ABSTRACT

Unexpected delays in completing a Liquid/Fluid Incinerating Facility for the Metropolitan Sewer District of Greater Cincinnati, Ohio permitted the implementation of modifications to reflect changes in waste quantities and characteristics, as well as to replace weather-damaged equipment. The systems installed include: a nitrogen blanket as an explosion retardant within the storage tanks; an electric heat trace system to replace a similar hot water system destroyed by freezing; new storage tank insulation; an insertion silencer to decrease excessive fan noise; a change in burner atomization; and grit hopper modifications. System startup is also discussed.

INTRODUCTION

In response to the need for efficient, environmentally correct disposal of industrial wastes in the Cincinnati area, the Metropolitan Sewer District of Greater Cincinnati, Ohio (MSD), constructed a Liquid/Fluid Incinerating Facility (L/FI) within the boundaries of the Cincinnati Mill Creek Wastewater Treatment Plant. The L/FI also is designed for disposal of sewage solids, which consist of skimmings, screenings and grit resulting from the sewage treatment processes. The design concept of the facility was described in Reference [1].

The L/FI was originally scheduled to be placed in operation in late 1975. However, because of numerous delays, startup of the facility was postponed until 1979. Most of the more than three year delay was caused by difficulties with the general contractor and a major subcontractor. The general contractor filed for bankruptcy early in the job and assigned completion of all remaining work to a third party. The Thermal Reduction Equipment subcontractor had a major reorganization during the construction period and this change in personnel, coupled with failure of the general contractor, also contributed greatly to the delay. While job progress was wanting, the situation presented an opportunity to reevaluate the nature and quantity of waste materials expected.

EXPLOSION MITIGATION MEASURES

The original study of waste disposal in the Greater Cincinnati area was undertaken in late 1970, and a waste survey performed by MSD early in 1977 indicated that in the interim the available wastes had degraded in quality and increased in quantity. Types of industrial wastes as determined by the 1970 and 1977 surveys are shown in Table 1. The change in both quantity and quality of the available wastes brought additional considerations to the fore.

Primary among the concerns was the fact that many wastes have relatively low flashpoints, and in fact the presence of an explosive mixture within the storage tanks became a significant possibility. To deal with this situation, a nitrogen blanket was used as an explosion retardant. Existing 4 in. (102 mm) vent piping, which was interconnected be-
TABLE 1. CLASSIFICATION OF LIQUID FLUID WASTES

<table>
<thead>
<tr>
<th>Category</th>
<th>General Description</th>
<th>Materials Included</th>
<th>1970 Survey Percent of Total</th>
<th>1977 Survey Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Light hydrocarbons &amp; non-aqueous solvents</td>
<td>Benzol, toluol, aromatics, cellosolve</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>Medium to heavy-weight hydrocarbons, etc.</td>
<td>Crankcase oils, still bottoms, transformer oils</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>III</td>
<td>Low water content aqueous wastes</td>
<td>Clabberstock, soaps, fatty acids, alcohols, cutting oils</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>IV</td>
<td>Dirty solvents</td>
<td>Kerosene, soluble oil residue, oil-soluble inks, ink wastes, organic pigments</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>V</td>
<td>High water content aqueous wastes, semi-solids and sludges &amp; low heating value liquids</td>
<td>Paint overspray, liquid polymers, chlorinated solvents, oil sludge</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>VI</td>
<td>Skimmings from Mill Creek WTP</td>
<td>Grease, soaps, etc.</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>VII</td>
<td>Spent earth</td>
<td>Diatomaceous earth, oils</td>
<td>13</td>
<td>0</td>
</tr>
</tbody>
</table>

Between all of the waste storage tanks, was utilized for nitrogen distribution. The nitrogen source was a liquid nitrogen storage tank, sized to provide 400 standard ft³ (11.3 m³) per hour of gaseous nitrogen at a system pressure of 0.1 in. (2.5 mm) water column. Vacuum breakers which had been provided to protect the tanks from collapse under draw of liquid were removed and the ports blanked off. Low pressure alarms were provided in the nitrogen supply header to signal the operator of the existence of low pressures within the tank farm. The operator would then have the option of increasing nitrogen flow or decreasing fluid flow from the tanks to prevent a low pressure condition which could damage the storage tanks. (Twenty two tanks ranging in size from 8 ft-18 ft (2.4 m-5.5 m) were pressurized with nitrogen.)

