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Project Summary

Plant-Scale Demonstration of Sludge Incinerator Fuel Reduction

Albert J. Verdouw, Eugene W. Waltz, and Webb Bernhardt

A field research and demonstration project was conducted to reduce fuel consumption in sludge incinerators by using a more fuel efficient incinerator operating mode and improving instrumentation and control systems. A low-capital-cost approach to achieving major fuel reduction was operationally demonstrated by the City of Indianapolis Department of Public Works at its Belmont Wastewater Treatment Plant Incineration Facility in Indianapolis, Indiana, using eight conventional multiple-hearth incinerators.

The existing incinerators were upgraded with modern instrumentation and control systems for sludge flow rate, fuel flow rate, fuel flow control, airflow control, and exhaust oxygen analysis of the combustion process. A more fuel efficient operating mode was developed from an extensive program of combustion engineering measurement, testing, and operational analysis. The incinerator operators were then given a training program on the new equipment and operating mode. The new operating mode with improved instrumentation and control systems was also effective in enabling the existing incinerators (equipped with low-energy, cyclonic-type scrubbers) to meet particulate emission standards.

During an 8-month period of routine operations, fuel consumption was reduced 34 percent, thus saving more than $900,000 per year. And because all eight of the incinerators, using the new operating mode, passed official particulate emission tests, the city saved more than $2 million in capital costs that would have been required to retrofit the incinerators with new scrubbing equipment.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Incinerating municipal sewage sludge often uses large amounts of auxiliary fuel. Increasing energy costs have made incinerator fuel consumption a major problem for many treatment plant operations. Using more fuel efficient operating modes and improving existing instrumentation and control systems can reduce incinerator fuel consumption and prove cost effective for municipal operators.

The City of Indianapolis Department of Public Works developed a new, more fuel-efficient incinerator operating mode through extensive operational testing at its Belmont Wastewater Treatment Plant Incineration Facilities. These tests determined, and operationally verified, the changes and improvements needed to reduce fuel consumption and achieve steady incinerator operation at reduced operating temperatures. The operational testing and analyses involved:

- A combustion engineering analysis of the multiple hearth incinerator operating process.
- Extensively instrumenting one incinerator to measure (a) excess air, (b) internal incinerator gas and sludge temperatures, (c) flow rates of all incinerator air supply sources and exhaust gas locations, (d) exhaust gas composition, and (e) total and burner-specific fuel flow rates.

- Parametric experimental testing to determine the effect of the following incinerator variables on fuel consumption: (a)excess air, (b) sludge load rate, (c) sludge moisture and volatile content, (d) incinerator airflow, (e) combustion zone location, (f) incinerator temperature, (g) fuel burner settings, (h) use of rabble arm cooling air, and (i) sludge residence time.
- A comparative analysis of the analytical and experimental data to determine the relationship between specific fuel consumption and key incinerator operating variables.
- A kinetic incinerator analytical model to predict the lowest possible fuel consumption from optimum incinerator operation. The model's predictions of incinerator fuel requirements provide a process-rate-determined solution that accounts for the gas temperatures, sludge composition, and heat transfer rates that vary throughout the incinerator volume.
- Using these test results and analyses to specify a new, more fuel-efficient operating mode.

New Operating Mode and Control System

The new operating mode and control system improvements were used in full-scale plant operations. The operating mode included specific, detailed settings for optimizing the combustion zone location, airflow management, fuel burner use profiles, and air and fuel flow rate guidelines for various sludge cake load ranges and moisture and volatile characteristics. The key features of the operating mode involve operational settings to maintain:

(1) a steady sludge cake feed rate,
(2) the lowest possible incinerator draft to reduce air leakage,
(3) the proper oxygen level associated with a given load rate and cake moisture and volatile content to maintain the most efficient excess air level,
(4) the minimum required fuel flow rate for a given load rate and cake moisture and volatile content (see Figure 1 for an example),
(5) control of combustion zone location with burner use firing profiles and air flow management, and
(6) optimum throughput rate with proper center shaft speed.

These guidelines and other equipment-specific techniques and instructions were included in an operational manual for training and instruction programs for the operators.

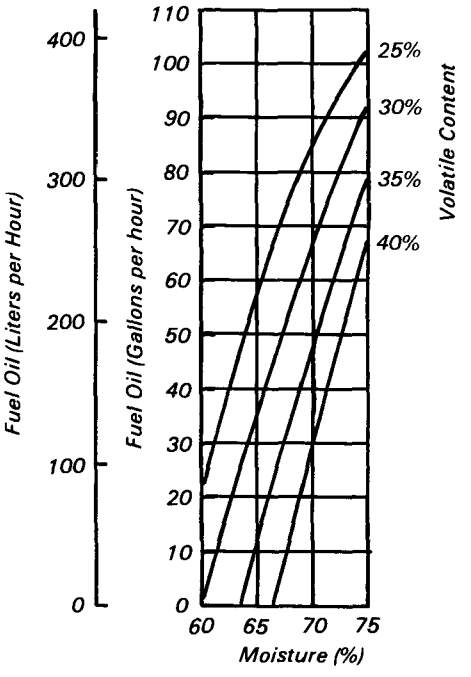

Figure 1. Fuel flow guidelines in liters of oil per hour for 6.4 metric tons (7 tons) of sludge cake per hour.

