DISCUSSION by Samuel M. Clarke, Greeley and Hansen

General
The authors have performed a valuable service in bringing together information on the several processes being proposed and investigated for so-called "total incineration."

The paper gets off to a poor start, however, with its gratuitous references to "bonfire ash" from conventional incinerators. A properly designed and operated continuous feed furnace is in no way comparable to a bonfire, nor is its residue "bonfire ash." With controlled underfire and overfire air and agitation of the fuel bed, such a furnace will produce a residue comparable in quality to that assumed to be produced by "total incineration." It has been adequately shown [1] that such a residue is suitable for fill or cover material.

Disposal of residue is seldom, if ever, a factor in the selection of an incinerator site, so that the statement at the end of the first paragraph of the paper has no basis.

Quantity of Residue
Using the refuse analysis in Table 1 and assuming that 5 percent of the combustible matter (a high figure) is unburned, the dry weight of residue is 466 lb per ton of refuse. Reference [1] indicates in-place densities of upward of 80 lb/ft³, which figure yields a residue volume of 5.8 ft³/ton of refuse. This is compared to the volume of 3.78 ft³/ton claimed for "total incineration," or a reduction from the refuse volume of 96.2 percent as compared to 97.5 percent.

Other Stated Advantages
The "advantages" described on page 123 do not appear to be peculiar to "total incineration," as follows:

Residue Quality: As stated above, residue from a conventional incinerator can and should be suitable for fill material without further treatment or cover.

Odors: A conventional furnace also provides temperatures in the range of 1800 °F for the combustion gases, and complete oxidation is accomplished.

Gas Volume: If the combustion gases are to be cooled to 1600 °F to 1800 °F with excess air, there will be no difference in the volume of gas entering the air pollution control equipment.

Elimination of Grates: The substitution for grates of equipment that must operate at the high temperatures indicated will not, in the writer's opinion, result in lessened operating difficulties; rather the opposite.

Cost
The statements in the paper regarding first and operating costs are entirely speculative. The writer's own speculations indicate a substantially higher first cost for a "total incineration" plant, and a great increase in labor and maintenance costs, which comprise the bulk of operating cost. In fact, at least two of the proposed processes simply carry on from the outlet of a conventional furnace.

Conclusion
The advocates of "total incineration" processes apparently propose substantial increases in cost and complexity for the sole advantage of reducing fill volume required for the residue from 5.8 to 3.8 cu ft per ton of refuse. Dependable cost figures will be needed in justification.
DISCUSSION by J. I. Frankel

This paper performs the very useful function of assembling in one compact article an excellent description of all the presently offered systems and designs for total incineration of municipal and some types of industrial refuse with the feature of high temperature slagging of residue. We are indebted to Bob Zinn and his able colleagues for providing us with this very useful reference.

Elmer Kaiser has already very adequately analyzed the technical aspects of one of these designs which in my opinion applies to a very large extent to the basic principles involved in most of the other systems, in a test report he prepared for the Department of Health, Education and Welfare in 1968. If I can contribute anything it is some practical considerations based upon a lifetime in this field which brought me in contact with the politicians involved in the decision making and the municipal employe who supervises and operates these facilities. We must never lose sight of these people when we design facilities for their use.

Before we seriously attempt to stand present day incineration technology on it's head to achieve very limited goals it may be useful to pause a little and survey what we have and how close we already are to the goals attempted here. In passing, whether these systems are adopted or not, very useful techniques gleaned from the study and testing of any of these systems will constitute a fringe benefit to the advancement of more conventional systems.

Total incineration's principal goal is to reduce the residue to it's utmost by very high temperatures in the furnace thus liquifying the slag, letting it run off and quickly quenching it. The paper also claims for this system that a by product is complete combustion of the combustible materials. Does high temperature alone insure complete combustion? I once, by chance, in peering through a glass protected observation port of a combustion chamber of a batch type incinerator, noticed a small sheet of newspaper which alighted on a refractory shelf in front of me. The temperature in the chamber was close to 2000 F; the paper was white hot. I could read the print. Then I slightly lifted the port to let a very little air in. The paper literally exploded in flames. Regardless of temperature, it still takes the other two T's to achieve complete combustion.

For more than 25 years there has been offered a European incineration design (Volund) which employs a kiln after the grate chambers to finally reduce residue to an almost combustible free state. How much difference in volume (since volume is the admitted yardstick) is there between the total incineration concept and this rather old, tried and conventional design? In passing I might mention that in the quarter of a century or so of its existence there has been no stampede to buy the plant I have mentioned.

The conventional designs are getting more and more efficient. The water wall system now gets by with less than 100 percent excess air. Some designs envisage using no more than 50 percent excess air so that that feature (of low excess air) claimed for total incineration diminishes.

The quality of residue is continually improving with the increased sophistication of conventional furnace designs and better supervision of operation. Bonfire ash indeed! Come, come now, residue with 2 to 4 percent combustible isn't exactly bonfire ash.

Incineration is now the most expensive means of municipal waste disposal. Adding a few dollars per ton to the cost of operation to achieve the limited goals of total incineration may well price incineration as a mode of waste disposal right out of the market.

Of all the designs described in the paper the Ferro-Tech System is the one that makes most sense to me. This concept does not require the complete abandonment of existing conventional means of materials handling, furnace configuration, etc. The only change occurs in the ash pit where a means of further treatment of the residue takes place. I might suggest that in lieu of preheated air which is not easy to come by (if you have had any experience in obtaining preheated air in incinerators) that oxygen enriched air as envisaged in Fig. 8 be employed here.