**ELECTRIC HEAT TRACE SYSTEM**

A hot water heat trace system was provided in the original facility design, with hot water produced by either of two 4 million Btu (4.22 GJ) per hour, No. 2 fuel-oil-fired, hot water heating units. This hot water supply is also used to heat waste fuels to control their viscosity. The lines were originally filled by the Contractor as part of a test of the system, and presumably drained. After acceptance, every effort was made to drain the heat trace system in preparation for the winter months, but enough water remained in the lines so that the cold winter effectively ruined the heat trace installation. Replacement of the hot water heat trace system with electric heat trace tape was examined. On a cost basis, the totals of operating cost plus amortized capital cost were equivalent for both systems. It was determined, however, that the electric heat trace system would provide more reliable freeze protection, and also promised lower maintenance costs. Self-limiting heat trace systems were available that limit the temperature of the heat trace tape to less than 200 F (93 C) through the internal physics of the tape. This type of electric heat trace was installed, replacing the damaged hot water heat trace system.

**NEW STORAGE TANK INSULATION**

A related problem occurred with the storage tank insulation. All the waste storage tanks are insulated to allow reasonable product temperatures to be maintained. However, as the tanks were idle for a period of years, moisture accumulated within the insulation through seepage in the insulating jacketing and through the natural humidity within the surrounding air. The insulation eventually became waterlogged and lost its structural integrity. To correct this problem, insulation on the tops...
of the storage tanks was replaced, not with the original fiberglass, but with expanded perlite. The perlite, although not as efficient a thermal insulator as fiberglass, has a water absorption coefficient close to zero. It is virtually unaffected by moisture, and will not “wick” up moisture, as fiberglass will. In addition to changing the insulating material, the construction of the jacketing material fastened to the tank top insulation was modified. Standing seams were used in lieu of lap joints to minimize, if not eliminate, the possibility of water passing through the jacketing and coming to rest on the steel tank top.

FAN NOISE REDUCTION

The thermal reduction equipment is driven by an Induced Draft (ID) fan, turned by a 1500 hp (1,120 kW) motor. The ID fan is rated at 120,000 ft³ (3400 m³) per minute and 50 in. (1.27 m) water column, and is close-coupled to the exhaust stack. The fan was placed in continuous operation during a period of four and a half days, during bake-out of furnace refractory. Noise produced by the fan was severe at the job site and was a cause of concern. In addition to local noise levels, however, a noise component was broadcast to the surrounding areas external to the facility. Complaints of noise were made by residents of luxury-type apartment buildings overlooking the plant (see Fig. 1). Under the threat of a lawsuit from the apartment residents, MSD had to promise not to proceed with any equipment checkout which would require operation of the ID fan until the broadcast noise was brought under control.

Investigation of the plant noise audible from the apartment left no doubt that it was generated by the ID fan. The fan turns at 1200 rpm, or 20 rps, and has eight blades, which produce a tone of 8x20 or 160 Hz. The measured peaks in the sound spectrum at the apartment complex were at 160 and integral multiples of 160, i.e. 320, 480, etc., Hz. To resolve this difficulty, an insertion silencer was designed and installed within the exhaust stack. It was of the splitter type with perforated splitter sections filled with sound-absorbing mineral wool, and provisions were included to prevent closing of the perforations from a build-up of particulate. Resonating type silencers were evaluated, but they were rejected in favor of the absorbing device. Although the broadcast noise generated was pure tone (160 Hz), the complexity of the equipment arrangement would not assure satisfactory attenuation if the pure tone was eliminated from broadcast by resonance.

In use, this silencer proved to be very effective,
TABLE 2. SOUND PRESSURE LEVELS IN OCTAVE BANDS AT THE APARTMENTS WITH 10 FAN ON AT FULL CAPACITY

<table>
<thead>
<tr>
<th>Octave Band Center Frequency, Hz</th>
<th>Before Silencer</th>
<th>After Silencer</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>72</td>
<td>69</td>
<td>71</td>
</tr>
<tr>
<td>125</td>
<td>78</td>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>250</td>
<td>80</td>
<td>60</td>
<td>62</td>
</tr>
<tr>
<td>500</td>
<td>64</td>
<td>57</td>
<td>58</td>
</tr>
<tr>
<td>1000</td>
<td>59</td>
<td>52</td>
<td>56</td>
</tr>
<tr>
<td>2000</td>
<td>54</td>
<td>46</td>
<td>50</td>
</tr>
<tr>
<td>4000</td>
<td>42</td>
<td>37</td>
<td>43</td>
</tr>
<tr>
<td>8000</td>
<td>37</td>
<td>37</td>
<td>61</td>
</tr>
</tbody>
</table>

Reducing the broadcast noise below that of the background, as can be seen in Table 2. The single tone reduction at 160 Hz was greater than 20 dB.

