PHARMACEUTICAL PLANT WASTE DISPOSAL
BY INCINERATION

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ABSTRACT
Pfizer investigated the use of on-site incineration for process wastes and plant trash at their Puerto Rico facility. After a series of test burns on a wide range of wastes, incineration was found to be technically feasible. The test burn program included the burning of each process waste category in two different types of incinerators. A rotary kiln incinerator was purchased for this facility, designed to meet RCRA standards at the time of purchase, and the incinerator and associated equipment were started up in 1982.

INTRODUCTION
The Pfizer facility at Barceloneta, Puerto Rico, generates solid, semi-solid and liquid waste from their production processes. Under a planned expansion the existing waste quantities were expected to increase.

After considering existing methods of waste disposal, (by private carter), and the impact of their future waste streams on the cost and reliability of waste disposal, in 1980 Pfizer authorized Malcolm Pirnie, Inc. to perform a feasibility study of on-site incineration.

The feasibility report concluded that on-site incineration including equipment, structures, utility tie-in and permitting would cost less than $800,000. The system could be designed to conform to RCRA standards for hazardous waste incineration although no hazardous wastes were being generated at the time the report was prepared. Equipment could be sized for the maximum anticipated loading and under lesser loading, the facility would be operated on a decreased schedule, e.g., 2 weeks per month for half-load instead of 4 weeks per month for maximum loading.

GENERAL PLANT TRASH
General plant trash was considered an incinerator candidate. Trash has a good heat content and using it to fire the incinerator would decrease the quantity of fossil fuel required to support combustion.

On the basis of the feasibility study Pfizer decided to procure an incineration system for disposal of their waste. This system would be designed for process waste, as well as plant trash, sized for maximum anticipated future generation rates.

WASTE STREAMS
The wastes generated consist of the following materials:
- Solid residues, including corn starch, sucrose and gelatin, halogenated materials and metal salts, with no more than 15 percent moisture. The heating value could be as high as 10,000 Btu/lb (23,000 kJ/kg) as received.
- Filter cakes, including carbon filters, spent carbon and diatomaceous earth, with a moisture content ranging from 30 to 60 percent and a heating value of from 3000 Btu/lb to 5600 Btu/lb (7000 to 13,000 kJ/kg) as received.
- Plant trash consisting of waste paper, wood, packaging waste and cafeteria waste up to 10,000 Btu/lb (23,300 kJ/kg) as received.
- Liquid organics including waste solvents, with less than 10 percent water content by weight, up to 15 percent halogens, and with a heating value of from 5000 Btu/lb to 19,000 Btu/lb (11,600 to 44,200 kJ/kg).

Waste quantities of the individual components vary, however, the total of solid residues plus filter cake was estimated at 140,000 lb/year (63,500 kg/year), 6000,000 lb/year (2724,000 kg/year), and 1800,000 lb/year (816,000 kg/year) for the three process waste categories.
lb/year (272,200 kg/year) of plant trash and 25,000 gal/year (95 m³/year) of liquid organic material. These quantities are existing generation rates.

EQUIPMENT SIZING

The incinerator was sized to burn the current process solid waste load in 500 hr of operation per year and the plant trash load in an additional 1500 hr/year, with liquid waste fired throughout this 2000 hr operating period. As the load increases the hours of operation will increase accordingly.

INCINERATOR ALTERNATIVES

As part of the feasibility study the various types of incinerators available were evaluated. Two of these appeared to be well suited for disposal of Pfizer waste:

- Modular Combustion Unit (MCU). This incinerator, shown in Fig. 1, was developed for the burning of trash. Waste is charged to a primary chamber where only enough air is provided for minimal burning. The burning rate is controlled to provide sufficient heat to char the waste, converting it to a sterile, carbonaceous ash plus an off-gas rich in organic material. This thermal process is known as starved-air combustion; it is not true burning because only a limited amount of burning occurs. By controlling the amount of air injected into the primary chamber, the temperature and burning process within the chamber can be accurately controlled.

A secondary chamber is provided for complete burn-out of the organics in the flue gas. Again, by control of the air flow admitted to this chamber the burning process can be carefully maintained and controlled. Complete burning occurs in this chamber producing a clean stack discharge.

Although this equipment was originally designed for paper waste it appeared to have applicability for liquid and semi-liquid waste also. Liquid waste could be injected into the secondary chamber for destruction. It cannot be injected into the primary chamber because sufficient air is not available for effective incineration. By appropriate design of the primary chamber, semi-liquid wastes might be effectively combusted.

