Measurement and Verification Final Report

for

Caesars Laundry

Ozone Injection System Installation

Caesars Project Number:

Mobius Project Number:
03197

Prepared by:

June 2005

Executive Summary

The first phase of a system that injects ozone into the wash and rinse water of six machines at Caesars Laundry was implemented between November 2004 and January 2005. The project reduces operating costs by reducing water consumption, natural gas use, and chemical consumption.

This first phase of the project involved the installation of a single Industrozone IO 24000 ozone laundry system. All power, water, and piping required for the system was connected to the output of the ozone laundry system and to each of the six washer/extractors with separate feeds to each washer (such that the existing wash formulas can be run for rewash purposes and/or during service or maintenance work on the ozone system).

The final project results are provided below. The project resulted in approximately 5 percent more cost savings than originally anticipated (using the utility rates from the original analysis – "low-case"), which can be attributed to the following:

- Water use by the ozone system is considerably less than anticipated originally, while measured water use for the pre-installation condition is close to the original estimate. This results in 62 percent higher water and sewer cost savings than expected.
- Water temperature rises on hot and cold-water loads were not 50°F, as originally assumed, but 45.5°F and 23.9°F, respectively. Although there are more water quantity savings, there is still a 5 percent reduction in natural gas savings over the pre-installation condition.

Post-Ozone Installation
6-Machine Laundry Water and Natural Gas Savings

	Daily Pre	Daily Post	Daily Savings	Annual Savings
Water Use (gallons)	98,749	71,799	26,950	9,836,800
Water Cost (low-case) ($)	336	244	92	33,400
Water Cost (high-case) ($)	505	367	138	50,300
Energy Use (DTherms)	37.8	2.8	35.1	12,800
Energy Cost ($)	340	25	316	115,200
Total Cost (low-case) ($)	676	269	407	148,600
Total Cost (high-case) ($)	845	392	453	165,500

High-case water rates are based on actual tariffs, and equate to $5.11/1,000 gallons

Actual energy and cost savings that will be realized moving forward will be greater than this, as water rates have increased since the project development. Water and natural gas cost savings are projected to be $165,500 per year, which is nearly 17 percent higher than originally projected.

Section 1: Project Description

The first phase of a system that injects ozone into the wash and rinse water of six machines at Caesars Laundry was implemented between November 2004 and January 2005. The project reduces operating costs by reducing water consumption, natural gas use, and chemical consumption.

This first phase of the project involved the installation of a single Industrozone IO 24000 ozone laundry system. All power, water, and piping required for the system was connected to the output of the ozone laundry system and to each of the six washer/extractors with separate feeds to each washer (such that the existing wash formulas can be run for rewash purposes and/or during service or maintenance work on the ozone system).

Section 2: M&V Methodology

Prior to installation of the ozone laundry system, water meter readings were taken on two representative machines to determine average water used per day. Temperature readings were also taken on the hot, cold, and re-use water feeds, as well as city-water temperature supplied to the building. These temperatures were used with the flow readings to determine how much energy was used to heat the water.

Following installation of the system, flow readings of total water supplied by the ozone system were recorded on a datalogger (all six machines) at 10-second intervals. These readings were used to totalize the water used by the ozone system. Water readings were continued on the original two machines to determine the hot and cold energy and water use that would still occur following installation of the ozone system. Use of the existing hot and cold water system is due to occasional ozone system downtime or inadvertent use of note-ozone wash programs. These calculations were performed over time, and used to determine per-day values.

The energy use and flow use from the ozone system and the post-installation hot and cold water use were totalized and used to calculate the post-installation energy and water use. These were compared to the pre-installation values to determine actual savings on a per-day basis. The daily savings were multiplied by 365 to determine annual savings. Although loads in the summer are typically higher than during the two monitoring periods, an adjustment for this was not made in the savings calculations, due to potential laundry use changes in the future.

Section 3: Pre-Installation Measurements & Calculations

Prior to installation of the ozone system, all wash loads were performed using hot and/or cold (tempered) water, with occasional use of re-use water. As part of the project development, calculations were performed using the total water use of the facility, and the following assumptions:

Project Development Assumptions

	Traditional		Ozone	
Water/Sewer	**Light Soil**	**Heavy Soil**	**Light Soil**	**Heavy Soil**
Pounds of Laundry per Day	149,600	37,400	149,600	37,400
Days Use per Year	365	365	365	365
Gallons per Year Consumed	91.7 million	34.1 million	76.9 million	30.7 million
Water/Sewer Cost/1,000 gallons	$3.40	$3.40	$3.40	$3.40

	Traditional		Ozone	
Hot Water	**Heavy Soil**	**Light Soil**	**Heavy Soil**	**Light Soil**
Gallons per Year Consumed	91.7 million	34.1 million	76.9 million	30.7 million
Ambient Water Temperature	110°F	110°F	110°F	110°F
Average Boiler Temperature	160°F	160°F	160°F	160°F
Boiler Efficiency	81%	81%	81%	81%
Cost per Therm	$0.90	$0.90	$0.90	$0.90

Using the above assumptions, total savings that could be expected by installing the ozone system on six machines was projected to be nearly $142,000 per year. Of this total, approximately 15 percent was anticipated to be in the form of water and sewer cost savings.

