DISCUSSION by Kenneth L. Woodruff, President, Resource Recovery Services, Inc., Woodbridge, New Jersey

This paper was found to be quite interesting in that it provided a summary of shredder operations from the point of view of a technically proficient observer. It indicates that substantial amounts of time were spent observing and examining numerous shredding operations and as such, presents a very good summary from a practical standpoint.

It is this discussor's experience, also, that the shredders presently in operation have yielded little worthwhile operational data which can be utilized in better design of waste shredders and shredding systems. However, by spending significant lengths of time with plant managers, operators and maintenance personnel, as well as observing the general operation, significant empirical data can be derived.

The author stresses the importance of the material handling equipment and treats the matter of waste shredding as a process, not just a unit operation. This is extremely important in that even the best shredder will not perform as desired if material can not be moved to and from the shredder in an expedient manner. Flow blockages are common when handling this type material and special care is required when evaluating methods of conveyance.

Little experience exists in shredding the larger tonnages of waste (75 tph or more) and although these larger mills are being specified more and more, it remains to be seen what type of operational performance will result. For the most part, shredder manufacturers are claiming these high tonnages even though no test work has been conducted. The author indicates that scale-up ability from small scale is limited. It is this discussor's observation from having inspected and evaluated shredding facilities, that the mills themselves, if constructed larger and with larger motor are likely to be able to handle the higher rates of feed presently being called for. However, the primary difficulty is the actual movement, or the feeding and discharge of material. Because refuse has such a low bulk density, the volume of material to be handled at the higher feed rates is quite large. Maintaining an even, constant flow is extremely difficult. Likewise, removing the material from the discharge point of the mill quickly, is a necessity. Materials must move through the mill as rapidly as possible in order to allow the large volume to be processed. This requires the even, constant flow of material to and from the mill. Most often, the conveying systems are the limiting factor in shredding capacity.

Regarding rotor windage, this discussor agrees that this phenomenon is extremely critical. This factor makes achieving the higher feed rates more difficult. To facilitate higher feed rates, a windage in the direction of material flow is desirable, and in fact, this is utilized in secondary shredding as the author indicates.

The main difficulty with shredders operating on household waste (packer truck material) is that hammermills presently in use were all originally designed to process uniform, friable materials, with impact being the principal size reduction mechanism employed. Municipal solid waste is obviously
not a uniform, friable material and as such, requires substantial usage of other size reduction mechanisms, including shearing and abrasion. All the mechanisms occur to some degree in the hammermill shredder, but the question which remains is what is the proper balance of these mechanisms to achieve the desired product with minimum power requirements. In shredding of automobiles and oversize bulky wastes, tearing and shearing achieve the desired product. In general, it is this discussor’s opinion that in order to better understand, and thus improve the shredding process for municipal wastes, the mechanisms required need to be better understood to see what modifications to the mills are necessary to facilitate more effective size reduction.

Once this has been done and experience has determined the best method of material handling, then the process of shredding will be more fully understood and can be utilized with full confidence.

The author is to be commended on this report of the state-of-the-art of municipal waste shredding. He fully realizes that although shredding systems are specified under the assumption that shredding is a fully proven process, there is really much which can be done to improve it.

TWO CHEMICAL INCINERATOR PLANTS WITH BY-PRODUCT RECOVERY

F. M. RHODES
Union Carbide Corporation
South Charleston, West Virginia

QUESTION by Yen-Hsiung Kiang, Trane Thermal Company, Conshohocken, Pennsylvania

Refer to Na-Waste Incinerator. At 1800°F operating temperature, Na₂CO₃ is in molten state. Since the incinerator is vertical upfired, do you expect molten Na₂CO₃ build-up at the bottom of the incinerator?

INCINERATION OF INDUSTRIAL WASTES AT A LARGE MULTI-PRODUCT MANUFACTURING PLANT

C. RANDALL LEWIS
RICHARD E. EDWARDS
MICHAEL A. SANTORO
3M Company
St. Paul, Minnesota

DISCUSSION by John L. Schaum (EPA, Office of Solid Waste Management Programs)

The subject report describes the incineration facility and associated disposal operation at 3-M’s plant in St. Paul, Minnesota. The facility appears quite successful from both a technical and environmental perspective. This reviewer was generally impressed with the operation and the well written report. However, some areas of the paper could be
expanded. Accordingly, the review comments are mostly of this type asking for further information or clarification of specific points.

The emphasis which 3-M places on the materials handling aspect of their disposal operation was appreciated. Frequently, interest in the actual disposal equipment overshadows interest in this critical area. Generally, 3-M's materials handling procedures are well conceived. Specific comments relating to this part of the disposal operation are listed below:

1. Some of the details of the chemical identification steps are not specified. For example, does it involve actual sampling and analysis? Is information other than an identification of the components determined, such as heating value, pH, percent solids, et cetera?

