Ultimate Disposal of Industrial Wastes

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INTRODUCTION

Today, equipment and methods are available to treat and reduce industrial wastes for ultimate disposal without polluting the surrounding air and water. This paper describes a new disposal facility designed to chemically treat and/or to incinerate, without pollution, industrial wastes received from process industries within a regional area.

Such an ultimate disposal facility will be the first regional plant, to be located in Logan Township, New Jersey, which will be put into operation during 1970. Process wastes, within a given area, will be picked up from chemical, petroleum, and other industries and hauled to a regional plant for ultimate disposal.

Noncombustible liquid wastes will be chemically treated to render them inoffensive and nonpolluting. The clean effluent will be returned to nature, and the solids will be used for land reclamation. Combustible liquids and combustible solids will be incinerated, using the resulting ash for land reclamation.

NEED FOR A REGIONAL FACILITY

Management in industry is faced with increasing costs for disposal of wastes that are now hauled to local dumping grounds. As time passes, air and water pollution standards are being raised, enforcement is becoming stricter, and the availability of dumping ground area is decreasing. This bleak picture of waste-disposal problems leads industrial management to search for new ways to dispose of its process wastes.

Management in industry should investigate the investment and operating costs of disposal plants on their own premises. These costs should then be compared with the costs of haulage and waste disposal charges by a regional plant operated by an outside contractor. A regional facility engineered and designed for the disposal of industrial wastes calls for an expenditure that cannot be justified by a single, average industrial plant. A regional disposal facility, designed, installed, and operated by an outside contractor to handle industrial process wastes within a chosen area may be an answer to economic disposal of wastes.

Recent surveys made by the writer show that some industrial organizations cannot economically justify their own operation of a disposal facility and that they welcome an outside-operated facility.

TYPES OF INDUSTRIAL WASTES

Wastes produced in an industrial plant can be classified into several categories:

- Garbage (cafeteria wastes)
- Refuse (office and packing discards, etc.)
  - Office records
  - Office correspondence
  - Office computer cards, tape, etc.
- Packing cartons
- Packing crates
- Pallets (wood)
- Demolition, debris
• Process wastes
  Defective merchandise
  (nonsalable, nonreworkable)
  Process cleaning

The first two categories, garbage and refuse, can be disposed of in the same manner as regular municipal disposal plant. The last category, industrial process wastes, cannot be disposed of in a municipal plant. Process wastes require a specially designed installation for disposal of industrial wastes without causing pollution.

Types of industrial wastes considered for ultimate disposal include the following:

- Solvents (alcohols, ketones, light aromatics, etc.)
- Waste oils – mineral, cutting
- Oil sludges
- Paint sludges
- Oil-water emulsions
- Monomers, polymers, and resins
- Chlorinated hydrocarbons, and solvents
- Industrial solid wastes, trimmings, etc.
- Phenols, cresols, tars
- Combustible chemicals
- Amines
- Greases and fats

CHEMICAL AND BIOLOGICAL TREATMENT

Chemical Treatment

Chemical-treatment stabilization and neutralization are required for the ultimate disposal of many wastes. For example, spent bath containing chromic acid must be chemically reduced to the trivalent chromium state, and then the trivalent chromium must be neutralized to the insoluble chromium hydroxide. Similarly, cyanide baths and other cyanide wastes must be oxidized to at least the cyanide state or preferably completely to carbon dioxide and nitrogen, then neutralized to precipitate heavy metals.

Other wastes that require chemical treatment before ultimate disposal can be accomplished are pickle liquors, etchants, bright dip and plating bath, spent acid, and alkali containing organic components. Frequently, one waste can be used to treat another if no side effect such as air pollution results.

Depending on the nature of the chemical wastes, flocculation and adsorption of organics and colloids followed by sludge thickening and dewatering may be necessary to reduce the volume of stabilized solid to go to landfill.

Biological Treatment

The filtrate, in addition to the supernatant from sludge thickening, may contain biological oxygen demand due to organic matter, and these substances are taken care of as discussed below.

