Food Service Technology Center

Ecodrain A1000 Heat Recovery Unit

Dish Machine Drain Water Application

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Performance Test Report

Food Service Technology Center Background

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Executive Summary

Dishwashers are a major source of energy and water consumption in commercial kitchens. During continuous operation, these machines dump hundreds of gallons of hot water at 140 to 160°F down the drain. The restaurant operator ends up paying for the water heater energy to heat up the water that eventually gets dumped down the drain. There is a way to recover this energy using a drain water heat exchanger. Ecodrain is a counter flow heat exchanger designed to recover the heat from hot drain water and transfer it to the cold supply water going into the water heater (Figure 1 and 2). This results in the water heater doing less work to heat up the water from a higher initial temperature resulting in significant water heater energy savings.

FSTC engineers tested the heat recovery unit under the tightly-controlled dish washer test method conditions of the American Society for Testing and Materials (ASTM). Heat recovery performance results were characterized by the increase of the supply cold water temperature as it flows through the heat exchanger under different dish washing scenarios. Drain inlet and outlet temperatures as well as the supply cold water flow rate, inlet and outlet temperatures were monitored. Because the performance of the heat recovery unit is dependent on the dish washing scenarios and the dishwashers themselves, FSTC engineers used three different dish wash scenarios on each of three different commercial conveyor type dishwashers to determine how much drain energy can be recovered by the heat exchanger. The test methods were used to simulate real world performance of dishwashers with one of the three scenarios following this ASTM test standard:

- *Standard Test method for Performance of Rack Conveyor, Commercial Dishwashing Machines* (F1920-11)[1]: This standard uses data gathered from consecutively washed racks of dishes to determine conveyor dishwasher performance.

Figure 1: Ecodrain A1000 Heat Recovery Unit

[1] American Society for Testing and Materials. 2011. *Standard Test method for Performance of Rack Conveyor, Commercial Dishwashing Machines.* ASTM Designation F1920-11, in *Annual Book of ASTM Standards,* West Conshohocken, PA.

The heat recovery unit was installed at a slope of 0.3°. During a continuous 30-minute wash cycle the Ecodrain exhibited an average supply water temperature rise of 16.6°F across 3 dish machines while resulting in a maximum water heater savings of 26.3% in one of the dishwashers. When washing 5 sets of 5 racks back to back, the Ecodrain achieved an average supply water temperature rise of 18.0°F, while resulting in a maximum 34.9% of water heater energy savings. And when washing 8 sets of 3 racks back to back the heat recovery unit reached a supply water temperature rise of 23.4°F, while resulting in 36.8% of water heater energy savings. All the results depend heavily on the dishwasher flow rates and drain patterns as well as the angle of inclination of the heat recovery unit. A summary of the test results is presented in Table 1.

Table 1: Summary of Ecodrain A1000 Performance

Test Scenario	Dishwasher A	Dishwasher B	Dishwasher C
Continuous Wash Temperature Rise (°F)	15.0	14.5	20.4
5 Sets of 5 Racks Temperature Rise (°F)	15.9	10.9	27.3
8 Sets of 3 Racks Temperature Rise (°F)	22.4	18.6	29.1
Continuous Wash Maximum Water Heater Savings (%)	21.7	21.5	26.3

Figure 2: Ecodrain A1000 Demonstrating Drain Water and Incoming Water Flow

Introduction

Background

FSTC field monitoring has shown that conveyor dishwashers can use up to 75% of the hot water in a commercial kitchen. It takes a large amount of energy to raise cold supply water to sanitizing temperatures to be used in high-temperature dishwashers. High-temperature conveyor dishwashers use 100,000 to 450,000 Btu/h of water heater energy for continuous operation which is up to 4.5 times more hourly energy use than the charbroiler, second largest energy using appliance. In the dishwashing process, most of the energy required to heat water is subsequently wasted when the wastewater is sent to the sanitary drain at scalding temperatures.

Some regions have requirements on the maximum water temperature allowed to be discharged to the sanitary drain. Dishwasher manufacturers offer drain water tempering kits to cool the 145 to 175°F drain water to 140°F. Thus, additional cold water in some jurisdictions is used to cool the dishwasher drain water resulting in even more water usage. In the last 10 years, vertical copper heat exchangers used primarily in residential applications where retrofitted on to a limited number of conveyor dishwashers in North America, but the technology remained unviable in most new and retrofit applications due to cost and space requirements. The Ecodrain is a horizontal heat exchanger that had not previously been tested outside a residential setting. It was identified as potentially being a viable technology, since it met the cost and space considerations with application to conveyor dishwashers. The goal of the Ecodrain lab testing was to see if it could serve two purposes, primarily as a heat recovery device to save water heater energy use and secondarily as a drain water tempering device to save water. If lab testing was deemed a success, it would open the door to field testing to gather real world data of the heat exchange and gauge how the heat exchanger effects fats, oils and grease that would be passing through it and may have the potential to foul the heat exchanger or coagulate at lower drain temperatures further downstream in the sanitary sewer line.

In order to characterize the operating performance of the Ecodrain heat recovery unit, it was connected to three different commercial high temperature sanitizing, rack conveyor type dishwashers. FSTC researchers utilized American Society for Testing and Materials' (ASTM) F1920-11 *Standard Test Method for Performance of Rack Conveyor, Commercial Dishwashing Machines* to establish standardized testing conditions for each dishwasher with and without the Ecodrain heat recovery unit connected to the machine. Heat recovery performance results were characterized by the increase of the supply cold water temperature as it flows through the heat exchanger under different dish washing scenarios. Drain inlet and outlet temperatures as well as the supply cold water flow rate, inlet and outlet temperatures were monitored. Because the performance of the heat recovery unit is dependent on the dish washing scenarios and the dishwashers themselves, FSTC engineers used three different dish wash scenarios on each of three different commercial conveyor type dishwashers to determine how much drain energy can be recovered by the heat exchanger. The test methods were used to simulate real world performance of dishwashers with one of the three scenarios following ASTM test method.