2. The simplicity of the categorization and segregation steps is an attractive feature. Although it is probably adequate, there appears to be some chance that noncompatible wastes within a category could be combined.

3. The packaging containers are described as "17H openhead drums and 17E closed head drums." Many readers may not be familiar with these terms. What are the size and materials of construction of these drums? Has consideration been given to the use of fiberboard drums since they would burn readily and cause less erosion to the refractory than the steel types? Also, can the liner material be specified?

4. The elimination of sampling and analysis of the wastes at the incinerator places a high degree of trust in the accuracy of the waste identification and drum labeling conducted at the waste course. Since some of these wastes are toxic, it may be worthwhile to double check their contents. The risk is somewhat reduced by the situation at 3-M where the wastes are in-house and therefore better controlled.

5. The personnel protection and safety precautions are not specified for the operators who open and inspect the drums. Can these be described? The technical description of the incineration system needs clarification on several points:

1. In the section entitled "Combustion Features," it is reported that the "kiln provides continuous ash removal" and in the section entitled "Maintenance," the report states "there is not a continuous ash removal system." Can this apparent contradiction be clarified?

2. How does the feed mechanism connect to the rotary kiln?

3. Can the operating variables such as kiln rotation speed, residence times (for solids and gases), and amount of excess air, be specified?

4. How does the "physical layout" help increase turbulence inside the kiln?

5. Why does accumulation of ash in the kiln reduce the efficiency of the secondary combustion chamber?

6. What is the capital expense of the incineration system?

7. Was the equipment in this system designed and built by 3-M?

The air pollution control equipment appears quite capable of providing adequate environmental protection. It is surprising that the condensation water in the stack would be acidic since the emissions are scrubbed in a caustic solution. Can this phenomenon be further explained? Also does this mean that the emissions from the stack are acidic?

The future plans for 3-M were not discussed. On the basis of the apparent success in this area, does 3-M have plans to become commercially involved in the area of incineration as either a manufacturer or a consultant? It is implied in this report that 3-M incinerates in-house wastes only. Does 3-M ever accept outside wastes? Does 3-M have any plans to offer a commercial disposal service?

**AUTHOR'S REPLY**

We are indebted to Mr. John Schaum of the U.S. Environmental Protection Agency for his pertinent comments concerning our paper. In response we will reinforce some ideas and concepts that we attempted to convey in the paper and, in addition, mention several areas which were not covered in the presented paper. The questions raised by Mr. Schaum with respect to the areas of waste materials handling procedures and technical considerations of the incineration system are addressed below in a sequential manner.

**WASTE MATERIALS HANDLING PROCEDURES**

1) Actual sampling and analysis of waste materials to determine specific characteristics, such as heating value, pH, percent solids, etc., has not been necessary since only waste materials generated "in-house" by 3-M are processed by the subject incineration facility. Although no actual sampling and analysis are conducted, the above char-
acteristics may be accurately deduced since the major chemical constituents and the manufacturing department are identified on the 3M intracompany label for wastes. These labels are attached to each drum of waste by personnel at the waste generation source who have the greatest knowledge of the exact characteristics of the wastes. They are also encouraged to note any special or unusual characteristics associated with the wastes.

2) The chance of combining noncompatible wastes within a specified category is minimized in several ways. First, the problem is restricted to pumpable wet scrap since nonpumpable wet scrap is handled in individual drums and are not mixed prior to the combustion process. Secondly, a single manufacturing location normally uses compatible solvents. Thus, the greatest chance that noncompatible wastes be combined occurs with pumpable wet scrap at the incineration facility. In the subject paper, it was noted that care must be exerted at the incineration facility to avoid mixing pumpable materials which react, solidify, and/or polymerize when mixed. Basically, proper labelling at the waste generation source and the experience and knowledge in liquid segregation of the incinerator operators, who are licensed boiler operators, have eliminated this problem. If there is any doubt about compatibility, bottle tests are conducted.

3) “17H openhead drums and 17E closed head drums” refers to Department of Transportation (DOT) drums specifications 17H and 17E. These specifications require a drum with a capacity of 210 liters (55 gallons) to have a minimum wall thickness of 18 gauge steel (1.087 mm or 0.0428 inch).

Fiberboard drums do not meet DOT regulations for over the road transportation with the classification of wet scrap produced by 3M. Attempts have been made to use fiber drums instead of polyethylene drum liners within steel drums to minimize steel drum losses caused by the inability to dump the waste contents out of the steel drum. This use of fiber drums was found to be uneconomical.

