<thead>
<tr>
<th>Type of Fuel</th>
<th>Steam Lvg.</th>
<th>#2 Fuel Oil</th>
<th>#2 Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superheated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4500 Btu/lb</td>
<td>113,000</td>
<td>30,000</td>
<td>2,500</td>
</tr>
<tr>
<td>Refuse A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3600 Btu/lb</td>
<td>120,000</td>
<td>30,000</td>
<td>4,700</td>
</tr>
<tr>
<td>Refuse B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6000 Btu/lb</td>
<td>109,000</td>
<td>30,000</td>
<td>None</td>
</tr>
<tr>
<td>Refuse C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2 Fuel Oil</td>
<td>135,000</td>
<td>None</td>
<td>9,400</td>
</tr>
</tbody>
</table>

Therefore, we do not agree with Mr. Hollander’s statement on page 2 that 530 TPD was a 10% increase in duty. Rather, the 530 TPD was a 77% increase in duty when compared to the original 300 TPD design or 47% increase when compared to 360 TPD.
We also question his statement in the second paragraph concerning the "derating" of the units from 109,000 lb/hr to 50,000 lb/hr for extended periods of time and that Thermal planned to operate each of the two boilers simultaneously at an average load of approximately 50,000 lb/hr, with the loading to be increased to approximately 100,000 lb/hr during periods of peak demand. Thus, the units were not "derated" to 50,000 lb/hr. Rather the preferred plan of operation was to operate each unit at an average of 50,000 lb/hr in order to meet the then average steam load on the system of 100,000 lb/hr. It is important to keep in mind that Thermal generates steam in response to the energy requirements of its heating and cooling customers. There is a significant difference between Mr. Hollander's statement and the actual method and plan of operation.

In light of the foregoing, we wonder if Mr. Hollander will still find it "startling to learn that in spite of this 54% derating, the system availability was only 81% for the first ten months at this modest duty." Most of the solid waste resource recovery projects with which we are familiar assume an annual plant availability in the range of 75-85% for planning purposes. For the fiscal year ended May 31, 1984, Thermal Management reported that it experienced plant availability of 85.6% for its two-boiler operation. We might add that this level of plant availability was achieved at the same time that 97.4% of Thermal's fuel requirements were met by the incineration of solid waste. This is not what we consider "modest duty."

The major problems with plant availability which have been experienced in the past year are related to the stoker-grate system. Thermal is currently planning to undertake a program of major improvements to the incinerator grate and grate-drive system. Thermal proposes to replace the grate system with a high chrome alloy in order to deal with the problems with grate failures. Modifications are also to be made to the drive system in order to improve reliability by strengthening the linkages and improving the bearing points.

We also take issue with Mr. Hollander's statement that: "Perhaps reliable operation will now be sustainable for longer periods!" Exclamatory statements of this sort serve no good purpose, particularly when one reviews Thermal's level of operation during the past two years. As we have already mentioned, Thermals' level of annual plant availability approaches that of any other resource recovery project with which we are familiar and the percentage of solid waste burned as fuel is very high. Furthermore, Thermal has provided uninterrupted heating and cooling services to its customers in downtown Nashville for the past two years. Thermal's actual performance shows that it is sustaining "reliable operation."

Regarding the final paragraph of Mr. Hollander's paper, we would agree with him that quoting out of context can be considered self-serving, just as mis-stating the facts as presented in papers can be misleading. If you had carefully reviewed the cited paper of 1980, one would notice that much of the information presented in our paper was presented in the 1980 paper. It is important to keep in mind that the purpose of our paper in 1984 was to show readers that proper loading of boilers is very important. It was not the purpose of the paper to go back and dredge up the past and point accusing fingers at various individuals. We cited the statements of the discussors of the 1980 paper because they were the equipment manufacturers for the boilers and stokers installed at Thermal, and their concerns with the level of operation served as the starting point for our investigation of the loading of the plant. We are of the opinion that these discussion papers were not quoted out of context. We saw no good purpose in including the entire discussion papers of 1980 as a part of our paper in 1984, and we included only the concerns of the equipment manufacturers, since it is our opinion that they have a better feel as to how their equipment should be operated than any other party.

We are also surprised that Mr. Hollander would take exception to the fact that, we "didn't mention the general failure of the original installation could be attributed at least in part to the contingent engineering expediencies resorted to by the facility designers and the compromised diligence by the underwriter's engineers to permit the project to proceed within the underestimated funds from the Bond issue." As was stated in the second paragraph of our paper, the purpose of this paper was not to go into the history of Nashville Thermal as we felt that: "There is little to be gained by dredging forth the past, beyond stating that it is extremely important for all parties to undertake proper and adequate planning in the early stages of project development, even when it appears that on is making a direct application of prior experience." We would ask Mr. Hollander, what good purpose is served by going back to 1972 and demonstrating the underestimation of capital and operating expenses by the then underwriter's engineers? Anyone familiar with Thermal knows the mistakes that were made in 1972, and we all enjoy marvelous hindsight when looking back twelve years into the past when there was very little historical information on solid waste resource recovery projects on which the facility designers and underwriting engineers could reply. The purpose of this paper is to build on the past and to provide assistance to planners in 1984 in developing their project.

Mr. Hollander seems to have adopted the attitude in
his paper that we are somehow attacking the former plant manager, the subsequent design engineers, and the Board of Directors. A more careful reading of our paper will indicate that this is not the case at all. In fact, much of our paper addresses the institutional problems which assailed Thermal management during the late 1970's and tries to place into context the complex nature of the many different problems which the plant encountered, including pressure from governmental sources to increase solid waste disposal production, while at the same time, pressure from energy customers to reduce the cost of heating and cooling services. We believe that Mr. Hollander has missed the entire tone of our paper, as well as its stated purpose. The title is “The Importance of Proper Loading of Refuse-Fired Boilers.” We have to believe that anyone as knowledgeable of the solid waste industry as Mr. Hollander would agree that proper loading of boilers is important. We also stated in the summary that, “a somewhat less obvious lesson deals with the determination by policy makers and plant superintendents concerning the primary function of a solid waste resource recovery facility. Is the principal goal to dispose of the maximum amount of solid waste possible, or is it to generate energy in the most cost-effective method possible? . . . Policymakers should answer these types of questions prior to the design of the facility so that the engineers are able to take such matters into account in the design of the project.”