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Project Summary

Sewage Sludge Incinerator Fuel Reduction at Nashville, Tennessee

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A field demonstration project was conducted to reduce fuel consumption in municipal sludge incinerators using a more fuel efficient incinerator operating mode, which was developed at Indianapolis, Indiana, Belmont Treatment Plant. The Nashville-Davidson County Department of Water and Sewerage Services demonstrated the new operating mode in Nashville, TN, with the use of two, conventional, multiple hearth incinerators.

The more fuel efficient operating mode was developed from an extensive program of combustion engineering measurement, testing, and operational analysis. Incinerator operators were given on-the-job training in the new operating mode during a 30-day demonstration-training period. After 1 year of routine operations in the new mode, the use of fuel was reduced more than 40%; this represents fuel cost savings of approximately $350,000 per year.

The project exemplified how cost effective efforts can improve and optimize existing incinerator operation. This project also successfully transferred and applied incinerator operating technology developed by the City of Indianapolis Department of Public Works and the Indianapolis Center for Advanced Research under sponsorship of the U.S. EPA Municipal Environmental Research Laboratory. The Indianapolis work included a projection that most plants could reduce their fuel costs 20% to 50% if fuel efficient operation were used, and this work confirms that projection.

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

Because incinerating municipal sewage sludge often uses large amounts of auxiliary fuel, increasing energy costs have made incinerator fuel consumption a major operating problem. Using more fuel efficient operating modes can reduce this consumption, and efforts to optimize existing operating systems can be cost effective for municipal operators.

The Department of Water and Sewerage Services of Nashville-Davidson County designed a new, more fuel efficient operating mode by adapting incinerator operating technology developed in Indianapolis, IN. The Nashville Center Wastewater Treatment Plant has two 10-hearth incinerators with a design capacity of 10 wet tons of sludge cake per incinerator per hour. With technical assistance from the Indianapolis Center for Advanced Research, the Nashville-Sewerage Department conducted a series of operational tests, measurements, and analyses to determine the specific operating settings and improvements required to reduce fuel consumption and achieve steady incinerator operation. A combustion engineering analyses was made of the complete incinerator operation including measurements of specific air flow rates, fuel flow, and load rate dependent performance parameters.

Performance tests determined the fuel consumption performance of the inciner-

ators at specific settings for excess air, load rate, sludge cake moisture and volatile characteristics, total airflow, burner use profile, and various airflow management approaches suited to the given equipment design and operational set-up.

A kinetic incinerator analytical model was also used to predict the lowest fuel consumption possible with optimum incinerator operation The model's predictions of incinerator fuel requirements provided a process-rate-determined solution accounting for gas temperatures, sludge composition, and heat transfer rates, which vary throughout the incinerator volume.

These test results were then used to specify a new, more fuel efficient operating mode for trial testing and demonstration.

New Operating Mode

In the past, incinerator operation was characterized by each operator having his own specific operating practices and techniques for maintaining temperatures on various hearth levels and for managing incinerator airflow. Several common operating problems were associated with the operator-specific modes:

- incinerator exhaust temperatures were too high in the furnace,
- incinerator draft pressure was greater than necessary,
- rabble arm cooling air return was underutilized,
- auxiliary air supply was being overused, and
- burner use pattern were not optimum.

Other problem areas, including the management of the sludge cake loading to the incinerators, were also contributing to high fuel consumption.

The new operating mode included specific, detailed settings for optimizing the combustion zone location, airflow management, fuel flow rates needed for given sludge cake load ranges, and moisture and volatile characteristics. The key features of the operating mode involved operational settings to maintain:

- a steady sludge cake feed rate,
- the lowest possible incinerator draft to reduce air leakage,
- the proper oxygen level associated with a given load rate to maintain the most efficient excess air level,
- the minimum required fuel flow rate for a given load,
- control of combustion zone location with burner use firing profiles and air flow management, and
- optimum throughput rate with proper center shaft drive speed.

Results

A full, plant scale, operational demonstration test was conducted to determine how much fuel was saved by using a more fuel efficient operating mode. The 10-month operational test period was from November 1980 through August 1981. A 29-month baseline operational period was used for comparison (January 1, 1978, through May 31, 1980). 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 analyses. The principal measure used for comparing fuel consumption was specific fuel consumption (SFC) defined in cubic feet of gas per dry ton of sludge cake incinerated. The SFC is also directly related to the absolute ratio of the sludge cake moisture to volatile content (M/V) on a weight basis. An accurate comparison of SFC must account and correct for the M/V ratio of the sludge cake being incinerated to avoid a distorted comparison. For this reason, the relationship of the daily average SFC with the sludge cake M/V ratio was computed and compared for the two periods.

A least squares regression analysis was made for the SFC versus sludge cake M/V ratios for both time periods. The results of these analyses can be compared in Figure 1. Table 1 shows the respective averages of the other operational variable for the two time periods.

As shown in Figure 1, the SFC was reduced, as well as the basic relationship between SFC and the sludge cake M/V ratio, reflected by the decreased rate of increase of SFC with M/V ratio. At the low M/V ratio of 6, the computed SFC difference was 22.6%, and at the high M/V ratio of 10, the difference was 42%. For the 10-month period, the average fuel reduction was 38.9%.