Several types of biological treatments are planned for the ultimate disposal facility. Certain of the organic wastes amenable to such treatment are deposited in a biological-solids filter system where degradation by a variety of micro-organisms takes place. Leachate from this treatment is collected and combined with other waste waters containing organics and treated by a more or less conventional biological system consisting of trickling filters and activated sludge. The effluent from this treatment is clarified and the sludge recirculated. Excess sludge goes to sanitary landfill. The treated water is used for scrubbing in the incinerator.

Monitoring of the effluent of biological treatment will consist of frequent analyses of composites for pH, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates, phosphates, phenol, and saline content. Should there be an excess of treated water that cannot be used in the operation of the incinerator, it will flow to a final oxidation pond for stabilization prior to discharge to a surface stream.

LAND RECOVERY

A properly located and operated sanitary landfill is an effective, safe, and inoffensive means of disposing many types of solid wastes and liquid residues. Unfortunately, in the past, most disposal was in open dumps, many of them burning. Increasingly strict regulations are being enforced to eliminate open dumps and to regulate sanitary landfills.

The disposal of industrial wastes in sanitary landfill requires careful attention to the choice and use of stabilizing chemicals that otherwise might leach out and pollute either the underground waters or streams. Leachate and run-off should be collected and treated by biological degradation so that it may be discharged into a receiving stream within established stream-quality standards.

After an area has been used for sanitary landfill and the elevation has been stabilized, it is usable for certain purposes such as a recreation area. An additional period of time is required before the land can be used safely for building. The amount of time that must elapse depends on the types of materials that have been deposited and on the treatment techniques employed with them. The substances
to be ultimately disposed of in these industrial-waste-treatment sites will be stabilized. This will provide filled-in land area, which can be used for the construction of industrial plants after a minimum of elapsed time, thus enhancing the value of the land.

**INCINERATION**

Preliminary investigations of available equipment to burn industrial wastes indicated the desirability of using two furnaces, one to burn solid wastes and sludges, another to burn liquid wastes. (See Fig. 1.) Both of these furnaces are connected in parallel to a common afterburner chamber where combustion is completed and noxious gases are destroyed. From the afterburner, the flue gases flow through a heat-recovery zone available for processes requiring an outside heat source. Flue gases leaving the heat-recovery zone flow through a chemical-treatment system where the acid condition of the flue gases is neutralized just before entering the water scrubber for removal of particulates. After the scrubber, the flue gases enter the induced-draft fan, which pushes the gases through a stack into the atmosphere.

**Solid Wastes and Sludges**

The installation has been designed for flexibility as to the type of wastes it may process. Industrial wastes vary with the industrial process they come from. Industry continuously has to develop and market new products, which in turn produce new types of wastes. The burning facility must be flexible and provide the means of burning industrial wastes — solid or sludge — as they are received at the regional disposal facility.

**Rotary Kiln**

The Bartlett Snow rotary kiln has been selected for burning solid wastes and sludges, since it seems that at present it meets the requirements for a flexible operation (Fig. 2).

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![Fig. 1 Thermal Reduction, Solid and Liquid Industrial Wastes](image-url)
The Bartlett Snow rotary kiln or rotary incinerator consists of a revolving refractory-lined cylinder, slightly inclined to the horizontal, supported by two riding rings resting on two trunnion rolls each, with the trunnion roll bearings mounted on a structural steel base. On each side of one of the riding rings, a flanged trunnion roll holds the cylinder in its proper longitudinal position. The cylinder is rotated by means of power-driven trunnion rolls with a through-shaft, which extends through two trunnion rolls on one side of the cylinder and is directly coupled to a helical gear speed reducer driven by an electric motor.

The inside of the cylinder is refractory lined along its entire length, suitable for the required operating temperatures and for the various waste materials to be handled.

The flow of waste material through the incinerator kiln is controlled by the slope of the cylinder to the horizontal, its rotational speed, and the velocity of the gases going through it. The revolving cylinder imports a rolling and mixing action to the material, which produces complete and thorough waste volatilization.

The kiln is automatically fed by a pneumatically operated feed-hopper arrangement. A feed scoop unloads the wastes through a refractory-lined sliding door at intervals on a programmed cycle. An auxiliary burner installed at the opposite end of the kiln provides supplementary heat necessary during startup and also maintains furnace temperature during operation. Adequate furnace draft and the necessary flue-gas velocity through the kiln is obtained from the effect of the induced-draft fan and stack.

