EMISSION ESTIMATES FOR MODERN RESOURCE RECOVERY FACILITIES

ROBERT D. GETTER
Metcalf & Eddy, Inc.
Wakefield, Massachusetts

Discussion by

Floyd Hasselriis
Forest Hills, New York

The author is to be commended for offering a method for deriving estimates of emissions for modern mass-burn facilities intended to avoid either overestimating emissions to such an extent that they will be perceived as a threat to health, or to underestimate them so that the vendor might not be able to meet permit conditions.

Estimating emissions is an extremely intricate and difficult task, especially when most of the data is based on tests of old or existing facilities which do not have the dry scrubber/baghouse pollution control systems. The author states that some vendors are now willing to guarantee maximum emissions of trace metals.

Before getting into the emissions side, I would like to support the statement that "combustion and emissions calculations can easily be combined in a spreadsheet computer format."

There is an urgent need for these calculating procedures to be standardized, and if the standards are in place or implied, to reveal them to the perhaps unsuspecting reader.

A specific case in point is the question of defining emission factors in "pounds per ton of MSW." Published data do not mention the heating value of the ton referred to. Over the course of years the 'reference' heating value has increased from 4500 Btu/lb to 5000 and now 5600 Btu/lb as cited by the authors. This has led to great confusion and inconsistency between numbers published in various data bases, permit applications and combustion and emission calculations.

It is entirely appropriate to calculate the emissions of planned facilities based on the anticipated annual average heating value and waste composition, using a suitable Dulong-type formula (see paper by Buckley and Domalski in this conference). This makes it possible to calculate the composition and quantity of the gaseous discharges on an actual basis (for modeling and fan sizing purposes), as well as on various dry bases to correspond to permit requirements. The use of scrubbers has made these calculations even more important, due to the large amount of moisture added.

These rational calculations can then be used as part of the acceptance and compliance tests to back-calculate the heating value of the MSW, and its approximate composition, especially moisture, based on stack test and boiler data.

The conversion of ppmv to lb/ton requires an assumption of the heating value of the MSW, which has been omitted from the author's Table 3, an unfortunate and common practice. How would a reader know what the reference heating value is if the table were taken out of its context? The mention that 173,308 dscf/ton was used is the only clue.

The regulated emissions are readily calculated, based on permit requirements, and can be guaranteed by full service operators or consultants who can pass these requirements on to their vendors or suppliers to the extent that means of controlling these emissions are available. CO can be controlled by furnace temperature, oxygen supervision and provision of computer controls of combustion air and waste feed. The acid gases can be controlled by the process, lime addition and temperature control; particulate control by baghouses is well understood and can be adjusted, if necessary, by operational procedures. NO_x can be limited, if necessary, by combustion modification, gas recirculation or ammonia injection.

Dioxins are controlled by maintaining furnace temperatures and oxygen and properly mixing combustion gases. They are also condensed and captured by acid gas controls which cool the gases below 300°F.

Finally, heavy metals are highly variable in MSW. Their fate depends on many factors, such as combustion temperature, furnace gas velocities, presence of HCl or chlorine in the gases, the amount of particulate, opportunities to form deposits on the boiler tubes or in the emission controls, and the temperature profiles from furnace to stack.

It is not possible to separate the effects of these factors. However, there are discernable differences between heavy metal emissions of different technologies. Specifically, starved-air incinerators do not volatize the heavy metals to the same extent as excess-air incinerators due to reduced bed temperatures, nor do they lift as much particulate for the metals to condense on. RDF furnaces have a different effect on particulate carryover, and generally have much higher particulate loadings than mass-burn incinerators.

In view of these factors, it is extremely difficult to predict uncontrolled emissions of these technologies because it is not possible to determine whether the differences are due to the waste composition or the technology. However, tests of similar technologies provide a data base which gives some indication of the variation in MSW composition.

A major factor in heavy metals control is the performance of the acid gas scrubber and baghouse combination in collecting not only acid gases but heavy metals. The Quebec tests by NITEP have demonstrated the specific effect of temperature on SO_2 and HCl. As temperatures approach 250°F, removal efficiency of these acids exceeds 90%. All of the metals are removed down to trace levels even at 400°F, seemingly independent of inlet loadings. Only mercury was sensitive to scrubber temperature: test data shows clearly that at temperatures below 285°F mercury removal was over 95%.