The older instrumentation and control systems of the Indianapolis operation were also upgraded to enable a greater degree of remote control by the operator in conjunction with the new operating mode. New systems were designed and installed for (1) air flow control, (2) fuel flow control, (3) oxygen analysis, (4) fuel flow rate measurement, and (5) sludge cake load rate measurement.

The total cost for the engineering design, purchase, and installation of these new systems averaged $20,000 per incinerator.

Results

Fuel Consumption

A full-scale plant demonstration determined that $900,000 per year of fuel was saved by using a more fuel efficient operating mode and upgrading the incinerator control systems. The 8-month operational test period from November 1980 through June 1981 was compared with the baseline operational year for 1977, the last full calendar year of operations before any changes were initiated in the incinerator operating mode or control equipment. Plant operational records for both periods were used to obtain fuel consumption, load rates, incinerator operating hours, and sludge cake moisture and volatile data for comparative analysis. The principal measure used for comparing fuel consumption was the specific fuel consumption (SFC) defined as liters of oil per dry volatile metric ton of sludge cake incinerated. The SFC is also directly related to the absolute ratio of sludge cake moisture to volatile content (kg/kg). An accurate comparison of SFC must account and correct for the moisture to volatile (M/V) ratio of the sludge cake being incinerated to avoid a distorted comparison. For this reason, the relationship of the daily average SFC and the sludge cake M/V ratio for the demonstration period was computed and compared with the same relationship recorded for the 1977 baseline operations.

A least squares regression analysis was made for the SFC versus sludge cake M/V ratios for both time periods. The computed regression straight lines, drawn to reflect the overall changes observed, can be compared (Figure 2). Table 1 shows the respective averages of the other operational variables for the two time periods.

As shown in Figure 2, the average sludge cake M/V ratio was higher for the demonstration period than in 1977; this reflects dewatering process changes that occurred between the two periods. The SFC was reduced, as was the basic relationship between SFC and M/V as reflected by the decreased rate of increase of SFC with M/V ratio. At the low M/V ratio of 6, the SFC difference was 27%, and at the high M/V ratio 8.5, the difference was 41% (Figure 2). The SFC difference corresponding to the average sludge cake M/V ratio for the demonstration period was 34%. This result does not represent the full fuel reduction potential since four out of the eight incinerators were not fully equipped with the new control systems until 3 months after the demonstration period began. Even so, the 34% demonstrated fuel reduction average represents annual fuel savings, or cost avoidance, of over $900,000 per year based on oil prices of $1.00 per gallon. A 2-day test period after the project was completed demonstrated that additional savings were possible. When technical supervision was present at the operation for 24 hours per day coverage, a 70% average decrease in SFC was demonstrated (Figure 2).

An analysis of operational data available from other cities shows that 20% to 50% fuel savings are possible if these cities use the fuel efficient mode of operation.

Table 1. *Daily Average Values of Key Operating Variables for Baseline and Demonstration Periods*

Operating Variable	Daily Average Value 1977 (12 Months)	8-Month Demo Period	Percent Difference
Cake Load:			
Wet Metric Tons	767.8	817.3	+6.5
Dry Volatile Metric Tons	78 1	83.5	+6.9
Percent Moisture	64.1	71.7	+11.9
Percent Volatiles	29.6	37.3	+26
Moisture/Volatile Ratio	6.13	7.07	+15
Incinerator Hours	115	116	--
Load Rate (Wet Metric Tons/ Incinerator/Hour)	6.76	7.04	+4