The ash is discharged at the opposite end of the kiln from the waste feed. From there it is sluiced to an elevated storage bin, where it will be loaded, by gravity, on a truck, for haulage to a landfill project.

This kiln is designed to minimize or prevent excessive air leakage by the provision of angle seal rings and asbestos seal segments at both ends of it. Kiln furnace temperature is automatically controlled with an auxiliary burner. When the furnace temperature drops below a predetermined setting, the controller increases the flow of fuel and air to the auxiliary burner, bringing the furnace temperature to a preset point. Should the furnace temperature increase, the auxiliary burner automatically cuts down the flow of fuel and air.

**Liquid Wastes**

Industrial liquid wastes do not follow a single pattern. They vary in viscosity, moisture content, heating value, grit content, and capacity to maintain combustion. As a result of a thorough investigation of presently available designs for burning industrial
liquid wastes, the cyclone furnace design was selected for this operation: the Loddby furnace.

The Loddby Furnace

The Loddby furnace selected to burn industrial liquid wastes was originally introduced in Sweden, a number of years ago, to burn waste sulphite liquor originating from pulp operations. The primary function of the Loddby furnace is to provide a combustion chamber relatively small in proportion to the waste being handled and surrounded by refractory material that radiates sufficient heat to keep the waste ignited. (See Fig. 3.)

The Loddby furnace is a horizontal cylinder in which fuel is fired, heat is released at extremely high rates, and combustion is completed. The liquid waste is introduced through an air-atomized burner on one end of the cylinder. About 20 percent of the combustion air enters the burner and imparts a whirling motion to the incoming waste. Secondary air at very high velocities is admitted in the same direction, tangentially, at the roof of the main cylinder and imparts a further whirling motion to the waste particles. The combustible material is burned at exceedingly high release rates of 250,000 Btu/h/ft² and gas temperatures exceeding 2500°F are developed. The secondary air tends to keep the refractory lining considerably cooler than the flame temperature in the center of the furnace. The tangential air also imparts a certain scrubbing action around the periphery. The same forced-draft fan supplies air both to the burner and to the furnace. A gas ignitor provides ignition for the waste-liquid burner.

The secondary air from the forced-draft fan passes through an air preheater before entering the furnace. The air preheater serves a double purpose: (1) to preheat the furnace after a shutdown and (2) to maintain furnace temperatures.

The flue gases from the Loddby furnace are discharged to a common afterburner chamber, together with the rotary kiln flue gases.

Particular attention has been given to the choice of liquid-waste burners for both the kiln and the Loddby furnaces. A high-speed rotary cup burner atomizes the liquid waste fed to the kiln, and an air-atomized burner disperses the liquid waste fed to the Loddby furnace. Both burners are designed to obtain a high degree of air mixing and dispersion.

HEAT RECOVERY

No heat recovery has been incorporated in the initial installation. Provision has been made for future heat-recovery installation, should the demand arise and economics justify the installation. Heat recovery can be accomplished through the addition of a waste-heat-recovery boiler to generate steam or through the direct use of the high-temperature flue gases in a process requiring external heat source.

Future installations will incorporate the addition of a steam boiler or the direct use of high-temperature flue gases for reheat, drying, or tempering furnaces.

POLLUTION CONTROL

Predictions of the extent of air pollution from operation of this incinerator installation are extremely difficult to make because the types of
wastes to be burned will vary with the contracts for waste disposal obtained.

The design of this burning facility incorporates equipment that attains complete burnout of wastes with a minimum of excess air. Both furnaces selected for this operation have been used previously for burning a variety of combustible materials and are noted for high-temperature, turbulent, efficient combustion.

The discharge gases from both the kiln and the Loddby Furnace enter a common afterburner, a refractory-lined baffled chamber, where the combustion of unburned particles present in the flue gases is completed before entering a common gas scrubber.

A gas-impingement scrubber has been selected to neutralize acids, remove particulates, and to cool the flue gases before entering the induced-draft fan. The gas scrubber has two systems of four banks each to provide water to the horizontal spray chamber and to the horizontal scrubbing chamber.