The 38.9% reduction represented a fuel savings of 5,612 cubic feet of gas per dry ton of cake incinerated. For the 10-month period, the total fuel savings was 59,670,154 cubic feet of gas. At this reduction level, the annual gas savings was approximately 71,604,180 cubic feet of gas that, at a gas price of $3.50 per 1000 cubic feet, represents direct savings of *$250,000 per year* for incineration fuel.

Operational records were also analyzed to determine the reduction in standby fuel resulting from improved sludge load management to the two incinerators as part of the new operating procedures. The plant loading rate was not large enough to keep both incinerators on line at, or near, design capacity. The past practice had been to run both incinerators at capacity until the sludge inventory level was reduced to a point that one of the incinerators had to be put on standby operation. In the new operating mode, both incinerators were operated continuously at lower loading rates thus enabling the standby fuel use to be drastically reduced. Comparison of standby fuel use rates during the 10-month demonstration period with past operational averages showed a dramatic 75% reduction amounting to 2,300,000 cubic feet of gas per month—an annual savings of $96,000 per year.

The total combined incineration and standby fuel savings by the Nashville operations using the new operating mode was approximately *$350,000* per year.

Conclusions

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

- incinerator auxiliary fuel consumption can be significantly reduced by using more fuel efficient operating modes derived from new operating technology and experience;
- fuel reductions can be easily and quickly achieved through operational changes alone in existing facilities without having to make major or high cost equipment changes;
- multiple hearth sludge incinerator technology can be cost effectively transferred and applied to many municipal operations because of the similarity in equipment *operational* practices;
- a 40% fuel reduction was achieved over a 10-month demonstration period representing an annual cost savings of approximately $350,000 per year;
- this work serves to substantiate the analysis made for the Indianapolis work, which indicated that savings of 20% to 50% are possible if the plants are operated in the fuel efficient mode.

The full report was submitted in fulfillment of Contract No. 68-02-3487 by Battelle Columbus Laboratories under the sponsorship of the U.S. Environmental Protection Agency.

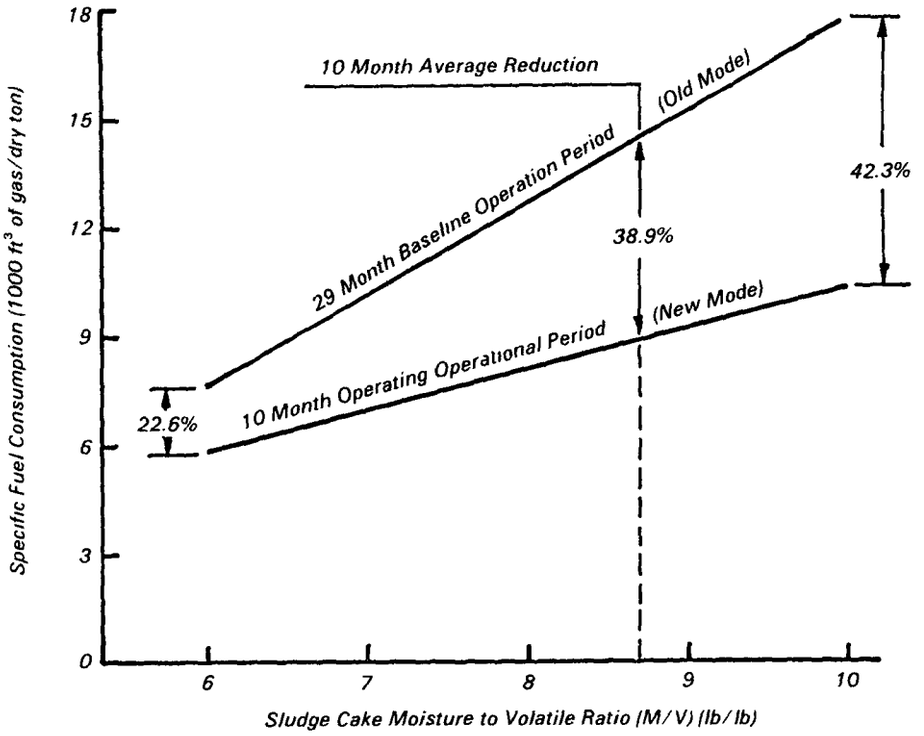

Figure 1. *Specific fuel consumption comparison.*

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

Variable	Baseline Period (29 Months)	Demonstration Period (10 Months)	Percent Difference
Wet Tons	202	226	+24
Dry Tons	35.7	35.8	+ 1
Percent Solids	17.8	16 1	- 1.7
Percent Volatiles*	61.9	62.9	+ 1 0
M/V Ratio	7.7	8.7	+ 1.0
SFC (1000 ft/dry ton)	14 4	8.8	- 5 6

* % Volatiles = thermally volatile portion of the dry solids
(% volatiles + % ash = 100% dry sludge)

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The complete report, entitled "Sewage Sludge Incinerator Fuel Reduction at Nashville, Tennessee," (Order No. PB 84-113 075; Cost: $10.00, subject to change) will be available only from:
National Technical Information Service
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