Objectives and Scope

The objective of this report is to examine the operation and performance of the Ecodrain A1000 heat recovery unit when used in conjunction with commercial high temperature sanitizing, rack conveyor type dishwashers. Each dishwasher was tested under three different test conditions based on the washing energy performance test specified in the ASTM test method. The scope of this testing is as follows:

The test scenarios can be used to estimate the amount of heat that could be recovered by a dishwasher drain heat exchanger in a typical restaurant operation. Each of the dishwashers was tested for a continuous period simulating a heavy use period. The ASTM F1920-11 test method characterizes the performance of conveyor dishwasher machines using sets of consecutively washed racks of dishes. Additional tests were performed to evaluate the heat recovery unit performance during intermittent dishwasher loading. The objectives of the testing are listed below:

1) Determine water temperature rise and energy recovered across the heat exchanger with three different conveyor dishwashers under the following scenarios:
    A. Continuous washing for 30 minutes after a 15-minute stabilization
    B. Washing five sets of 5 racks after a 5-minute and 5-rack stabilization period
    C. Washing eight sets of 3 racks after a 2-empty-rack and 3-full-rack stabilization period
2) Determine the water heater energy savings in each of the above scenarios
3) Determine the effect of the heat recovery unit angle of inclination on the performance
4) Estimate the annual operating savings of the heat recovery unit for each dishwasher tested

Product Description

The Ecodrain A1000 Drain Water Heat Recovery unit (Figure 3) is a heat exchanger intended to operate in either concurrent flow or countercurrent flow conditions. It is designed to transfer energy from hot drain water into the incoming clean cold water, preheating it before it is routed to the water heater, and thereby reducing the water heater energy consumption. While this unit was specifically designed to be used as a residential shower heat recovery unit, this report evaluates the performance potential of this heat recovery unit as adapted to a commercial conveyor dishwasher scenario.

The supply water inlet and outlet are ¾″ copper threaded pipe while the drain connections are 2-inch ABS pipe. The 4-foot long heat exchanger copper surface is designed to induce a turbulent drain water flow to increase the heat transfer effectiveness.

Figure 3: Ecodrain A1000 with Plastic Cover Removed

Methods and Results

Setup and Instrumentation

The Ecodrain heat recovery unit was tested with three 44-inch long high temperature sanitizing, rack conveyor dishwashers. Table 2 lists the continuous hot water flow rate for each of the three test dishwashers.

Table 2: Dishwasher Flow Rates

Dishwasher	A	B	C
Flow Rate During Continuous Operation (gpm)	3.7	2.2	2.2

Dishwasher A utilized an external booster heater to raise the rinse water temperature to 180°F, while dishwashers B and C utilized internal booster heaters. Dishwasher energy consumption was not directly impacted by the heat recovery unit in any way. The heat exchanger specifications are listed in Table 3.

Table 3: Product Specifications

Manufacturer	Ecodrain
Model	A1000
Generic Appliance Type	Heat Exchanger
Construction	Copper exchanger core with plastic housing
Supply Water Connection Dimensions	¾" threaded
Drain Water Connection Dimensions	2" ABS
External Dimensions (W x D x H)	8 ½ " x 48" x 5 ½"

During operation, the drain water from the dishwasher flows partially from the rinse tank overflow and partially from the water cascading through the wash tank. The machines use the rinse runoff to maintain the level of the wash tank while the wash water is in suspension. During testing, this results in drain water flowing continuously after the rinse cycle has completed at a lower flow rate than the flow rate of the incoming water supply for the machine. After the last rack (from a batch) has passed completely through the machine, the rinse cycle ceases and the wash pump continues circulating water in the wash area for about a minute. The wash cycle continues for about a minute, then stops; the water in suspension falls back into the wash tank and any excess water is then drained. Drain water flow rates were not measured and it cannot be assumed that the drain water flow rates are the same as the supply water flow rates measured by the water meter leading to the dishwasher inlet.

The heat exchanger was installed on a level tiled floor behind the conveyor dishwasher location. The dishwasher drain was located centrally below the dishwashing machine with a 5-inch clearance between the floor and the center of the 1.5-inch diameter drain outlet. The drain pipe height clearance of all three dishwashers limited the angle of elevation of the heat exchanger; all the tests were performed with one end of the heat exchanger raised by ¼-inch resulting in a 0.3 degree angle unless stated otherwise. This is representative for most restaurant applications, as the dishwasher drain is located below the wash tank, which typically offers limited clearance above the floor. From the machine drain outlet, a 2-inch ABS pipe that included a 1.5 to 2-inch diameter expansion connector was run from the drain toward the wall. That piece was connected to a 2-inch diameter elbow and a 1-foot straight run going into the drain inlet of the heat exchanger. Figure 4 shows the Ecodrain as installed behind a test dishwasher.

Type K thermocouple probes were installed at the heat recovery unit drain water inlet and outlet openings and within the cold water inlet and preheated water outlet piping. The city cold water supply was rerouted from the water heater inlet and connected into the cold water inlet of the Ecodrain. The outgoing preheated water was fed into the primary hot water heater located 10 feet away from the heat recovery unit. The water flow rate was measured on the hot water inlet of the dishwasher using a mechanical water flow meter (Omega FTB 4605, 0.15-13 gpm range) with a resolution of 150 pulses per gallon. During all testing, the dish machine was the only appliance drawing any hot water from the primary water heater. All temperature measurements and water flow rates were recorded by a computerized data acquisition at 5-second intervals.

Figure 4: Ecodrain A1000 Setup Behind the Dishwasher

Test Conditions and Observations

During testing, the drain water outlet thermocouple readings were observed to be inconsistent in some cases, and it was theorized that the geometry of the heat exchanger caused localized temperature variations within the drain water thereby not representing the bulk average outlet temperature. The cold water supply temperature to the Ecodrain was not conditioned and varied somewhat from machine to machine, as the tests were conducted over a several-month period. Incoming water at a lower temperature would result in a higher heat exchanger heat transfer efficacy. The ASTM F1920-11 specified test conditions were maintained for the incoming water supply to the dishwasher, the minimum wash tank temperature and minimum rinse water supply temperature. The city water supply temperature will tend to vary based on regional climates and seasonal variations. An increase in the distance between the heat recovery unit and the water heater could negatively impact on the water heater savings; however thicker pipe insulation will retain the heat going from the Ecodrain into the water heater. The outgoing supply temperature was measured at the heat recovery unit and does not account for the pipe heat losses between the heat recovery unit and the primary water heater.

Conveyor Dishwasher Tests

The Ecodrain heat recovery unit was tested under three different scenarios:

A. Continuous washing for 30 minutes after a 15-minute stabilization
B. Washing five sets of 5 racks after a 5-minute and 5-rack stabilization period
C. Washing eight sets of 3 racks after a 2-empty-rack and 3-full-rack stabilization period

Scenario A results were based on a single 45 minute test. Scenario B and C results were based on three test replicates for each dishwasher tested. Water heater energy savings were calculated purely on the temperature rise of the primary water heater supply water encountered during the test and the volume of water consumed. The water heater energy was calculated based on raising the water temperature from 60°F to 140°F by a commercial water heater and a 75% water heating system efficiency. Energy savings were based on the actual temperature rise of the supply water across the Ecodrain during the test and adjusted to match the efficiency of the water heater. Since the temperatures were measured at the heat exchanger, water temperature drop in the pipes leading from the Ecodrain to the water heater is not accounted for in the calculations. The actual water heater savings would be less, depending on how far away the water heater is located from the heat exchanger, the type of pipe insulation and ambient conditions.