As part of the savings verification process, water meter readings were taken on two machines (Machine 1 and Machine 4) prior to project implementation to develop baseline water use for the laundry. These readings are shown in the table below.

Pre-Ozone Installation
Water Use Metering

Read Date	Days	Mach. 1 Hot (Gallons)	Mach. 1 Cold (Gallons)	Mach. 4 Hot (Gallons)	Mach. 4 Cold (Gallons)	Total (Gallons)
11/9/2004	18	172,507	114,236	181,407	107,849	575,999
11/19/2004	10	107,793	61,289	115,342	58,166	342,590
11/29/2004	10	105,350	63,558	101,923	58,936	329,767
12/7/2004	8	82,419	49,708	84,715	48,949	265,791
Totals	46	468,069	288,791	483,387	273,900	1,514,147
Daily Avg.		10,175	6,278	10,508	5,954	32,916

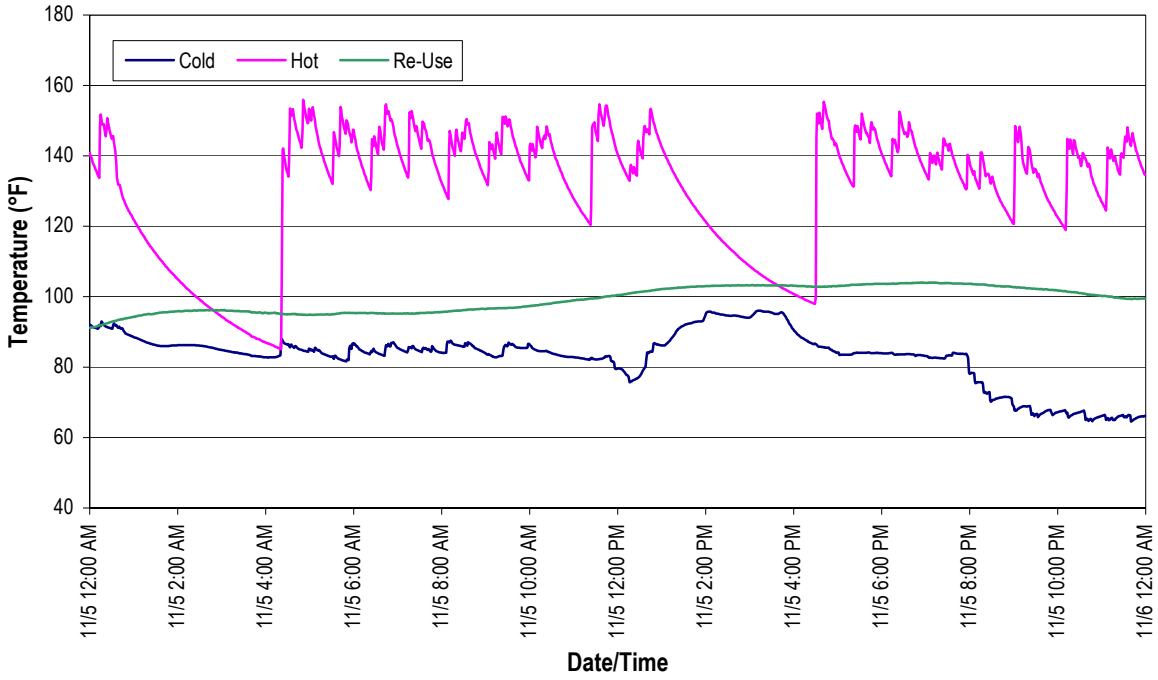
Since the ozone system was to be installed on six machines, the total use for Machines 1 and 4 were multiplied by three to obtain an approximately equivalent use to the post-installation scenario. Over the 46-day pre-installation period, daily water use for six machines was extrapolated as follows:

Pre-Ozone Installation
Extrapolated 6-Machine Water Use

	Total Water Use (Gallons)	Average Daily Water Use (Gallons)
Hot	2,854,368	62,051
Cold	1,688,073	36,697
Total	4,542,441	98,749

In addition to water use measurement, temperature logging was set up on hot, cold, and re-use lines to determine the temperatures from which and to which the hot and cold wash water streams were heated. Temperatures for a typical day are shown in the graph below. Since fill times are relatively short, the graph shows the hot water cooling down in the pipe after each fill cycle. The important value is the temperature to which the graph spikes (145.5°F average), which is the temperature used in the wash cycles.