Alkali-pH-controlled water supplies one spray system for the spray chamber to neutralize any acids present in the flue gases and to reduce their temperature to 675°F. The scrubbing chamber is supplied by the second spray system to further cool the flue gases to 300°F and remove the particulates in the flue gases before entering the induced-draft fan. The scrubbing wastewater is taken to a bio-treatment tank or bled with plant wastewater in the final oxidation pond before returning it to nature.

### TRANSPORTATION

Industrial wastes will be picked up from various plants, loaded on special trucks, and hauled to the disposal facility.

Liquid wastes will be transported in 2500 to 7000-gal tank trucks. Small liquid-waste loads will be placed in 55-gal drums and loaded on trucks. Semi-solid sludges will also be placed in 55-gal drums and loaded on trucks. Solid wastes will be loaded directly into special 20-ton trucks and hauled to the disposal facility.

All wastes will be weighed, inspected, and routed to their respective storage areas according to the process required to dispose of them. The noncombustibles will be segregated from the combustibles.

Solid wastes will be placed in a storage area separate from that assigned to combustible liquid wastes.

### MATERIAL HANDLING AND STORAGE

#### Solid Wastes

Although processing (sizing) of solid wastes is desirable, no attempt is made at this time to provide size reduction or magnetic separation of ferrous metals. The wastes will be placed in containers on a conveyor system pneumatically controlled for automatic discharge into the kiln according to a programmed time cycle.

The major portion of solid wastes will be stored in 55-gal drums. The wastes will be stored in the drums as they are received, placed on pallets, and stacked three to four high in the storage area. The drums still on pallets will then be removed, one load at a time, from the storage area and placed on a feeding conveyor for automatic firing in the kiln.

####液Wastes

Combustible liquid wastes will be stored in a segregated area adjacent to the solid-waste area. Storage tanks will be designated to receive certain wastes according to predetermined specifications. The tank storage area has been designed to meet all local ordinances and F.I.A. (Factory Insurance Association) requirements.

Liquid wastes are taken from various storage tanks and pumped into batch tanks equipped with continuous mixing. The liquid wastes in the batch tanks are blended to a uniform viscosity and consistency to maintain ignition and flame characteristics. Two batch tanks are provided, so that, while one tank supplies fuel to the furnace, the other tank is being processed. Batch tanks supply a uniform waste that is very helpful in the control of good burner performance. Controlled batch mixing assures that the fuel and moisture content are within an acceptable range to maintain ignition and sustain the flame.

### OPERATION

The rotary kiln and Loddby furnace operate in parallel with exhaust gases discharged into a common afterburner chamber. The exhaust gases then pass through a multiple-purpose heat-recovery chamber, a spray and scrubbing chamber from which the flue gases are drawn by an induced-draft fan to a steel stack for discharge to the atmosphere.
Fig. 4 Burning-Facility Flow Diagram, Solid and Liquid Wastes
The facility can operate with both furnaces on or with one furnace on while the other furnace is off (see Fig. 4).

**Furnace load (Btu/h x 10^6):**

<table>
<thead>
<tr>
<th></th>
<th>Continuous</th>
<th>Maximum-2h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiln</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Loddby</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>145</td>
</tr>
</tbody>
</table>

**Gas temperatures (°F):**

<table>
<thead>
<tr>
<th></th>
<th>Kiln – out</th>
<th>Loddby – out</th>
<th>Afterburner – out</th>
<th>Spray – out</th>
<th>Scrubber – out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1400 – 2400</td>
<td>2200 – 2800</td>
<td>1700 – 2550</td>
<td>675</td>
<td>300</td>
</tr>
</tbody>
</table>

**Air temperatures (°F):**

<table>
<thead>
<tr>
<th></th>
<th>Kiln – in</th>
<th>Loddby – in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70</td>
<td>400</td>
</tr>
</tbody>
</table>

**Water flow (gal/min):**

<table>
<thead>
<tr>
<th></th>
<th>Scrubber – in</th>
<th>Evaporation</th>
<th>Waste</th>
<th>Recirculated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>450 – 575</td>
<td>150 – 200</td>
<td>50 – 75</td>
<td>250 – 300</td>
</tr>
</tbody>
</table>

**Rotary Kiln**

Solid wastes are fed into the furnace automatically, on a preprogrammed cycle, one batch at a time. Feed hoppers of 8-ft³ capacity are placed on a conveyor to be unloaded into the furnace one at a time. The opening of the furnace door, unloading of the hopper, and the closing of the furnace door are all operated automatically.