Scenario A: 30-Minute Continuous Washing

This test was performed to simulate a continuous washing operation, which can be encountered at the end of the restaurant day. To simulate this, the dishwasher wash and rinse cycle was turned on for a period of 45 minutes; the first 15 minutes were used as a stabilization period allowing the drain and inlet temperatures to stabilize. The typical drain water and supply water profiles are shown in Figures 5a and 5b.

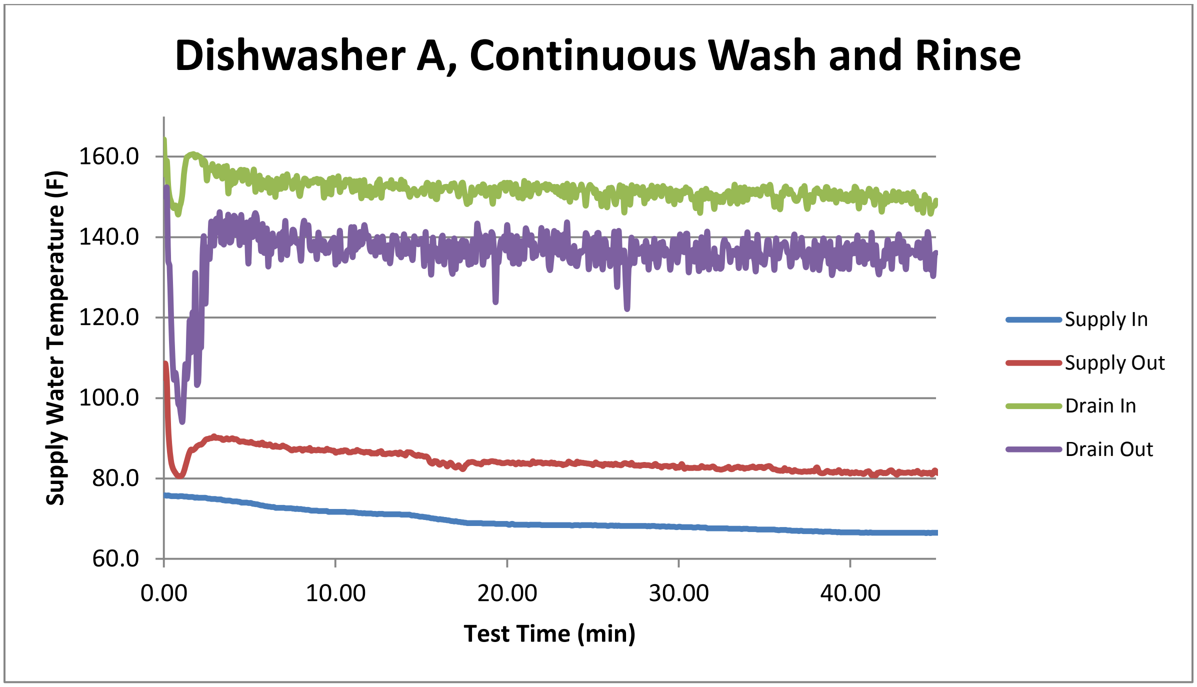

Figure 5a: Supply and Drain Temperature Profiles During a 30 Minute Continuous Wash

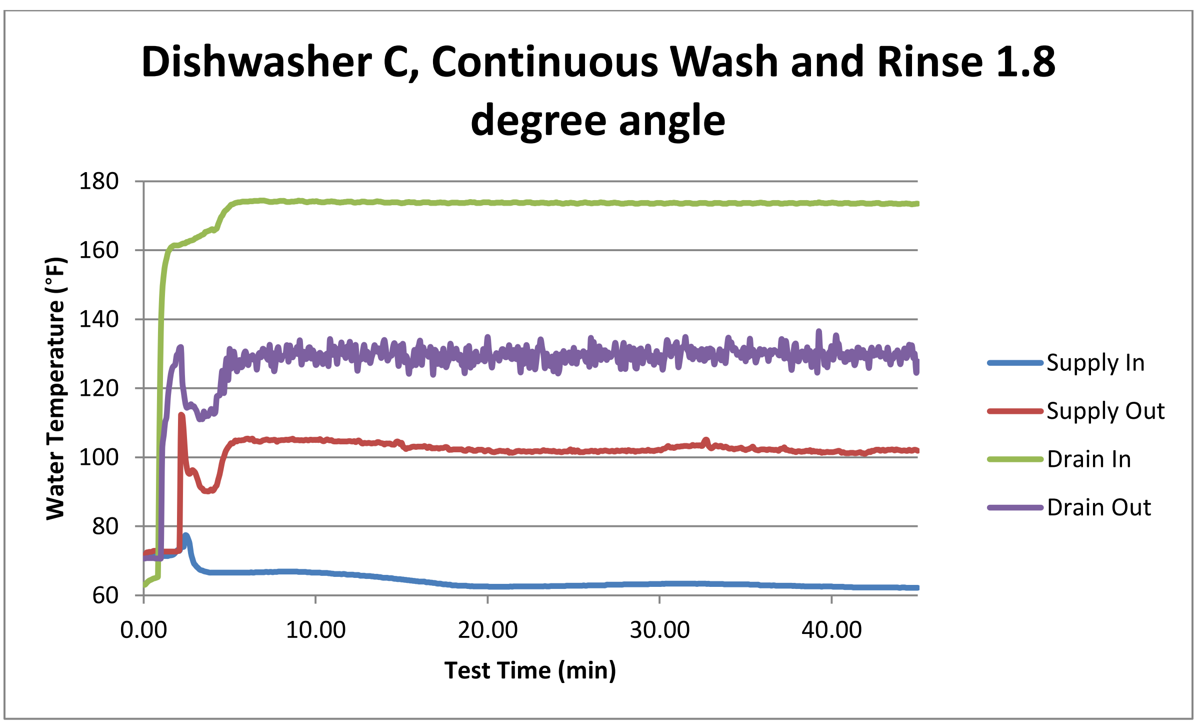

Figure 5b: Supply and Drain Temperature Profiles During a 30 Minute Continuous Wash with a larger angle of inclination.

The incoming water temperature rise and drain temperature drop is proportional for both machines. The outlet drain water temperature fluctuated due to the turbulent flow created by the heat exchanger in relationship to the location of the temperature sensor. Dishwasher C was tested with the Ecodrain tilted to a 1.8° angle, in addition to the standard tests at a 0.3° angle. From the results, it is evident that the supply water temperature rise was greater with a larger incline.

Dishwasher A was tested in the summer with a warmer ground water supply temperature (72°F), whereas Dishwashers B and C were tested in the winter with lower ground water supply temperatures (64°F). The Ecodrain was more effective with cooler ground water supply temperatures. The efficacy of the heat recovery unit improved greatly with a larger angle of inclination, as was demonstrated in the two tests for Dishwasher C. Table 4 lists the summary of the heat recovered off the Ecodrain during the 30 minute continuous test.