In view of the above, and the statement by the author that his paper presents emissions estimates for modern mass-burn facilities equipped with scrubber/baghouse pollution control systems, it is incongruous for him to use data from facilities with ESP emission controls without scrubbers or other means to reduce the stack temperatures to the condensing temperatures of the acid gases and mercury.

The data base which the author used in Table 5 for the heavy metals is from a wide range of plants. Three, with the highest emissions, had wet scrubbers without boilers; Braintree was operating badly when tested. The rest are plants with ESPs, with the exception of Tsushima and Marion which have scrubber/bag-houses. ESPs do not control emissions as effectively as baghouses, even when they are equipped with scrubbers, at least unless the stack temperatures are reduced to the level where condensation of acid gases and mercury can take place.

The author states that the ESP data were used "due to general lack of data from newer facilities, particularly arsenic, cadmium, chromium and nickel. However, use of the data in the form of concentrations of metal on controlled particulate matter should correct for differences between particulate control efficiencies of the older facilities compared to new facilities." This method can be used to correct the emission factor obtained at a low particulate emission level, such as 0.004 gr/dscf, attained by baghouses, for permitted levels of, for instance 0.010 gr/dscf, provided that the trace metals on particulate were measured at a plant with similar emission controls.

I would like to point out that while the particulate control efficiencies can be used as a conservative correction, the percent of metals on the particulate is not a constant. While the lead found on particulate of some ESP plants was several percent, with improved ESP or baghouse efficiencies the percent of lead fell to a small fraction of a percent.

The use of the mean plus one or two standard deviations is approximately the same as using the highest of the available data. When these values came from old plants, they distort the mean as well as the mean plus standard deviation, and overestimate the emissions. To avoid this, all efforts should be used to use data from plants having scrubber/baghouses.

The standard deviation as a percent of the mean (coefficient of variance) is an important indicator of the data. A given plant may have a CV of less than 15%, and a group of similar plants less than 25%. When the CV exceeds this, there are probably more than one population present, one of the plants may be operating substantially differently from the others, or the MSW is different.

