Commercial Kitchen Ventilation
Performance Report

Condenser Unit Performance
with the Hobart AM15T Dishwasher

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Prepared by:
Rich Swierczyna
Paul Sobiski
Architectural Energy Corporation

Don Fisher
Fisher-Nickel, Inc.

Prepared for:
Pacific Gas & Electric Company
Customer Energy Efficiency Programs
P.O. Box 770000
San Francisco, California 94177

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Objective and Scope

The objective of the laboratory testing was to measure the convective heat load generated by the Hobart AM15T commercial dishwasher during the dishwashing process and the effectiveness of the Condenser Unit to prevent the convective heat load from entering the space. The specific objectives were to:

(1) Measure the amount of convective heat (i.e., sensible and latent) released by the Hobart AM15T during normal operation in low temperature chemical sanitizing mode.
(2) Measure the amount of convective heat (i.e., sensible and latent) removed by the Hobart AM15T during operation in high temperature sanitizing mode with an integral Condenser Unit.
(3) Compare the differences in total convective heat load to the space between the two operations and a standard high temperature sanitizing mode operation.

The convective heat load added to the space was measured indirectly using a canopy hood over the dishwashers to capture and contain the equivalent heat load that would otherwise be added to the space.
Equipment

Hobart Model AM15T Dishwasher

The Hobart Model AM15T dishwasher measured 68.3 inches high by 24.5 inches wide by 30.5 inches deep (see Appendix A). The electrically powered dishwasher operated with a high temperature sanitation cycle and a low temperature chemical sanitation cycle. It was equipped with an electric booster heater. The electrical specifications of the unit were 208-240V, 60Hz, 3Ph, 24.6A. The booster heater was rated at 208-240V, 60Hz, 3Ph, 31.3A. The dishwasher test set-up is shown in Figure 1.

![AM15T Dishwasher](image)

Figure 1. AM15T Dishwasher
The Condenser Unit assembly connected to the top of a second identical AM15T dishwasher and stood approximately 12 inches above the unit, as shown in Figure 2. It consisted of a recirculating fan that drew the air from the wash cavity through five rows of finned water coils and discharged it back into the wash cavity. Tap water at approximately 71°F was supplied to the coil at a pressure of 40-42 psi.

Figure 2. Close-Up View of Condensing Unit
Wall-Mounted Canopy Hood

For testing purposes, the dishwashers were positioned under a wall-mounted canopy hood to capture and contain the sensible and latent heat from the dishwasher during the operating cycle. The hood was 2.0-feet high by 5.0-feet wide by 5.0-feet deep, featured a 1.5 inch inward flange along its front and side edges, and did not contain filtration. The hood was exhausted through a 12.0-inch by 12.0 inch collar centered along the rear of the hood.

The dishwasher was positioned to provide a 24.0-inch front overhang. The appliance was centered left-to-right under the hood, which provided a 17.8-inch side overhang. The test set-up with the AM15T and Condenser Unit is shown in Figure 3.

![Figure 3 Test Set Up for AM15T Dishwasher with Condensing Unit](image)
Method of Test

The dishwashers were operated according to the manufacturer’s recommendations and ASTM F1696 Standard Test Method for Energy Performance of Hot Water Sanitizing, Door-Type Commercial Dishwashing Machines.

Operational Parameters

A cycle rate of 30 racks per hour was maintained for the dishwashers with and without the Condensing Unit. The wash cycle was 40 seconds and the rinse cycle was 10 seconds. The dishwasher’s water inlet was supplied through an electric booster heater located outside of the laboratory. The average water temperature at the booster heater outlet was regulated to 140°F. The flowing temperature at the dishwasher machine’s inlet during the rinse cycle was 185°F for high temperature sanitizing mode, and 124°F for low temperature chemical sanitizing mode. The flowing pressure during the rinse cycle was between 17-20 psi for the machines in low and high temperature sanitizing mode. Wash, rinse, or sanitizing chemicals were not used.

The operational timing is shown in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Low Temperature Chemical Sanitizing</th>
<th>High Temperature Sanitizing with Condensing Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wash Time (sec)</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Rinse Time (sec)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Condense Time (sec)</td>
<td>n/a</td>
<td>30</td>
</tr>
<tr>
<td>Cycle Time (sec)</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>Load Time (sec)</td>
<td>70</td>
<td>40</td>
</tr>
<tr>
<td>Total Cycle (sec)</td>
<td>120</td>
<td>120</td>
</tr>
</tbody>
</table>

During the predetermined load time, one rack of dishes weighing approximately 19.5 pounds remained in the machine as the door was opened and closed.