Table 4: Ecodrain A1000 30 Minute Continuous Washing Test Results

	Dishwasher A 0.3° angle	Dishwasher B 0.3° angle	Dishwasher C 0.3° angle	Dishwasher C 1.8° angle
Water Consumed by Dishwasher (gal)	103.5	102.8	61.0	61.0
Drain In (°F)	159	151	169	174
Drain Out (°F)	138	136	94[b]	130
Supply In (°F)	72	68	64	63
Supply Out (°F)	86	83	85	102
Avg Supply Temp Rise (°F)	**14.45**	**15.00**	**20.44**	**39.25**
Energy Recovered by Ecodrain (Btu)	12,408	12,786	10,330	19,835
Energy Consumed by Water Heater (Btu)[a]	77,047	78,636	52,351	53,016
Energy Saved by Ecodrain (Btu)[a]	16,544	17,048	13,773	26,448
Water Heater Energy Savings (%)	**21.5**	**21.7**	**26.3**	**49.9**

[a]*Energy is based on water heater temperature rise of 80° and system efficiency of 75%*

[b]*Drain water thermocouple was not fully submerged in the drain flow at that slope*

Scenario B: Five Sets of 5 Racks (ASTM Test)

This test was performed to simulate batch washing operation which can be encountered throughout the middle of the restaurant operation day. This test is based on the washing energy performance test outlined in the ASTM F1920-11 test method. The washing energy performance test consisted of a 5-minute continuous wash and rinse stabilization period, followed by six batches of five racks run back-to-back through the dishwasher. Each rack was loaded with ten 9-inch dinner plates to simulate a typical dishload. After each batch of 5 loaded racks has run completely through the dishwasher, the machine was allowed a recovery period to replace lost heat back into the washtank. Recovery was established as the time from the last (of five) rack exiting the machine until the wash tank heaters cycled off. The first batch was considered a stabilization batch, and was not used to calculate the results. Three replicates were performed for each ASTM washing energy performance test. The water temperature profiles for the three dishwashers are shown in Figures 6a to 6c.

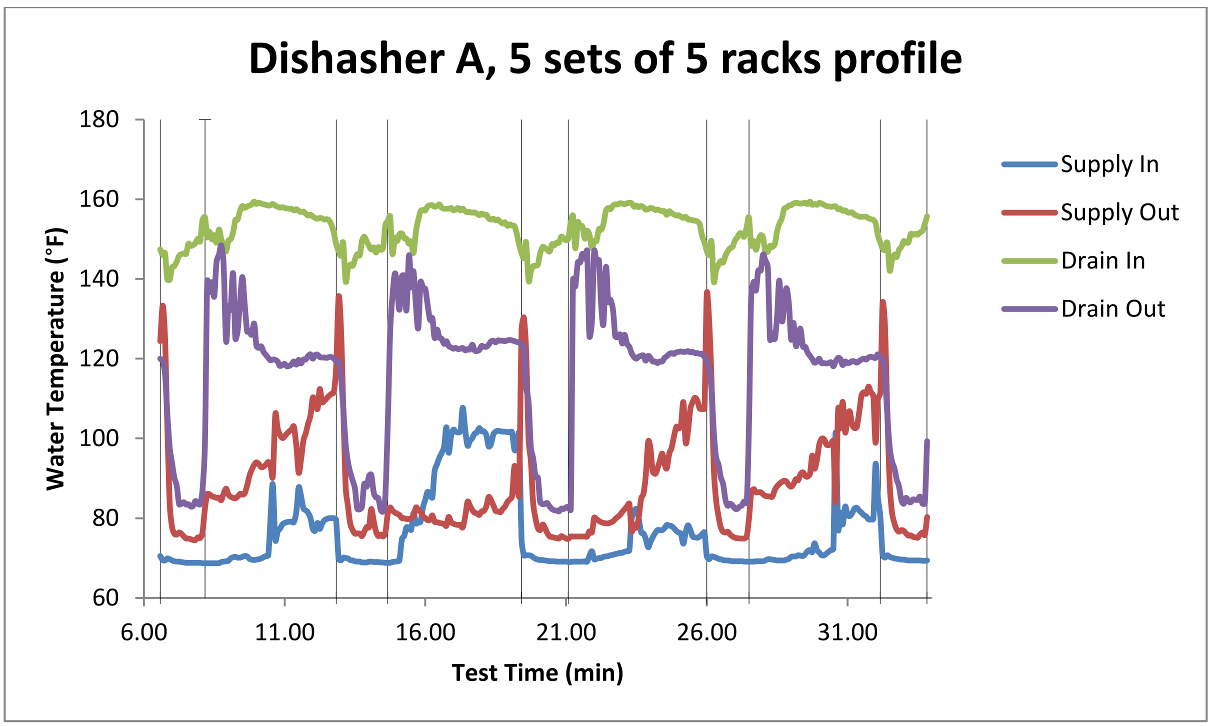

Figure 6a Dishwasher A Supply and Drain Temperature Profiles During the ASTM 5 Rack WashTest