The rotary-kiln afterburner, 9 million Btu/h, is a high-speed rotary cup burner designed to burn liquid wastes and/or natural gas. The afterburner is a complete unit with its own forced-draft fan and combustion safeguards required by the F.I.A. Any drop in fuel pressure, flame failure, or other combustion safeguard malfunction, will shut off the operation. The afterburner preheats the kiln prior to startup, after which it maintains furnace temperature.

In an emergency, should the Loddby furnace be out of service, the kiln can maintain operation by burning liquid wastes and solid wastes on a limited capacity.

The rotary kiln is equipped with furnace temperature control, temperature recorders, furnace-draft indicator, and a high furnace-temperature alarm.

**Loddby Furnace**

The Loddby furnace is designed to burn liquid wastes only. The liquid wastes are pumped from a batch-blending storage tank to an air-atomized burner located in the center of the horizontal furnace. The burner can fire liquid waste and/or natural gas. The natural-gas burner maintains combustion when liquid wastes cannot independently maintain combustion in the furnace. An automatically operated ignitor lights the fuel from the main burner. A forced-draft fan furnishes combustion air for the burner and introduces secondary air, tangentially, into the furnace through a number of ports along the barrel. Dampers for each port control the secondary-air supply.

The secondary air is heated to about 400°F by an air preheater located between the forced-draft-fan outlet and the Loddby furnace. The air preheater – 6 million Btu/h – is a direct-fired natural-gas heater, automatically controlling the temperature of the secondary air entering the Loddby furnace.

Necessary combustion safeguards for the Loddby operation have been included to meet F.I.A. requirements and local ordinances. Combustion controls and instrumentation installed to provide good operation of the Loddby include the following:

- **Combustion Control**
  - Fuel-airflow ratio
  - Draft control
- **Temperature Control**
  - Flue-gas furnace outlet temperature
  - Secondary air – air-preheater outlet temperature
- **Indicator – Recorder**
  - Airflow
  - Waste fuel flow
  - Flue-gas temperature
  - Secondary-air temperature
  - Furnace draft

A fully enclosed self-standing control cabinet will house the instrumentation and controls. The burner-control arrangement permits burner-front operation. The burner-control system and the combustion-control panel are located in the vicinity of the burner front for easy visual observation by the operator.

**Startup Sequence**

The following conditions must be proved prior to and during purge:

1. Fuel trip valves closed
(2) Forced-draft fan induced-draft fan in operation
(3) Purge flow established greater than 30 percent.
Purge is then initiated.

Air Preheater

After successful completion of purge, the direct-fired heater may be energized, provided that purge flow is maintained. As soon as air-heater flame has been proved, the air-heater combustion control may be transferred to modulating control.

Main Gas Burner

After completion of the purge, the main gas ignitor may be activated provided that purge airflow is maintained. At this point, the regular sequence follows:

1. Prove the ignitor.
2. Open gas-valve low-fire position.
3. Light main burner.
4. Adjust fuel-air ratio.

Main Liquid-Waste Burner

Before placing liquid-waste burner in operation, the operator should be satisfied that the Loddby operating temperature has been reached. After that, the procedure is similar to that of lighting the gas burner.

CONCLUSION

The entire operation has been designed for the maximum efficiency available with today's knowledge and a minimum of operating personnel. The installation will undergo a series of tests to obtain the following information:

1. To verify the design parameter.
2. To prove the system design criteria.
3. To develop data for future improvements in the art of burning industrial wastes.

ACKNOWLEDGMENTS

The author wants to take this opportunity to thank the following for their cooperation in preparing this paper: A.B. Mindler, P. E., International Hydronics; L. J. Cohan, Combustion Engineering, Inc.; and E. M. Polsak, P.E.; Bartlett Snow Company.