The Condenser Unit was supplied with tap water to the coil at approximately 71°F and at a pressure of 40-42 psi. The Condenser Unit fan switched on after the 50 second wash/rinse cycle and continued for 30 seconds.

Heat Load Calculations

Capture and containment performance of the hood and appliance configurations were verified using flow visualization techniques. One focusing schlieren system and two shadowgraph systems were used to observe the thermal plumes from the dishwashers. To ensure valid and repeatable test results, the ASTM F1704-05 Capture and Containment Performance of Commercial Kitchen Exhaust Ventilation Systems was applied to the hood performance validation. All heat load tests were run at an exhaust airflow rate of 1700 cfm, which was verified for hood capture and containment.
The calculations used to determine the amount of convective (both sensible and latent) heat load from the dishwasher were derived by applying existing standards. These standards included ASTM F 1696 Standard Test Method for Energy Performance of Hot Water Sanitizing, Door-Type Commercial Dishwashing Machines, and ASTM F 2474 Standard Test Method for Heat load to Space Performance of Commercial Kitchen Ventilation/Appliance Systems.

With the dishwasher operating under a canopy hood that exhausted outside the laboratory, the dry bulb temperatures, dew point temperatures, and airflow rates were measured for the exhaust, and makeup air streams. From these measurements, the humidity ratio, enthalpy and heat loads were calculated and averaged over the test period. The convective energy measured in the exhaust airstream represented the heat load to the space if the dishwashing operation was unhooded. The sensible and latent heat loads to the space is reported as measured in the exhaust airstream. The laboratory energy balance is shown in Figures 4. The calculations that were applied are shown in Equations (2) and (3).
Figure 4. Laboratory Energy Balance Diagram

Energy Balance

\[ E_{\text{mua}} - E_{\text{exh}} - E_{\text{radiation}} + E_{\text{appliance}} + E_{\text{water inlet}} - E_{\text{water drain}} = 0 \]  \hspace{1cm} (1)

Where:
- \( E_{\text{mua}} \) is the energy in the makeup air stream
- \( E_{\text{exh}} \) is the energy in the exhaust air streams
- \( E_{\text{appliance}} \) is the energy input to the dishwasher
- \( E_{\text{water inlet}} \) is the energy in the makeup hot water to the dishwasher
- \( E_{\text{water drain}} \) is the energy in the water overflow from the dishwasher down the drain
The convective heat loads as measured in the exhaust airstream are calculated by:

**Convective Loads**

\[
q_{\text{space-sensible load}} = 1.08 \ Q_{\text{exh}} (T_{\text{db-exh}} - T_{\text{db-mua}}) \quad (2)
\]

\[
q_{\text{space-latent load}} = 4840 \ Q_{\text{exh}} (W_{\text{exh}} - W_{\text{mua}}) \quad (3)
\]

Where:

- \(q_{\text{space-sensible load}}\) is the convective sensible heat load to the space in Btu/h
- \(q_{\text{space-latent load}}\) is the convective latent heat load to the space in Btu/h
- \(Q_{\text{exh}}\) is the volumetric flow rate of the exhaust air stream in cfm
- \(T_{\text{db-mua}}\) the dry bulb temperature of the makeup air stream in °F
- \(T_{\text{db-exh}}\) is the dry bulb temperature of the exhaust air stream in °F
- \(W_{\text{mua}}\) is the humidity ratio of the makeup air stream in pound of water per pound of dry air
- \(W_{\text{exh}}\) is the humidity ratio of the exhaust air stream in pound of water per pound of dry air
Results and Discussion

The total convective heat loads (sensible and latent) are compared for the AM15T operating in low temperature chemical sanitizing mode, and high temperature sanitizing mode with and without the Condensing Unit. The data for the standard machine in high temperature sanitizing mode were taken from a prior test report.

Convective Heat Loads during Washing Conditions

The convective heat load tests were run at an airflow rate of 1700 cfm. The heat load results during washing conditions are summarized in Table 2.