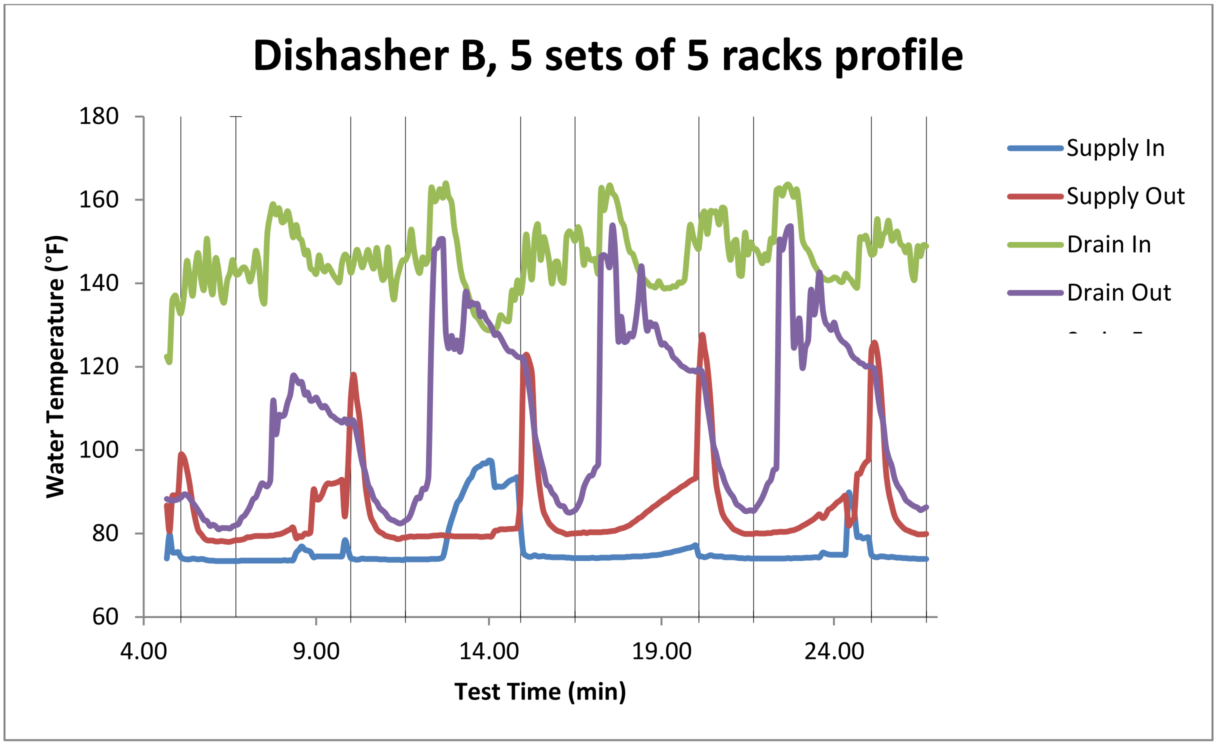

Figure 6b Dishwasher B Supply and Drain Temperature Profiles During the ASTM 5 Rack WashTest

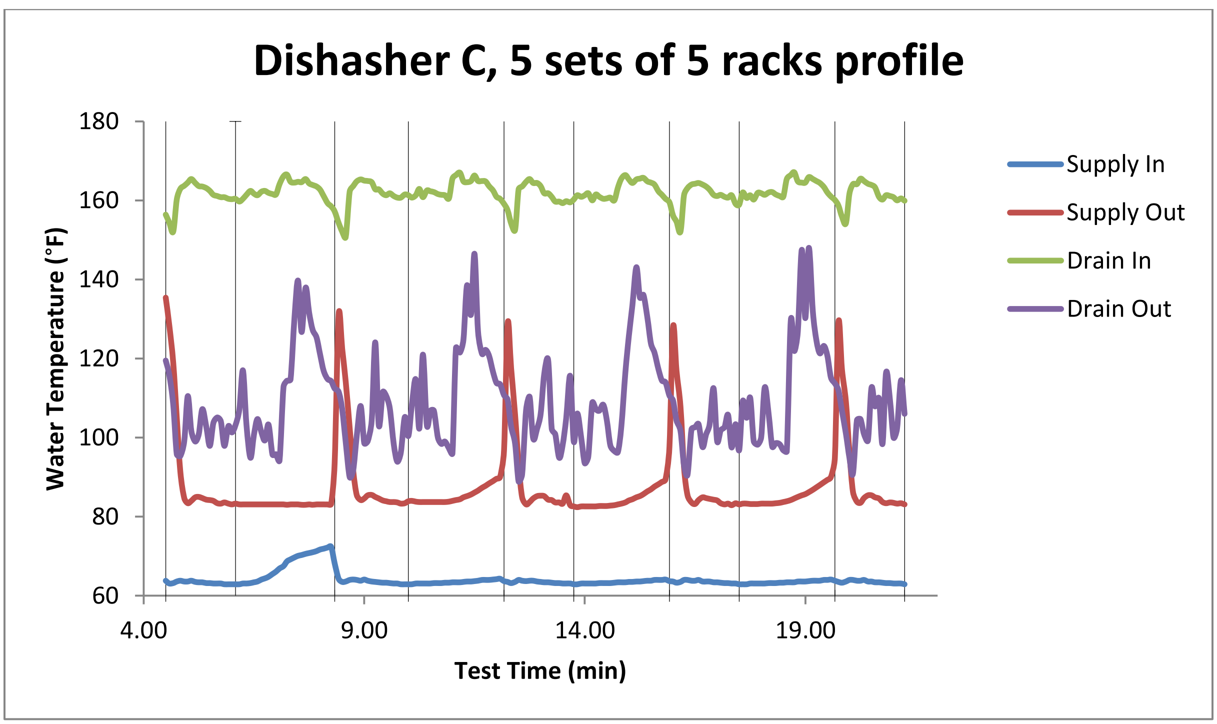

Figure 6c Dishwasher C Supply and Drain Temperature Profiles During the ASTM 5 Rack WashTest

To quantify the energy recovered by the Ecodrain heat recovery unit, drain and supply water temperatures were analyzed only when the dishwasher was drawing water (e.g., during the rinse cycle). Figures 6a-6c illustrate the entire washing energy performance test for each machine, with the rinse cycles denoted by vertical lines. When the rinse cycle is not engaged, water is being drained over the heat exchanger; however no water is being drawn resulting in stagnant water temperature spikes in the heat exchanger. The water drawn in by the water heater in the beginning of the rinse cycle is much hotter, due to hot water being drained over stagnant cold supply water inside the heat exchanger, and then begins to drop in temperature as the cycle progresses. Table 5 shows the details of the testing for each dish washer with the Ecodrain unit at a 0.3 degree slope.

Table 5: Ecodrain A1000 5 Sets of 5 Racks Dish Washing Test Results

	Dishwasher A	Dishwasher B	Dishwasher C
Water Consumed by Dishwasher (gal)	26.81	17.18	16.99
Drain In (°F)	147	144	162
Drain Out (°F)	93	87	103
Supply In (°F)	70	75	64
Supply Out (°F)	86	85	91
Avg Supply Temp Rise (°F)	**15.86**	**10.90**	**27.27**
Energy Recovered by Ecodrain (Btu)	3,398	2,185	3,935
Energy Consumed by Water Heater (Btu)[a]	27,373	15,197	15,023
Energy Saved by Ecodrain (Btu)[a]	4,531	2,914	5,247
Water Heater Energy Savings (%)	**16.6**	**19.2**	**34.9**

[a]*Energy is based on water heater temperature rise of 80° and system efficiency of 75%*

Scenario C: Eight Sets of 3 Racks Test

This test was performed to simulate intermittent batch washing, which can be encountered throughout the middle of the day. The test consists of two empty rack wash stabilization and nine batches of three racks, loaded with 10 dishes each and run back to back through the machine. After each batch of three loaded racks has passed through the machine, the dishwasher was allowed to recover before the next batch was washed. The first batch of 3 racks was considered stabilization and was not used to calculate the results from the test replicate. Three replicates were performed for each test. Representative the temperature profiles for the three machines are shown in Figures 7a-7c.