As mentioned above, the drum liners are of polyethylene construction.

4) Since 3M has not encountered any cases where normal 3M procedures were inadequate, it is not believed that it would be substantially beneficial to routinely double check the contents of each drum of waste that is received at the incinerator facility. The primary reason that double checking is not required is the “in-house” nature of the 3M incineration operation and the rigorous efforts made to assure proper identification and labelling at the waste generation source.

5) Many safety precautions are used for the protection of the operators who open and inspect the drums prior to incineration. Safety features include: explosion proof electrical equipment, automatic fire doors, a “light water” system, dry chemical and CO₂ fire extinguishers, special safety diesel fork trucks with nonsparking forks, nonsparking tools, air operated pumps, safety showers and eye washes, safety glasses and face shields, and a ventilation system which makes a minimum of three (3) air volume changes per hour in all areas and thirteen (13) air volume changes per hour in the drum pumping room and in the nonpumpable staging room.

The nonpumpable dry scrap is packaged in drums with polyethylene liners. These liners are doubled-over and taped in such a manner that the operators are not directly exposed to the waste materials when the lids are removed.

In addition, the 3M Industrial Hygiene Department inspects the incineration facility on a routine basis to ensure a safe operation for all personnel involved.

INCINERATION SYSTEM CONSIDERATIONS

1) An intrinsic characteristic of a rotary kiln is continuous ash removal. The subject incinerator uses a rotary kiln as the primary combustion chamber and, thus, has continuous ash removal from this chamber. The statement referenced by the discusser in the “Maintenance” section of the paper pertains to the secondary combustion chamber which is a stationary chamber and has no provisions for continuous ash removal. It is recommended that continuous ash removal considerations be implemented in future installation of such stationary secondary combustion chambers.

2) The feed chute of the incineration system enters the rotary kiln through the stationary head wall on which the burners are also mounted. The stationary head wall and the rotating portion of the kiln are not physically attached but have close clearance tolerance which minimizes air leakage into the kiln. Too much air leakage at this point causes deterioration of the refractory due to the thermal shock.

3) The rotary kiln has a variable speed drive and is normally operated at 0.1-0.4 rpm. The rotational speed of the kiln directly affects the retention time of the solid residue in the kiln which is
usually 45-60 minutes. The gases have a 3 second residence time within the combustion system before reaching the air pollution control equipment.

4) It is desirable to induce turbulence within a combustion system to ensure the most complete mixing and combustion of gases and entrained particulate. The secondary chamber is offset from the centerline of the kiln and air pollution control equipment such that the combustion gases must make a 90° turn to enter the secondary chamber after existing from the kiln. Before leaving the secondary chamber, the combustion gases encounter two additional 90° turns. This physical layout of the secondary chamber in relation to the kiln creates increased turbulence and more complete mixing of the combustion gases.

5) Ash accumulation occurs in the secondary combustion chamber not the rotary kiln. This ash buildup is the result of settling of particulate carried over in the gas stream from the primary chamber (the kiln). The accumulation has two deleterious effects.

First, since it reduces the volume of the secondary chamber, it shortens the residence time of gases in the secondary chamber. Reduced residence time means that larger carbon particles are not completely combusted.

Second, reducing the volume of the chamber increases the linear velocity so that particulate that would have settled is carried through to the air pollution control equipment. This increases the load on the air pollution control equipment. There may also be some re-entrainment of deposited ash since the inorganic fraction of the particulate measured at the stack increases when the chamber has substantial ash accumulation.

6) The total capital expense of this 3M incineration system was $4.5 million.

7) 3M Company assumed ultimate responsibility for design and construction of the incineration facility. However, the Environmental Control Systems Division of the Dow Chemical Company was hired as a prime consultant for the project. The combustion equipment was purchased from International Incinerator, Inc.

The air pollution control system does not use caustic solution as the scrubbing media. Natural well water is used for scrubbing effluent gases. This scrubber water is neutralized with a caustic solution during the waste-water treatment process after use in the air pollution control equipment and prior to discharge from the plant site. The water condensate sampled at the base of the stack is acidic due to the chlorine contained in some waste materials which is emitted with the combustion gases and combines with the scrubber water to form hydrochloric acid. The water condensate sampled at the base of the stack is acidic since the stack functions as a reflux condenser in concentrating the acid. Analysis of the stack gases shows that the acid concentration is negligible and easily meets all federal, state, and local regulations.

Although this 3M incineration operation has been extremely successful, 3M does not foresee becoming commercially involved outside of 3M in waste disposal by incineration. It is expected that 3M will continue their policy of incinerating only "in-house" wastes. 3M does not currently plan to manufacture or serve as consultants in the area of incineration and certainly has no plans to offer a commercial disposal service.