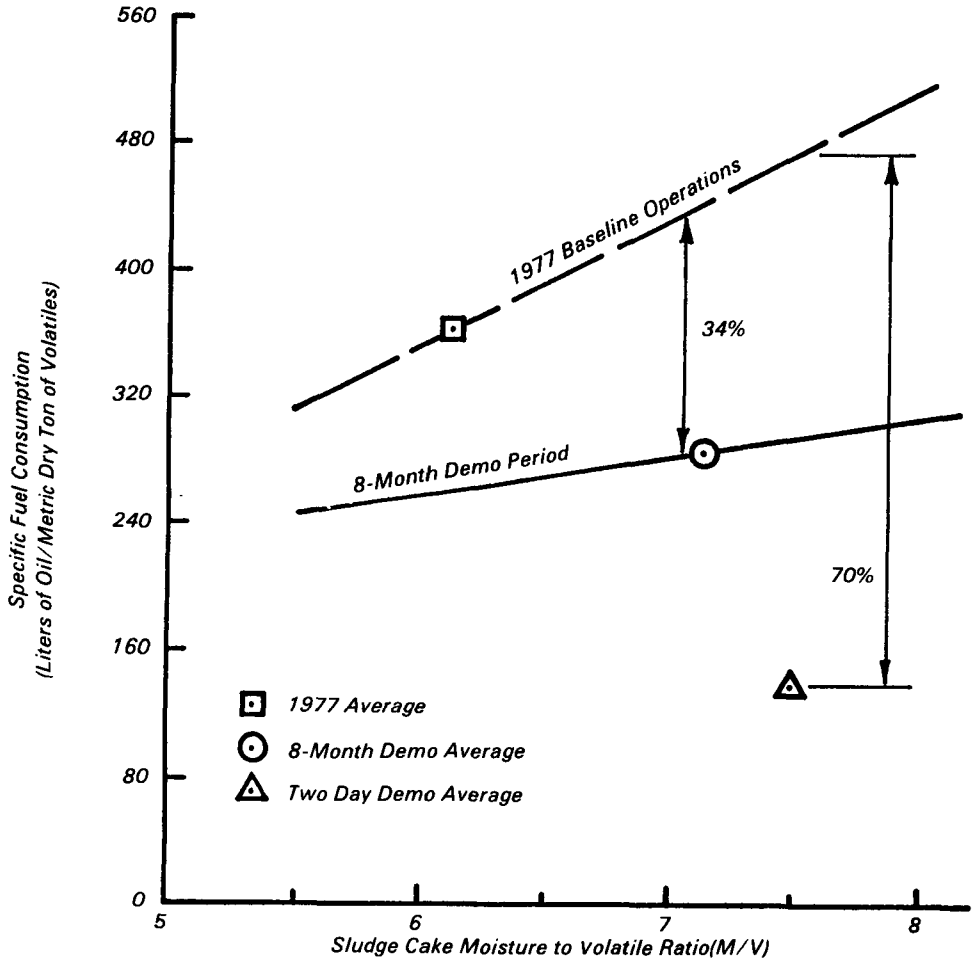

Figure 2. *Comparison of specific fuel consumption for the 1977 baseline and the 8-month demonstration period.*

Particulate Emissions

The impact of the new operating mode and control systems on incinerator particulate emissions was also assessed. The Indianapolis incinerators are equipped with low energy cyclonic stack gas scrubbers with no impingement trays for particulate removal. When the incinerators were tested before this project began, they were in violation of the emission standard with readings as high as 0.6 g of particulate per kilogram of dry exhaust gas corrected to 50% excess air.

All eight incinerators were officially tested using the new operating mode and control systems. The average emission level of these tests was 0.135 g per kilogram of exhaust gas; this represented a 75% reduction in emission levels. Because all eight incinerators were brought into official compliance, a $2 million bond issue, needed to fund retrofitting the incinerator scrubbing system, was avoided.

Conclusions

The principal conclusions from this in-plant research and demonstration project were:

- Incinerator auxiliary fuel consumption can be significantly reduced by using more fuel efficient operating modes and improving existing operating control systems.
- Fuel reductions can be easily and quickly achieved through operational mode changes alone in current incinerator facilities without having to make major or high cost equipment changes.
- The use of more fuel efficient operating modes will also reduce maintenance costs and incinerator downtime.
- Significant reductions in particulate emissions loadings to the stack gas scrubbers are achieved when fuel efficient operating modes are used.
- A 34% fuel reduction was achieved over an 8-month, plant-scale demonstration period representing a savings of over $900,000 per year. Limited analysis of operational data from other cities shows similar potential savings from 20% to 50% are possible.
- Costs for upgrading instrumentation and control systems and operator training totaled approximately $20,000 per incinerator with a payback period in fuel savings or cost avoidance of less than 3 months.

Recommendations

- Most municipal sludge incinerator operations are still experiencing high

fuel consumption rates as a result of using improper incinerator operating modes. Incinerator operating modes should be technically investigated to identify inefficient practices, instrumentation and control inadequacies, and special operator training needs so they can be cost effectively corrected to achieve significant fuel savings.

- Operational tests are critically needed to further verify the interrelationship of incinerator operating modes with particulate emissions and pollution control equipment. Such tests are essential to correct a serious void that currently exists in the analytical and operational understanding of how incinerator operating modes affect particulate emissions. This information would help municipal operators comply with incinerator particulate emission standards.
- Operational tests should be conducted to determine the effect of fuel efficient operating practices on hydrocarbon or odor emissions.

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Albert J. Verdouw and Eugene W. Waltz are with Indianapolis Center for Advanced Research, Indianapolis, IN 46204; and Webb Bernhardt is with the City of Indianapolis, Department of Public Works, Indianapolis, IN 46204.
***Howard O. Wall** is the EPA Project Officer (see below).*
The complete report, entitled "Plant-Scale Demonstration of Sludge Incinerator Fuel Reduction," (Order No. PB 83-259 697; Cost: $11.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

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