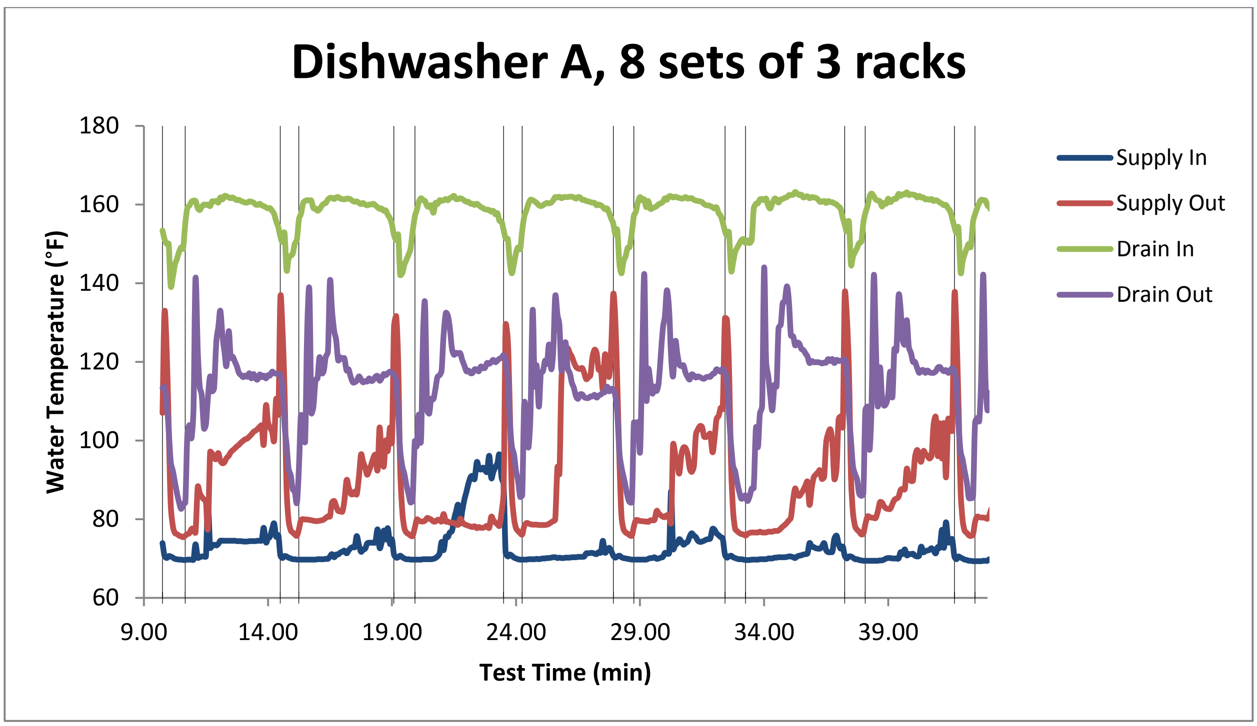

Figure 7 a: Dishwasher A Supply and Drain Temperature Profiles During the 3 Rack Wash Test

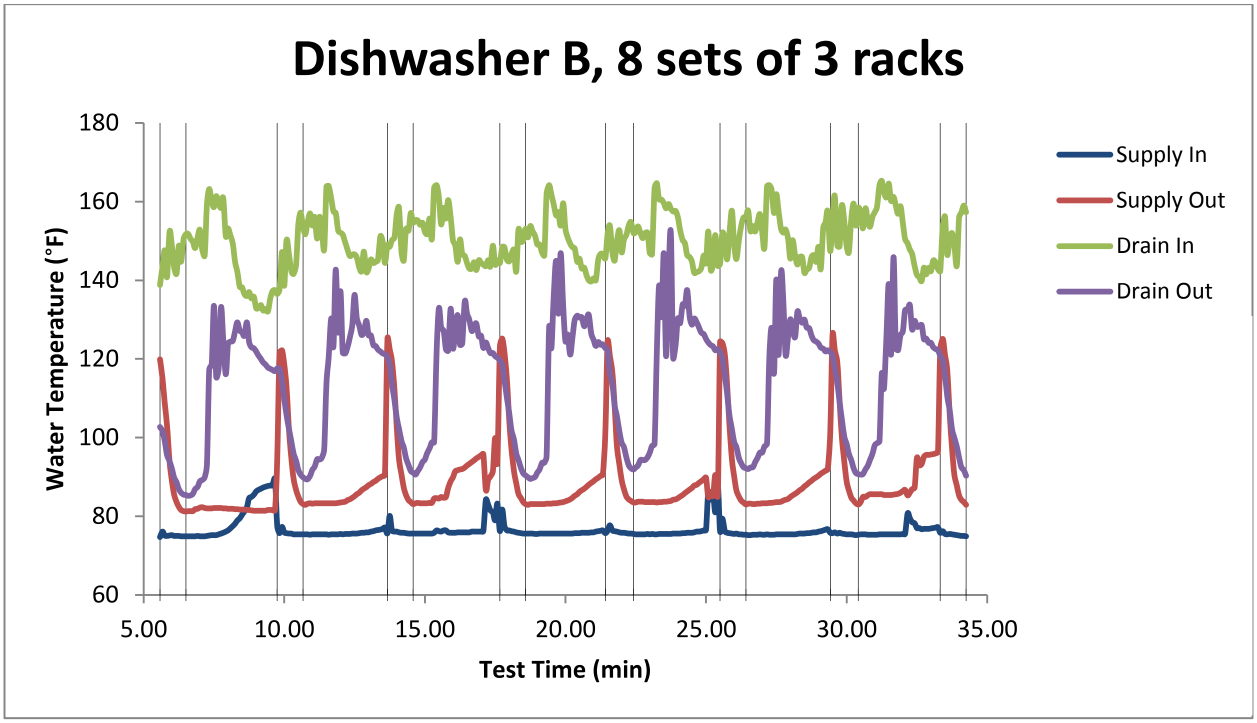

Figure 7 b: Dishwasher B Supply and Drain Temperature Profiles During the 3 Rack Wash Test