CHANGES IN BURNER ATOMIZATION

As designed initially, the two furnaces had identical burner arrangements: one center gun, with a second as a spare, for burning high-quality fuel, and four peripheral guns for the high-aqueous, higher-viscosity waste fuels. These ten burners were designed with compressed air as the fuel-atomizing medium, and two 500 standard ft³ (14.2 m³) per minute air compressors were provided at the facility for this purpose. Air flow was automatically modulated in the center guns to provide 35-50 psig (241-345 kPa) above the fuel delivery pressure. No automatic equipment was provided for the peripheral guns, which were designed to have their atomizing air supply set manually in response to the viscosity and pressure required by the waste fuels. The burners supplied by the equipment manufacturer, however, required more atomization (pounds per hour of compressed air) than was available.

On the basis of a cost-effective analysis, it was decided to keep the center burner guns on air but to change atomization on the peripheral burner guns to steam. Later, however, the scarcity and cost of fuel oil made it advisable to change the center guns to the externally atomized type. Steam was chosen for the atomizing fluid because the necessary additional air was not available and installation of air compressor equipment would have been too costly. A source of steam was available some 2500 ft (762 m) from the burning equipment, and was calculated to be more economical even considering the cost of transmitting steam this distance and the fuel oil required to produce the necessary amount of steam.

Control of atomization at the peripheral burner guns was manual, and changing from compressed air to steam required virtually no changes to the piping or valves. However, use of steam in the new center burner guns required modification of the burner control train to insure compatibility with the steam temperature and its residual moisture. Atomizing steam was provided at the thermal reduction equipment at a pressure of 100 psig (689 kPa), nominal, saturated, which has a temperature of approximately 338 F (170 C).

The new center burner design (Coen Dual Liquid Atomizers) provides for the simultaneous burning of fuel oil and waste by means of three concentric cylinders terminating in a nozzle. Waste flows through the inner cylinder [½ in. (12.7 mm) dia.], and fuel oil through the outer cylinder [2 in. (50.8 mm) dia.]. The assembly terminates in a nozzle with peripheral holes for ejection of a fuel-oil-steam mixture and an inner circle of steam jets to atomize waste flowing from the inner cylinder. With this design, fuel oil will support initial combustion, while the burning of waste containing filterable solids, but otherwise of sufficient heating value, begins from the inner cylinders. Once this combustion has been established the fuel oil supply may be shut off.

GRIT STORAGE SYSTEM MODIFICATIONS

Grit from the treatment plant is stored at the L/FI in a series of three hoppers. This material is granular and contains from 15-25 percent moisture by weight. It will usually pick up a grease coating from the grease and scum component of the wastewater. Although the hoppers were designed to free-flow grit by gravity, the grit did not behave as expected, and instead caked and would not flow. Furthermore, the stored grit gradually hardened to form a solid mass which had to be mechanically removed from the hoppers.

Air guns were installed, three guns in each of the three hoppers. Compressed air was sequenced with automatic timers to blast inside the hopper, one gun at a time. The air guns were found to be very effective in agitating the grit, preventing it from agglomerating and allowing it to flow to discharge conveyors beneath the hoppers.

SYSTEM START-UP

LF/I operation began in the Fall of 1979. After the equipment was checked out using No. 2 fuel oil, high quality wastes were introduced into the system. These initial wastes were received from a local waste collection service and was a mixture of acetates, mixed ketones, industrial solvents and...
other materials. They had a low moisture content, a chloride component of as much as 5 percent by weight, and heating values ranging from 7500-14,000 Btu/lb (17,400-32,600 kJ/kg).

The center guns were started up on fuel oil, using steam as the atomizing medium. After the furnace was brought to operating temperature, waste fuel was admitted to the appropriate annular space in the burner, so that waste fuel and fuel oil were firing simultaneously. After satisfactory firing of both fuels was demonstrated the fuel oil stream was shut off, and firing continued with the waste fuel as the only fuel fired. The temperature at the outlet of the cyclone furnace was controlled to 2500 F (1371 C).

The Coen Dual Liquid Atomizers (the center guns) operated in a satisfactory manner on both No. 2 fuel oil and waste fuel. Further downstream in the process the alkali scrubbing was fully operational. A relatively constant pH levels was maintained in the scrubber/quencher water flow by automatic alkali injection in response to pH value.

The cyclone furnace peripheral burners operated satisfactorily during a two hour demonstration burn using waste of 7500 Btu/lb (17,400 kJ/kg) heating value.

Work in the immediate future will include optimizing the steam-waste ratio and testing the system for the destruction of waste having a high chloride content.

REFERENCE


Key Words
Cincinnati
Cyclone
Emission
Environment
Incinerator
Municipality
Rotary Kiln