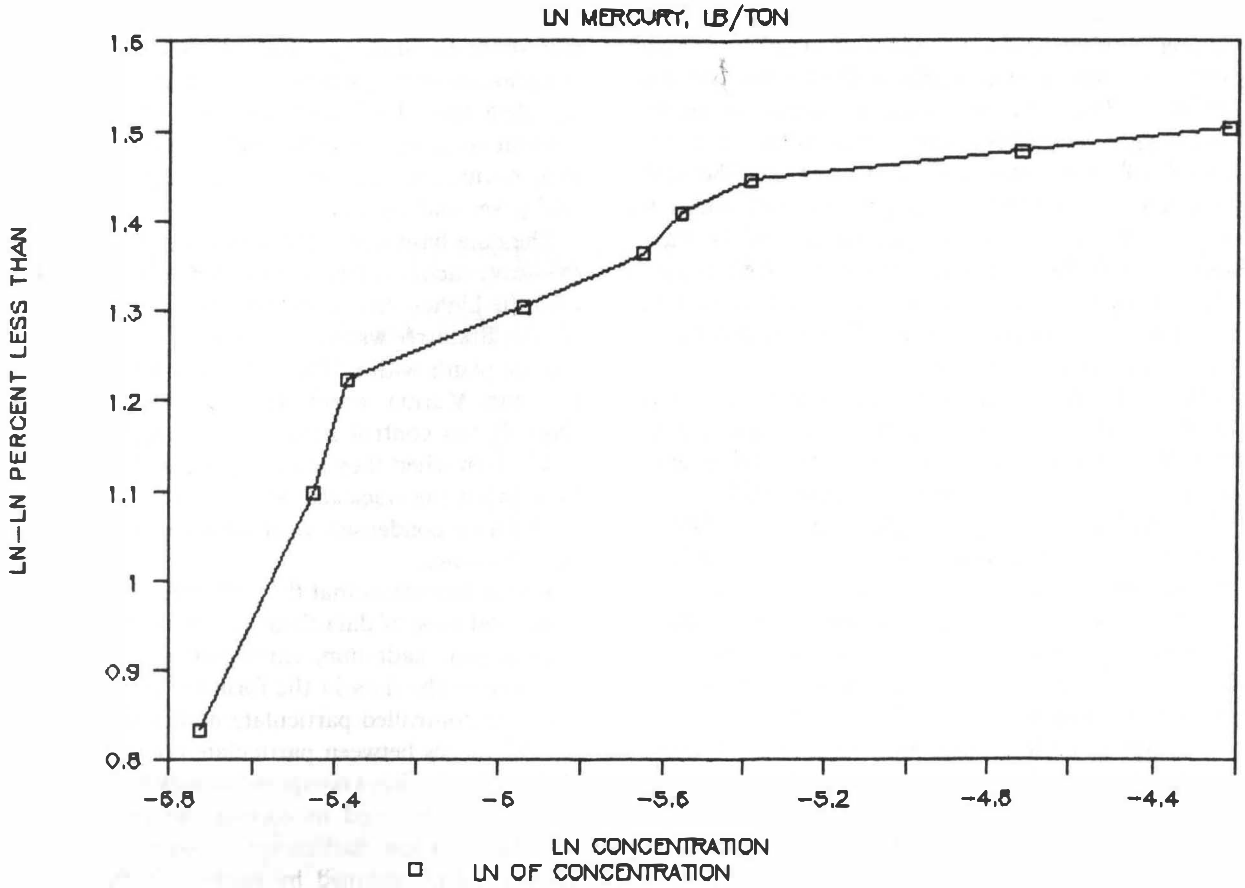

FIG. 1 CONCENTRATION VERSUS PERCENT LESS THAN

The author has not included the data from the NITEP pilot scrubber tests at Quebec City. While it can be argued that this data may not be typical of a full-scale plant, this data is remarkably consistent with data from Marion County, Commerce and Tsushima, all of which have spray-dry scrubbers and baghouses.

When statistical analysis is used to interpret data, the data should be examined to determine if it is bimodal, that is, whether or not it includes more than one population. When this is done, it becomes obvious that the plants with scrubbers are a distinctly different population from those with ESPs. Therefore the standard deviation of the scrubber plants should be used, not the standard deviation for all plants including ESPs.

This point is made more evident when the data is plotted on log probability paper, which shows consistent data as a straight line, as compared with curved or wavy lines which indicate more than one population. As seen in Figure 1, showing dioxin toxic equivalents, you could gamble on getting any one of all the plants in the world, with a wide range of emissions (range 0.1 to 9), or you can select only plants with scrubbers, a range from 0.1 to 0.5 ng/m^3 EPA toxic equivalent. One standard deviation in this group represents two times the mean.

A final point: emission estimates are used for several purposes. For health risk estimates, where averages for the year are appropriate, the mean or average test values would be appropriate if the data reflects normal operation of a typical plant. The standard deviation may be used when looking at the estimated health risk itself.

The situation is entirely different when considering emission factors which will be written into a permit to operate, and which can be used to shut down the