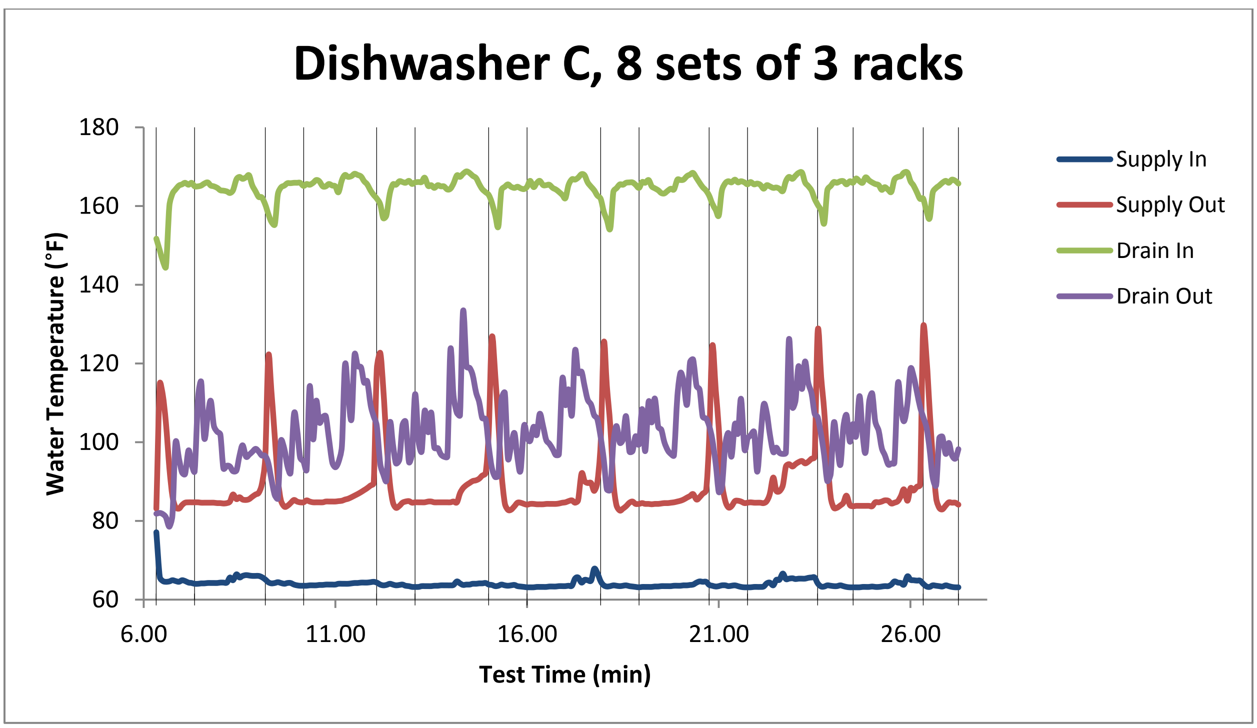

Figure 7 c: Dishwasher C Supply and Drain Temperature Profiles During the 3 Rack Wash Test

To quantify the energy recovered by the Ecodrain heat recovery unit, drain and supply water temperatures were analyzed only when the dishwasher was drawing water (e.g., during the rinse cycle). Figures 7a-7c illustrate the 8-batch test for each machine, with the rinse cycles denoted by vertical lines. Table 6 shows the details of the testing for each dish washer with the Ecodrain unit at a 0.3 degree slope.

Table 6: Ecodrain A1000 8 Sets of 3 Racks Dish Washing Test Results

	Dishwasher A	Dishwasher B	Dishwasher C
Water Consumed by Dishwasher (gal)	23.37	17.21	17.60
Drain In (°F)	150	146	163
Drain Out (°F)	97	93	98
Supply In (°F)	69	76	64
Supply Out (°F)	91	93	93
Avg Supply Temp Rise (°F)	**22.41**	**18.63**	**29.05**
Energy Recovered by Ecodrain (Btu)	4,294	3,169	4,287
Energy Consumed by Water Heater (Btu)[a]	23,772	15,223	15,532
Energy Saved by Ecodrain (Btu)[a]	5,725	4,225	5,717
Water Heater Energy Savings (%)	**24.1**	**27.8**	**36.8**

[a]*Energy is based on water heater temperature rise of 80° and efficiency of 75%*

Angle of Inclination

The manufacturer typically recommends installing the Ecodrain at a minimum angle of 5° for residential (shower) applications. This angle could be achieved when installing the heat exchanger in a new construction, however in this retrofit scenario the inclination angle was limited by the clearance between the bottom of the dishwasher and the floor. To assess the impact of the installation angle, additional tests were performed on Dishwasher C. The inclination angle of the Ecodrain was adjusted from horizontal (0°) to 1.8° and the dishwasher was tested in accordance with Scenario C. Table 7 shows the results of the angle tests.

Table 7: Ecodrain A1000 8 Sets of 3 Racks Dish Washing Test Results at Different Inclination Angles

Inclination Angle (degrees)	**0.0**	**0.3**[b]	**0.9**	**1.8**[b]
Water Consumed by Dishwasher (gal)	17.37	17.56	17.31	17.24
Drain In (°F)	153	163	165	165
Drain Out (°F)	99	98	106	123
Supply In (°F)	64	64	66	64
Supply Out (°F)	87	93	99	99
Avg. Supply Temp. Rise (°F)	**23.30**	**29.05**	**33.30**	**35.13**
Energy Recovered by Ecodrain (Btu)	3,395	4,287	4,886	5,079
Energy Consumed by Water Heater (Btu)[a]	15,365	15,532	15,306	15,245
Energy Saved by Ecodrain (Btu)[a]	4,526	5,717	6,515	6,495
Water Heater Energy Savings (%)	**29.5**	**36.8**	**42.6**	**44.4**

[a]*Energy is based on water heater temperature rise of 80° and system efficiency of 75%*

[b]*Results based on three replicates*

The chart in Figure 8 shows that dramatic benefit can be achieved with as little inclination as 1° from horizontal. From the results, it is evident that the angle of inclination has a significant effect on the heat transfer of the heat exchanger.