Pre-Ozone Installation
Typical Wash Water Temperatures

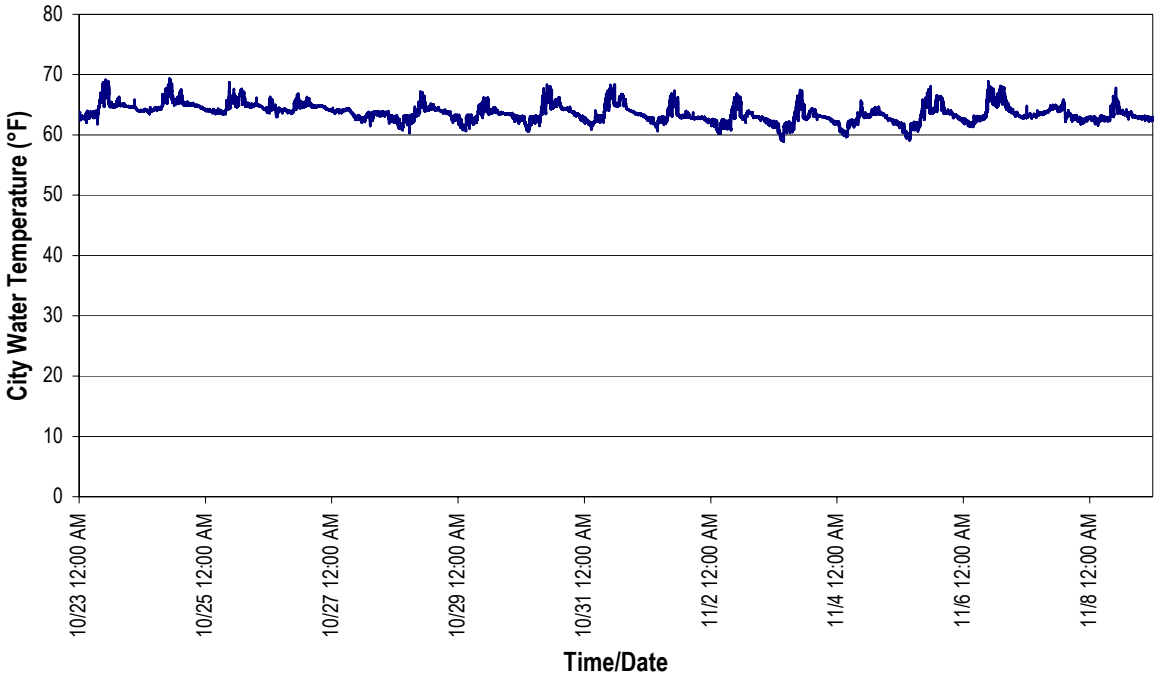


Since the laundry uses a heat reclaim system, the hot-cycle water is not heated from city water temperature to the desired temperature, but is preheated by recovering heat from the wastewater prior to sending the wastewater into the sewer system. Only each machine's first load of each shift would require the additional heating from city water temperature to the

required hot-cycle temperature. This additional first cycle heating was ignored for this analysis, but does contribute to additional savings.

In addition, the "cold" cycle does not use city water directly, but uses water heated from city water temperature to the desired wash temperature (87.5°F average). City water temperature supply to the building over a two-week period is shown in the following graph, and averaged 63.6°F over the monitoring period.

Pre-Ozone Installation
City Water Temperature



Using the collected data, water costs and water heating costs were calculated on a daily basis. These calculations were based on water and sewer costs of $3.40/1,000 gallons and natural gas costs of $0.90 per therm.

Pre-Ozone Installation
6-Machine Daily Laundry Water and Natural Gas Costs

	Hot	Cold	Total
Water Use (gallons)	62,051	36,697	98,749
Water Cost ($)	211	125	336
Energy Use (DTherms)	28.8	9.0	37.8
Energy Cost ($)	259	81	340
Total Cost ($)	470	206	676

Section 4: Post-Installation Measurements & Calculations

Following installation of the ozone system, water meter readings were continued on the hot and cold water feed lines at the laundry on Machines 1 and 4. These readings are shown in the table below.