The other methods Dravo/Falk, American Themogen, etc. embark on a completely radical departure from the conventional, entailing all the risks associated with such enterprises. For instance I have yet to see any practical and workable conveyor for refuse charging at rates anywhere near 10-25 ton/hr in modern plants. I would also like to see the final hardware designs (beyond the diagramatic stage) for the submerged refuse breakers and feeders required for the Dravo/Falk system.

There is many a slip twixt the gleam in the inventors eye and the finished hardware.

In the light of these considerations it is a bit of a sweeping statement to say "... it is believed that
the state of the art is advanced to the point that total incineration must be given consideration as an acceptable method of disposal of solid refuse." I would give much to eavesdrop and hear one of the proponents of these systems appear before some municipal decision-making body or Authority and persuade them that they should spend some $5–10 million for the construction of any of these systems.

My idea of an exercise in futility is to compare construction costs between conventionally designed projects with a completely and radically different concept on the basis of size of hardware alone. The author finds on this basis that the costs would be almost a standoff. My guess would be that the cost of construction and debugging of the new concept would be significantly higher (if you could find someone to take the total risks).

I do not wish to be thought completely pessimistic. (My advice is to proceed slowly trying out the many facets of this idea, the different components, materials of construction, etc., before advocating it forcefully on a large project.) I have seen too many of these things fail because of premature promotion only to have the effect of damaging the image of incineration.

DISCUSSION by D. L. Luckinbill, Tennessee Technological University, Cookeville, Tenn.

We are indebted to the authors and the NAPCA for assembling so much information on the variety of efforts to reduce the volume of our accumulation of solid waste. The very breadth of the coverage reveals a number of questions, answers to which may not now be available, but which are, nevertheless, of interest.

(1) What is the dollar benefit in segregating metal and glass? How much does this save in cost of reduced amount of flux? What does it cost to segregate? What dispositions can be made of the metal and glass? What is the effect on final total volume? What amounts of combustible and putrescible materials accompany these non-incinerated items? What would similar segregation do for incineration on traditional grates?

(2) What difference would it make in performance if all of these methods used shredded stock as some of them do? With what degree of success could the "shredded" units operate without shredding? Admittedly, the Sira System needs shredding. What would shredding do for improved performance of traditional grates?

(3) Might the Ferro-Tech or Electric Furnace concept be applied to the reduction of residue from a bank of traditional furnaces? Could we develop dry seals for, and hot storage from, these furnaces to provide constant feed to such a slagging operation? Might we go so far as to shift the oxygen enrichment idea to a finishing operation patterned after the present basic oxygen steel production? How much added combustible would be needed to take the place of the carbon burned out in making steel?

(4) What degree of merit should be credited to total incineration for its complete combustion contrasted with unburned material in conventional residue?

(5) Might it be fruitful to consider the feasibility and cost of compacting and baling conventional residue, and the disposition of such bales? Comparison should then be made with the cost and results of compacting with track-laying bulldozers in the ultimate landfill.

(6) Some of the schematic arrangements include gas cooling provisions. It is assumed that the others have this need also. What has been the experience with fouling of the heat transfer surfaces in the air heaters?

(7) Are any data available on the area needed for slow cooling? Have any studies been made on the optimum dimensions for cooled pieces? Or, has this cooling been confined to dumps similar to blast furnace slag dumps? If so, does the slag lend itself to similar recovery methods and uses?

In closing, it is a pleasure to acknowledge the valuable information assembled by the authors. It is encouraging to note that costs alone do not determine the pros and cons for Total Incineration.

AUTHOR’S CLOSURE

In response to discussers Sam Clarke,

1. “Bonfire ash” was defined as the ash residue from incineration at 1800 F furnace temperature; it is not the ash from an open burning fire.

2. In spite of some reported high density refuse ash landfills, the 1800 F incinerator requires access to a disposal site for the ash residue; no disposal site is required for slag residue, since the slag would be used for high load-bearing fill, for shoreline control, and other uses now supplied by crushed stone.

3. With total incineration, less excess air is used and thus the volume of flue gases is less, excess air is not used for cooling of flue gases by dilution.

Discussers Frankel’s philosophical remarks are
acknowledged and appreciated. It is agreed that high temperature alone does not insure complete combustion, – nor do the other two T’s (time and turbulence) insure complete combustion without adequate oxygen available to react with the combustible.

It is acknowledged that the Volund incinerator does produce a higher-than-usual ash density; however, only with ash fusion can a high load-bearing residue be produced.

A lesser amount of excess air in a water wall incinerator does not produce a fused ash, since the furnace temperature is lower from the loss of heat to the heat sink in the water walls.

With reference to the comments by Professor Luce, the concept of Total Incineration could be applied to the reduction of residue volume from a group of 1800 F incinerator furnaces. Designs and hardware are available from the metallurgical and pyroprocessing industries for seals, hot storage, and feeding a slagging operation.

Heat exchanger surfaces for gas cooling should reflect the fouling experience with steam boiler tubes in incinerator furnaces and breechings.

No information on the baling of incinerator residue is available, or whether there is adequate particle adherence to produce a bale.

Data on the slow cooling of slags are available from Tennessee Valley Authority for phosphorus furnace slags, from technology of lightweight aggregate, and from metallurgical and pyroprocessing technology.

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