- Rotary Kiln System. This equipment, shown in Fig. 2, is generally more expensive than the modular combustion unit. The rotary kiln is a refractory lined cylinder rotating slowly about its horizontal axis, at a slight angle to the horizontal. Waste is charged at one end of the kiln. The kiln speed is varied to provide sufficient retention time for burn-out of the waste to ash by the time the charge reaches the discharge end of the unit. Off-gas passes through a secondary chamber, or afterburner, where its
The temperature is raised to insure complete combustion of the organics.

The circular motion of the kiln tends to create more air-borne particulate (fly ash) than the MCU, where there is a minimum of physical motion of the waste charge. Complete burning occurs in the kiln, as compared to starved-air combustion in the MCU, and the higher required air flow in the kiln is an additional factor in the release of particulate to the flue gas stream. Air emission control, therefore, is more critical for the kiln than for the MCU.

The kiln is a universal incinerator. Solid or sludge waste is dropped on the kiln hearth and the kiln rotating speed (and its angle to the horizontal) can be adjusted to provide the desired turbulence and burnout. Liquid wastes can be injected into the kiln or into the afterburner.

**TEST BURN**

A number of wastes were known to be difficult candidates for incineration. Spent powdered carbon and some of the sludge wastes do not readily burn and incinerator selection is critical to their effective destruction. The modular combustion unit system requires minimal operator attention and is relatively inexpensive, however, the kiln, with its more complex air pollution control system and the greater degree of operations scrutiny required, is a more versatile system, capable of handling more varied types of wastes.

It was decided to conduct a test burn in an MCU. If the wastes were effectively destroyed, this type of unit would be specified. If the MCU did not prove satisfactory, another test burn would be performed, in a rotary kiln.

A MCU that appeared to be well adapted for the Pfizer waste destruction was used. It has a suspended hearth, as shown in Fig. 1. A burner beneath the hearth provides the initial heat required to bring the charge up to operating temperature, at least 1000°F (540°C). The hearth is perforated to provide a path for the hot gases beneath it to penetrate and heat the waste charge. A controlled air supply is admitted to the furnace beneath the hearth and the suspended hearth openings, therefore, provide a means for this air to reach and contact the waste. It was believed that the air and flue gas flowing through the hearth openings would be of sufficient velocity to create a turbulent condition with some of the difficult waste, such as powdered carbon, to help promote its burning.

Pfizer sent a dozen drums of typical wastes to central Virginia, to the MCU test burn facility. Before the wastes were charged, paper and cardboard trash were charged to the primary chamber and fired, along with the burner beneath the hearth, to raise the furnace temperature to 1,000°F. Wastes were carefully cataloged and measured
and then charged into the primary chamber of the incinera-
tor. Air emission equipment was available, but emission
testing would not be performed until burning of all of the
waste streams was visually observed. The first charge in-
cluded pharmaceutical rejects, and they burned to destruc-
tion. The furnace temperature increased to 1200°F
(650°C) during this burn-out.

The next charge included powdered waste, i.e., corn
starch and carbon. The top surface of the charge appeared
to char, however, no waste burning was observed and the
chamber temperature did not increase, as with the previous
charge. The furnace temperature was increased to 1400°F
(760°C) and additional materials were charged. The
powdered waste previously fired did not appear to burn.
The velocity of air rising from the suspended hearth was
insufficient to provide significant motion to the powdered
waste.

The focus of attention was, for the remainder of this
test burn, destruction of the powdered waste. Air flows
and temperatures were altered in an attempt to obtain
combustion. The charge was maintained in the furnace for
a period of time in excess of 16 hr. The corn starch
and other white powdered materials eventually burned,
however, the carbon did not. The carbon, which sat on
the hearth to a depth of up to 10 in. (0.2540 m), had a
layer of ash no more than one half in. (0.0127 m) thick,
on this exposed surface. The rest of the carbon was un-
burned.

It was concluded that this unit did not effectively in-
cinerate a significant portion of the waste material and
was, therefore, unacceptable. The suspended hearth design
was expected to be more effective than other MCU designs,
where the charge is placed on the bottom surface of the
chamber. If the suspended hearth was ineffective other
standard MCU designs would also be ineffective for this
waste. The use of an MCU was rejected and preparations
were made for a second test burn, in a rotary kiln.

The majority of waste materials were not used and
they were re-shipped to Springfield, Ohio, to the kiln test
burn facility. The facility utilized a small (3 ft diameter
by 3 ft long (0.9144 by 0.9144 m)) rotary kiln with a
secondary chamber, exhausting into a gas scrubbing
system. The kiln rotation speed was variable.

Waste materials were identified, weighed, and charged.
Samples of the individual wastes were fed to the kiln and
burnout of all of them was satisfactory. The powdered
carbon required a longer retention time for effective burn-
out and the kiln speed was decreased accordingly. Testing
occurred over a period of two days.