Post-Ozone Installation
Water Use Metering

Read Date	Days	Mach. 1 Hot (Gallons)	Mach. 1 Cold (Gallons)	Mach. 4 Hot (Gallons)	Mach. 4 Cold (Gallons)	Total (Gallons)
1/12/2005	14	71,635	43,597	64,202	40,006	219,440
1/27/2005	15	32,440	19,318	30,014	16,053	97,825
2/7/2005	11	4,029	6,442	4,241	3,007	17,719
2/28/2005	21	18,789	18,055	15,372	11,829	64,045
Totals	61	126,893	87,412	113,829	70,895	399,029
Daily Avg.		2,080	1,433	1,866	1,162	6,541

While hot and cold loads continued on a regular basis early-on, and while occasional hot and cold water use continued throughout the post-installation period, the readings show a drastic reduction in hot and cold water use over the pre-installation period. As reliability of the system improved by early February, the six machines (equivalent) began to use an average of 7,700 gallons of hot and cold water per day, as shown in the following table (over a 21 day period):

Post-Ozone Installation
6-Machine Water Use – Hot and Cold

	Total Water Use (Gallons)	Average Daily Water Use (Gallons)	Pct. of Pre use
Hot	127,293	3,978	6.4%
Cold	117,999	3,687	10.0%
Total	245,292	7,665	7.8%

The remaining hot and cold water flow indicates that overall, approximately 7.8 percent of the wash loads are still done using non-ozone water sources (6.4 percent of the hot loads and 10 percent of the cold loads).

Further data were collected on the flow of water through the ozone system. Flow readings were taken every 10-seconds on the ozone system. These readings were converted to total gallons used, by shift, according to the following table:

Post-Ozone Installation
Ozone System Water Use

Month	Days	AM Shift Average Use (Gal)
January	1	24,519
February	25	32,375
March	14	33,976
Average		32,739

Month	Days	PM Shift Average Use (Gal)
January	2	30,149
February	24	28,367
March	15	31,988
Average		29,778

Month	Days	Daily Average Use (Gal)
January	1	57,030
February	23	60,440
March	12	67,827
Average		62,807

Since operation of the system was unstable in January, only water use from February and March were used to predict total daily water use for hot, cold, and ozone loads combined. These are shown in the table below.

Post-Ozone Installation
Total 6-Machine Water Use

	Average Daily Water Use (Gallons)	Pct. of Pre use
Hot	3,978	6.4%
Cold	3,687	10.0%
Ozone	64,133	n/a
Total	71,799	72.7%

Using the collected data, water costs and water heating costs were calculated on a daily basis. These calculations were also based on water and sewer costs of $3.40/1,000 gallons and natural gas costs of $0.90 per therm. These costs are shown in the table, below.

Post-Ozone Installation
6-Machine Daily Laundry Water and Natural Gas Costs

	Hot	Cold	Ozone	Total
Water Use (gallons)	3,978	3,687	64,133	71,799
Water Cost ($)	14	13	218	244
Energy Use (DTherms)	1.8	0.9	-	2.8
Energy Cost ($)	17	8	-	25
Total Cost ($)	30	21	218	269

The pre-installation costs were compared to the post-installation costs to determine the daily energy and cost savings. These savings were extrapolated over an entire year, with the assumption that the daily use in March is representative or average. These results are shown below. Since the water and sewer costs used in the analysis have increased, a "high-case" cost analysis was completed; these values are also included below.

Post-Ozone Installation
6-Machine Laundry Water and Natural Gas Savings

	Daily Pre	Daily Post	Daily Savings	Annual Savings
Water Use (gallons)	98,749	71,799	26,950	9,836,800
Water Cost (low-case) ($)	336	244	92	33,400
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Energy Use (DTherms)	37.8	2.8	35.1	12,800
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Total Cost (low-case) ($)	676	269	407	148,600
Total Cost (high-case) ($)	845	392	453	165,500

High-case water rates are based on actual tariffs, and equate to $5.11/1,000 gallons

Section 5: Conclusion

The final project results are provided below and are compared to the original energy savings calculations. Comparing predicted savings to actual savings using the utility rates specified in the original analysis show approximately 5 percent more cost savings than anticipated. This can be attributed to the following:

- Water use by the ozone system is considerably less than anticipated originally, while measured water use for the pre-installation condition is close to the original estimate. This results in 62 percent higher water and sewer cost savings than expected.
- Water temperature rises on hot and cold-water loads were not 50°F, as originally assumed, but 45.5°F and 23.9°F, respectively. Although there is more water savings, there is still a 5 percent reduction in natural gas savings over the pre-installation condition.

Project Results

	Annual Savings				
	Water Consumption		Gas Consumption		Total
	gal	$$*	Therms	$$*	$$*
Original Estimate	6,066,667	$ 20,627	134,602	$ 121,142	$ 141,769
Post-Installation	9,836,800	$ 33,400	128,000	$ 115,200	$ 148,600
% Variance	62%	62%	-5%	-5%	5%

*

"Original Estimate" and "Post-Installation" cost savings are based upon the prevailing 10-year, forward curve market price utility estimates at the time of the project's development. Those estimates are updated on a regular basis for each project site. Actual cost savings will vary from year to year as market conditions change and the prevailing forward curve pricing is adjusted.

Actual energy and cost savings that will be realized moving forward will be greater than this, as water rates have increased since the project development. Water and natural gas cost savings are projected to be $165,500 per year, which is nearly 17 percent higher than projected.