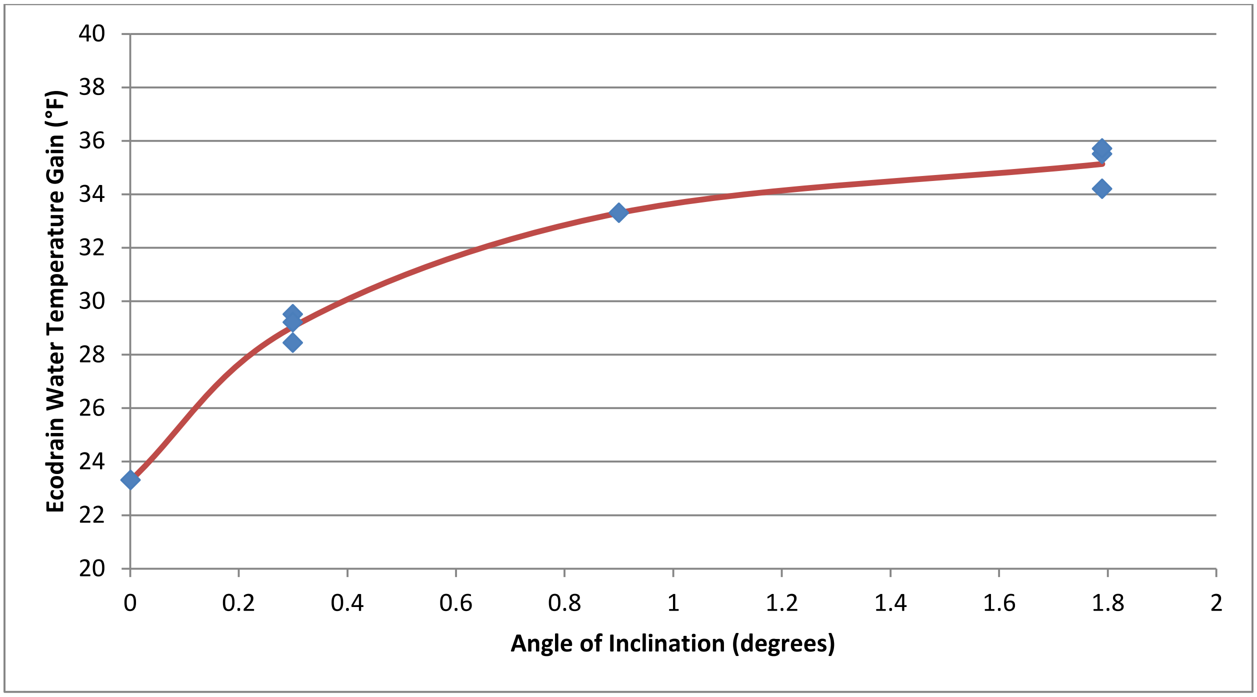

Figure 8: Ecodrain Cold Water Temperature Gain vs. Heat Recovery Unit Angle

Energy Cost Model

The test results can be used to estimate the annual energy consumption and cost for the different test scenarios. A cost model was developed based on the dishwasher washing 1000 racks per day, 364 days a year. For simplicity, the model assumed that the dishwasher used a dedicated primary hot water heater to provide 140°F water to the machine. Water heater energy usage was calculated based on a 75% system efficiency and an incoming cold water supply of 60°F. The Ecodrain temperature rise during washing was based on the averaged values between Scenario B (5- rack batches) and Scenario C (3-rack batches). The results of the cost model for the three dishwashers are shown in Table 8.

Table 8: Estimated Energy Savings and Cost

	Dishwasher A	Dishwasher B	Dishwasher C
Water Consumption (gal/rack)	0.979	0.701	0.677
Daily Water Consumption (gal)	979	701	677
Estimated Water Heater Gas Consumption (Btu/day)	869,874	622,862	601,537
Average Ecodrain Temperature Rise During Washing (°F)	19.15	14.75	28.20
Estimated Energy Saved by Ecodrain (Btu/day)	208,226	114,840	212,042
Annual Gas Energy Saved by Ecodrain (therms/year)	**758**	**418**	**772**
Annual Water Heater Energy Savings ($/year)[a]	**758**	**418**	**772**

[a] Water heater gas energy costs are based on $1.00/Therm

The drain water temperature of all three machines tested exceeded 140°F, which is above the maximum allowable drain temperatures in some regions by code. In these circumstances, additional cold water is mixed with the drain water to lower the temperature to acceptable limits. During this performance testing with the Ecodrain heat exchanger installed, the drain water temperature was lowered well below 140°F, eliminating the need to use additional cooling water and improving the operating cost savings potential of the Ecodrain.

Conclusion

The Ecodrain A1000 heat recovery unit offered significant energy savings potential when paired with a high temperature sanitizing rack conveyor dishwasher. The efficacy of the Ecodrain in a commercial dishwashing application would depend on the dishwasher type, usage patterns, incoming cold water supply temperature, distance from the heat recovery unit to the primary water heater and the angle of inclination of the heat recovery unit. While there are many variables that would impact the efficacy of drain water heat recovery, the results of this study have indicated that there is a moderate cost savings potential ($418 – $772 per year) for combining the Ecodrain heat recovery unit with a high temperature sanitizing, rack conveyor dishwasher in a commercial foodservice operation. The Ecodrain energy savings potential would increase with operations using larger machines or machines that have higher water consumption.

Additional Resources

1. American Society for Testing and Materials. 2011. *Standard Test method for the Performance of Rack Conveyor, Commercial Dishwashing Machines.* ASTM Designation F1920-11, in *Annual Book of ASTM Standards,* West Conshohocken, PA.

Appendix A: Glossary of Terms

Booster Heater
Water heater for taking supply hot water (typically 140°F) up to 180°F+ for sanitizing rinse; the booster heater may be separate from dishwasher or integral.

Concurrent
Flowing in an parallel direction to another

Countercurrent
Flowing in an opposite direction to another

Dishload
Peg-type, polypropylene dishrack of a specified weight, loaded with ten 9-in. plates of a specified weight, used to put a thermal load on the dishwasher during the washing energy test.

Dishwasher
A machine that uniformly washes, rinses, and sanitizes eating and drinking utensils.

Drain
A channel or pipe carrying off surplus liquid from the dishwasher

Heat Exchanger
A device for transferring heat from one medium to another

Heat Recovery
The use of heat that is produced in a thermodynamic cycle, in another process, such as heating feedwater

Hot Water Sanitizing Machine
A warewashing machine that applies potable hot water to the surfaces of wares to achieve sanitization.

Pipe Insulation
Thermal insulation used to prevent heat loss and gain from pipes, to save energy and improve effectiveness of thermal systems.

Recovery Time
Time from the end of washing a dishload to until the wash tank heaters have cycled off.

Rinse Cycle
The removal of soap with clean hot water in the final stage of washing

Sanitary Sewer
A separate underground carriage system specifically for transporting sewage from houses and commercial buildings to treatment or disposal.

Set Point (°F)
Targeted temperature set by appliance controls

Single Tank Conveyor Dishwasher
A warewashing machine that employs a conveyor or similar mechanism to carry dishes through a series of wash and rinse sprays within the machine. Specifically, a single tank conveyor machine has a tank for wash water followed by a final sanitizing rinse and does not have a pumped rinse tank. This type of machine may include a pre-washing section before the washing section. Single tank conveyor dishwashers can be either chemical or hot water sanitizing, with an internal or external booster

Stabilize
To keep from fluctuating or put into an equilibrium

Test Method
A definitive procedure for the identification, measurement and evaluation of one or more qualities, characteristics, or properties of a material, product system, or service that produces a test result.

Typical Day
A sample day of average appliance usage based on observations and/or operator interviews. Used to develop an energy cost model for an appliance.

Warewashing
The cleaning and sanitizing of utensils and food-contact surfaces of equipment.

Wash Cycle
The removal of food debris by high pressure water jets in the initial stage of washing

Wash Tank
Dishwasher's largest heated water tank used to supply the water for the wash cycle

Water Heater
An automatically controlled, thermally insulated vessel designed for heating water and storing heated water at temperatures less than 180 degrees Fahrenheit.