Emissions opacity testing was performed and the kiln
residue was collected and evaluated. The opacity was
acceptable, less than 20 percent throughout the test burn.
Burnout varied with the material charged. It was measured
as unburned organics in the ash and varied from 15 percent
when burning powdered carbon to less than 5 percent
with the majority of other waste materials. The test kiln
had disposed of the waste in a satisfactory manner.

On the basis of these two test burns, both of which
were successful in evaluating incinerator operation on the
Pfizer waste stream, the rotary kiln was chosen.

REGULATORY REQUIREMENTS

To provide the maximum degree of flexibility for
present, anticipated future operations and possible future
operations, the incinerator system was specified to conform
to the standards of the Resource Conservation and
Recovery Act (RCRA) for hazardous waste treatment. The
portions of RCRA that applied to incineration in-
cluded the following provisions:

- The waste off-gas must be maintained at 1832°F
(1000°C) for a period of at least two seconds unless the
waste has a significant halogen component.
- Where a waste contains 0.5 percent or more of halo-
gens, maintain the gaseous products of combustion at a
temperature of 2192°F (1200°C) for a period of at least
two seconds. Ninety-nine percent of the hydrogen chloride
produced must be removed from the exhaust gas stream.
- Particulate emissions must not exceed 0.08 grains
per dry standard cubic foot of exhaust gas, corrected to
12 percent CO2.

These parameters were included within the RCRA
requirements (proposed regulations) in effect at the time
of placement of the equipment order, in early November,
1980. Since that time, the RCRA incinerator regulations
have changed to include requirements for a test burn in
lieu of a temperature/time requirement.

The incinerator is designed for 2 sec retention at 2200°F
(1200°C) at maximum furnace throughout. This operating
condition will fully destruct anticipated hazardous mate-
rials charged (such as chloroform). The incinerator design,
under previous RCRA (proposed) regulations is more
severe than is required under the existing RCRA regula-
tions.

SYSTEM DESCRIPTION

The heart of the incinerator system, shown in Fig. 3,
is the rotary kiln. The kiln has a capacity of 11 million
Btu (12 billion J) hr, equivalent to approximately 2200 lb
(1000 kg) hr of plant trash, or 25 tons (22.7 t)/day.

Trash and other non-granular solid and sludge waste,
including waste packaged in plastic bags and small fiber
packs are placed in the hopper of the ram feeder. A guill-
otine damper at the entrance of the kiln is sequenced to
raise and lower in response to the movement of the ram feeder, as it inserts its charge into the furnace.

A screw feeder is provided for charging powders, fines and other free-flowing waste into the kiln. The screw is mounted on the front face of the kiln assembly, adjacent to the ram feeder. Both feeders are water cooled, to protect them from the furnace heat. The screw end extends into the kiln whereas the ram sees the heat of the furnace only when charging, i.e., when the guillotine damper is opened.

The rotary kiln is 6 ft 0 in. (1.8288 m) OD by 14 ft (4.2672 m) long. It is lined with 9 in. (0.2286 m) of refractory brick. The unit has a nominal speed of one rpm which can been varied to provide differing residence time to suit the waste charged.

Ash from the kiln discharges into a removable container. While in place, the interface between the ash container and kiln discharge form a relatively air tight seal, preventing admission of large quantities of infiltration air.

Hot gases from the kiln enter the after-burner section, a horizontal cylinder 6 ft 6 in. (1.9812 m) OD by 17 ft (5.1816 m) long lined with 12 in. of refractory. Gases exit the afterburner to either a venturi scrubber or an emergency discharge stack. This 30 ft (9.1440 m) high stack provides an alternate path for the hot gases if a fault arises in the exhaust gas cleaning system. It allows an orderly shutdown, preventing equipment damage in case of failure of downstream systems or equipment.

The hot gases are quenched and particulate matter is removed in the venturi scrubber. The exhaust gas is cooled further in the packed tower where a caustic soda solution is circulated to remove acidic components from the stream. The bottom of the packed tower is a sump which provides a wet well for the recirculation pump and acts somewhat as a stilling chamber for solids separation.
An induced draft fan downstream of the scrubbing system draws flue gas through the flues and the gas cleaning system, exhausting through the main stack. The main stack exhausts saturated flue gas at an elevation of 30 ft (9.1440 m).

**SYSTEM OPERATION**

System operation is indicated in Fig. 4, the Process Flow Diagram. There are three burners provided for the system, one at the kiln entrance and two on the forward face of the afterburner. The three burners are identical, however, one of the burners in the afterburner is dedicated to firing liquid waste while the other burners fire supplemental fuel. The kiln burner can also fire liquid waste.