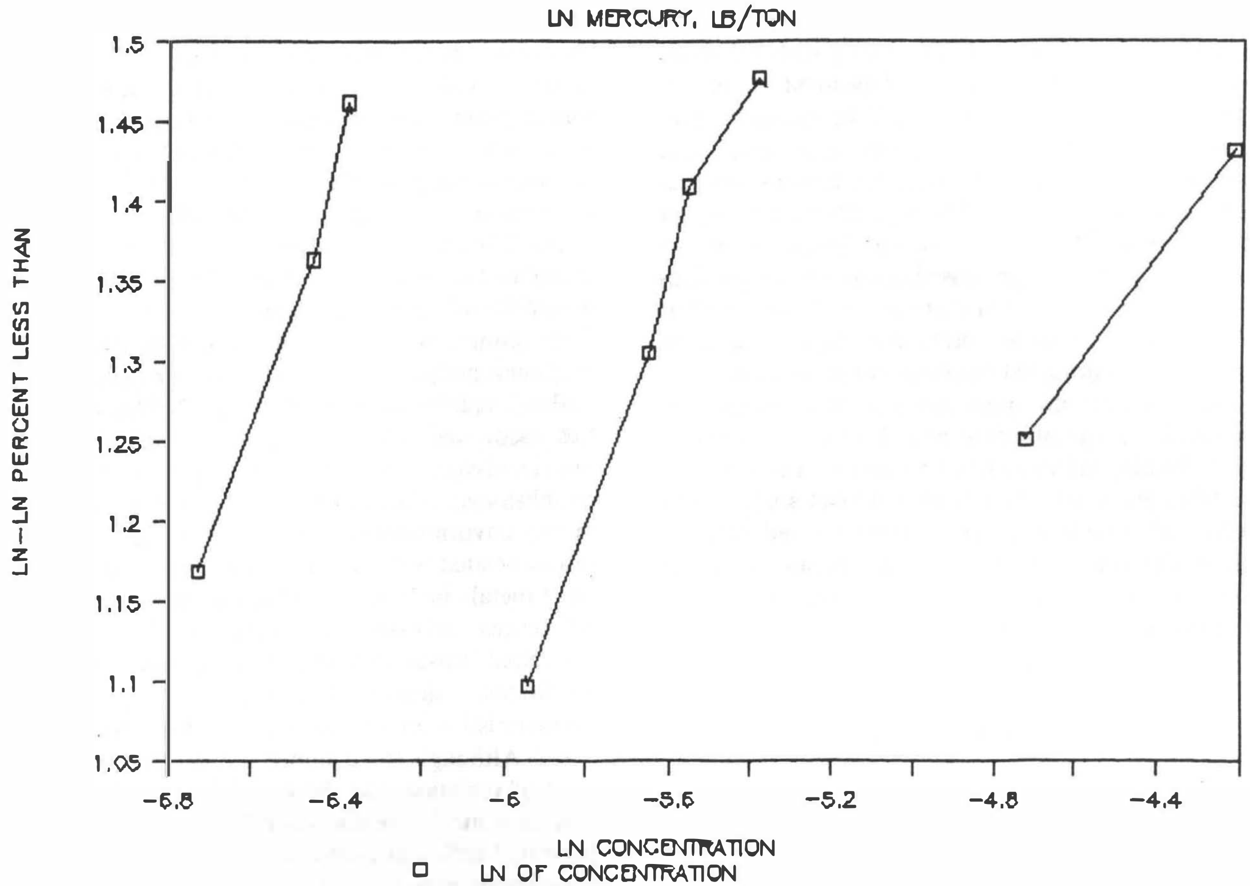

FIG. 1 (Cont'd)

plant if they are not met. For this purpose, much more conservative estimates must be used to set 'not to exceed' limits. For a vendor to guarantee such limits, he must have confidence that they really will not be exceeded as long as the plant is operated properly, and the waste is normal waste.

In conclusion, a vendor cannot guarantee anything which is not within his ability to control. Modern technology can control emissions of priority pollutants, including acid gases, CO and particulate by operating the plant properly. He cannot control the refuse which comes in beyond looking it over. However, scrubber/baghouse systems operated at suitable temperatures are effective in removing organics and heavy metals, so the operator need only supply lime and maintain the right temperatures to assure required performance.

Discussion by

Mitchell Wurmbrand
Environmental Risk Limited
Bloomfield, Connecticut

The author has done an admirable job of describing a scientifically sound method designed to generate emission factors for a resource recovery facility. In the introduction to his paper, the author states "This paper presents a method for deriving preliminary emission estimate on a not-to-exceed basis using statistical analysis of existing test data and State of New Jersey emission guidelines." However, this objective is accomplished only for refuse having a higher heating value of 5600 Btu/lb.

Regulatory agencies have enhanced their level of sophistication to the point where they now recognize that worst-case emissions are dependent upon the higher heating value of the fuel. They recognize that vendors have contractual agreements and that throughput may actually exceed maximum-rated capacity for solid waste having a relatively low higher heating value. The agencies also understand that just because more waste is processed at lower heating values does not necessarily mean that more pollutants will be emitted. Emissions, in part, are dependent upon throughput, heating value, composition, and flow rate.

Recent air permit applications in New Jersey have presented a range of refuse with four or five different higher heating values. The worst-case fuel type is then identified and used for air quality impact analyses and health risk assessments. It is recommended that the author develop a scheme to demonstrate what the worst-case fuel would be for a resource recovery facility equipped with a dry scrubber/baghouse.

AUTHOR'S REPLY

To Floyd Hasselriis

The following are responses to various points raised by Mr. Hasselriis:

(a) A thorough reference for combustion calculations is the book entitled *Steam/Its Generation and Use,* 38th Edition, by Babcock & Wilcox, 1972, pp. 6-10 to 6-19. One should keep in mind that excess air ratios and economizer exit gas temperatures may vary for different combustion and steam generation systems. Moisture evaporated into the flue gas in the spray dryer is related to the temperature drop across the scrubber as follows:

$$H_2O \text{ Mass Flowrate} = \frac{(\text{Flue Gas Flowrate}) \times (\text{specific heat}) \times (T_1 - T_2)}{\text{Cp, water } (212°F - 60°F) + \text{hfg} + \text{Cp, steam } (T_2 - 212°F)}$$

Excess air and moisture do not affect the flue gas volume corrected to seven percent oxygen. However, these factors are necessary for computing stack parameters for air modeling.

(b) Representation of the 5600 Btu/lb (HHV) fuel as a "reference" heating value was not intended. The point is that each facility has a specific upper limit for waste throughput that depends on heating values, and that emissions calculations should be based on the expected peak operating condition (maximum heat release). Emissions limitations not based on the peak operating condition run the risk of not passing environmental compliance tests, both initially and in the future, possibly limiting future operation. For the example presented in the paper, 5600 Btu/lb was selected as the peak operating condition to emphasize this point. In reality, the peak HHV will vary from one facility to the next depending on the types of wastes delivered.

(c) The author acknowledges the limitations of the paper's calculation of trace metal emissions. There is a need for additional test data on trace metal emissions from municipal waste incinerators with spray dryer/baghouse pollution control systems. However, it is the author's opinion that, considering all of the uncertainties associated with preliminary estimates of trace metal emissions, the method presented best assures the establishment of emission limitations that can be met during environmental compliance testing. Uncertainties associated with preliminary emission estimates for trace metals include the unknown current and future differences between the trace metal contents of municipal waste streams, and unknown operating conditions, design features, and performance characteristics for the spray dryer/baghouse.

(d) Although the comments concerning the coefficient of variation and the possibility of bimodal data may have merit, the discussor does not appear to have presented sufficient evidence that there are in fact two populations present. For example, the following unsubstantiated statements are made:

> "A given plant may have a cv of less than 15%, and a group of similar plants less than 25%."
>
> ". . . it becomes obvious that the plants with scrubbers are a distinctly different population from these with ESPs."

Further explanation seems to be called for regarding why it is obvious that the plants with scrubbers are a distinctly different population, especially given the fact that the "population" of plants with scrubbers is composed of only two facilities (for mercury). Also, it is unclear what Fig. 1 is being referred to with respect to dioxin emissions.

(e) The author agrees that not-to-exceed emission factors in actual operation are always higher than annual average emissions. However, it has been the author's experience that the not-to-exceed emission estimates used to set emission limitations are also used to perform health risk assessments, adding to the conservation of the health risk assessment. Basing the health risk assessment on guaranteed emission levels ensures that the assessment is thoroughly defensible as conservative (i.e., not underestimating health risks).

The idea of using the standard deviation in looking at the health risk is a very good point. However, this may not be allowed for comparison of predicted pollutant impacts to acceptable ambient levels, which have now been proposed by several states.

To Mitchell Wurmbrand

The author is in agreement that a more complete analysis would give consideration to higher heating values (HHVs) other than 5600 Btu/lb for the purpose of calculating stack parameters.

Different HHVs may require different excess air ratios, and may also result in variations in temperatures at the economizer outlet for a given combustion system. A higher excess air ratio would tend to increase the volume of flue gases at the stack exit to be input to the air modeling. A higher temperature at the economizer outlet would result in an increased moisture addition to the flue gas in the spray dryer (assuming outlet temperature control), which would also tend to increase the volume of flue gases at the stack exit. These increases in flue gas stack exit volume would be translated into a higher stack exit velocity, and possibly different modeled ground-level concentrations of pollutants.

Consideration to alternative HHVs for the purpose of deriving emission estimates is not necessary due to the correction of flue gas volumes. It is necessary, however, to represent a flue gas flow corresponding to the maximum heat input to the furnace units, or peak operating condition.