The purpose of the supplemental fuel system is to bring the incinerator chambers to operating temperature at start-up and to maintain operating temperature during waste firing if the waste will not support autogenous combustion. Supplemental fuel for this equipment can be either kerosene, ethyl acetate, ethanol or hexane, depending on availability at the plant.

The rotary kiln is normally operated in the range of 1200°F to 1600°F (650°C to 870°C). Interlocks prevent waste feeding unless the kiln temperature is at least 1000°F (540°C), and is no more than 2200°F (1200°C). The secondary chamber, or after-burner, will normally operate in the range of 1850°F to 2000°F (1010°C to 1090°C) when process wastes are incinerated.

The kiln rotation under normal operation will be from 0.2 to 0.4 rpm and it has the ability to run continuously or intermittently. Intermittent rotation, (e.g., rotating 5 min, stopping for 10 min, etc.); may be desirable with certain materials which require sustained flame impingement for expeditious combustion.

The venturi/quench water supply is adjusted to 53 gpm and recirculation to the packed tower is 105 gpm (400 L/min.). During normal operation 7.5 gpm (28.4 L/min.) is continually blown down to the drain to maintain a reasonable solids concentration. A maximum of 2 percent...
suspended solids and 3 percent dissolved solids is allowed. The pH of the recirculated water flow is monitored and is automatically adjusted, by addition of NaOH to the tower sump, to maintain a value of 8.0.

The pressure drop across the venturi is adjustable by manually adjusting the flap across the venturi throat. The pressure will normally be adjusted within the range of 25 to 30 in. (0.6350 to 0.7620 m) WC. The pressure drop across the packed tower and demister is approximately 4 in. (0.1016 m) WC.

The induced draft fan is rated at 4500 ACFM (130 atmospheric m³/min, drawing 35 in. (0.8890 m) WC at 170°F (77°C). It is powered by a 50 horsepower (37.300 w) motor.

**PROCESS CONTROL**

A control panel is provided for central control of the process. All system controls except for waste feeding controllers are included in this panel. Switches and controls for operation of the screw feeder and ram feeder are located adjacent to this equipment.

Major control loops include burner firing and emergency stack operation. Burners will fire in response to a temperature set point. As the furnace temperature rises to approach the set point the firing rate will decrease and, conversely, the firing rate will increase if the furnace temperature is increasingly less than the set point.

The emergency damper will open, bypassing the gas cleaning train, to prevent equipment damage upon downstream equipment failure. For instance, if the recirculating water pump fails, continuation of the flow of hot flue gas could damage the tower packing. To allow an orderly shutdown, preventing equipment damage, upon a loss of water flow in the gas scrubbing system the ID fan will automatically shut off, and the emergency damper will open, exhausting gas downstream of the after-burner and directly to the atmosphere.

A maximum of two people are required to operate the incinerator system. One is an equipment (incinerator) operator and the other is occupied with the receipt, storage, and charging of the waste and handling of the ash.

**ERECTION AND START-UP**

The equipment specifications called for a preassembled, pretested unit which would be erected on foundations at the site, connected to power, fuel, and water and be ready to run. In practice this was not achievable. The unit is much too large for this approach so that compromises were required. The equipment was preassembled to a large degree but required some final piping and conduit runs in the field. Therefore, erection required the installation of support utilities plus the erection, hookup and step by step checkout of the various systems. The equipment, also, was pre-bricked at the factory (it was transported to the site with no refractory damage).

One major start-up problem was encountered. This resulted from the racking of a support frame during erection. Kiln misalignment resulted when the equipment was brought to operating temperatures. It was corrected by a redesign of the thrust bearings to withstand the longitudinal thrust caused by the misalignment. The remainder of the problems were minor and involved such items as support utilities and calibration and adjustment of controls.

The equipment is now operating as a nonhazardous waste incinerator. Excellent results are being obtained.

**PERMITTING**

The equipment was purchased in early November 1980 and it qualified as an existing unit under RCRA regulations. It was also included in the RCRA Part A filing of Pfizer's Hazardous Waste Permit Application and has interim status under the RCRA regulations. The incinerator was tested and permitted as a non-hazardous waste incinerator by the Puerto Rico Environmental Quality Board late in 1982. The plant has also submitted a Part B hazardous waste permit application to the USEPA and expects to conduct test burns and receive a USEPA RCRA permit in 1984.

**CONCLUSION**

This facility has been designed to dispose of waste in an efficient and trouble-free manner; preliminary test burns were very useful. With on-site incineration Pfizer has direct control of waste disposal.

Permitting efforts are well underway; it was shown that the Part B RCRA effort should not be underestimated. Pfizer has provided clean, effective waste disposal and has increased its good-neighbor relationship with the surrounding community.