Table 2. Data Summary for Testing During Washing Operation

<table>
<thead>
<tr>
<th></th>
<th>Low Temperature Chemical Sanitizing</th>
<th>High Temperature Sanitizing with Condensing Unit</th>
<th>High Temperature Sanitizing without Condensing Unit¹ (i.e., Standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Convective Heat Load [Btu/h]</td>
<td>17,100</td>
<td>17,800</td>
<td>29,400</td>
</tr>
<tr>
<td>Sensible Heat Load [Btu/h]</td>
<td>3,900</td>
<td>4,800</td>
<td>8,000</td>
</tr>
<tr>
<td>Latent Heat Load [Btu/h]</td>
<td>13,200</td>
<td>13,000</td>
<td>21,400</td>
</tr>
<tr>
<td>Average Maximum Wash Tank Water Temperature (°F)</td>
<td>129</td>
<td>150</td>
<td>155</td>
</tr>
<tr>
<td>Average Rinse Water Temperature (°F)</td>
<td>124</td>
<td>185</td>
<td>181</td>
</tr>
<tr>
<td>Average Drain Water Temperature (°F)</td>
<td>125</td>
<td>142</td>
<td>155</td>
</tr>
<tr>
<td>Water Consumption (gal/rack)</td>
<td>0.68</td>
<td>0.90²</td>
<td>0.64</td>
</tr>
</tbody>
</table>

²Measurement includes four double fill machine errors

The heat load values in Table 2 represent the sensible and latent heat loads that the space would gain if the dishwasher was unhooded during the specific operating conditions. The wash tank temperatures were the maximum recorded temperatures during the wash/rinse cycle. The rinse water temperatures were the average flowing temperatures during the rinse cycle. The drain water temperatures were the average flowing temperature of the bulk drain water per cycle. The water consumption was weighed and calculated on a cumulative and per rack basis.

The average wash tank temperature for the low temperature chemical sanitizing machine was 129°F, the high temperature sanitizing machine with the condenser unit was 150°F, and for the standard high temperature machine the average wash temperature was 153°F. The rinse water temperature for the low temperature machine was 124°F, while the high temperature machine with the condenser unit was 185°F and without the condenser unit was 181°F. The average bulk drain water temperature was 125°F for the low temperature machine, the high temperature machine with the condenser unit was 142°F and without the condenser unit was 147°F. The water consumption for the low temperature machine was 0.68 gallons per rack. The water consumption for the high temperature machine with the condenser unit was artificially high at 0.90 gallons per rack.
rack. During the testing, the rinse pump triggered twice, instead of once, for four of the twenty cycles. The standard high temperature machine consumed 0.64 gallons per rack. The Condenser Unit consumed approximately 0.76 gallons during the 30 second condensing cycle.

From the airflow, dry bulb and dew point temperature measurements, the heat loads were calculated. The total heat loads released to the space (for an unhooded application) and the sensible/latent fractions are shown in Figure 9.

\[ \text{Sensible Heat Load (Btu/h)} \]
\[ \text{Latent Heat Load (Btu/h)} \]

![Figure 5. Convective Heat Load to Space from Hobart AM15T with during Low Temperature Chemical Sanitizing Operation and High Temperature Sanitizing Machine with and without the Condensing Unit.](image)

In comparing the two high temperature sanitizing machines with and without the Condensing Unit, when the Condensing Unit was added to the high temperature sanitizing machine, the total convective load was reduced by 11,600 Btu/h, or 39%, from 29,400 Btu/h to 17,800 Btu/h. The load from the high temperature sanitizing unit with the condensing unit, 17,800 Btu/h, was 700 Btu/h above the load from the low temperature chemical sanitizing unit, 17,100 Btu/h. Without the condensing effect from the condensing unit, the latent load was 21,400 Btu/h from the standard high temperature sanitizing machine. The same machine with a Condensing Unit generated a latent load of 13,000 Btu/h. The condensing unit reduced the latent load by 8,400 Btu/h, or 39%. Similarly, the sensible load was reduced by 3,200 Btu/h, from 8,000 Btu/h to 4,800 Btu/h.
In comparing the loading from the high temperature sanitizing machine with a condensing unit to a low temperature chemical sanitizing machine, it was found the total loading was slightly higher due to the increase in sensible heat from the increased wash tank temperature. The total convective heat gain from the high temperature sanitizing machine with the condensing unit was 700 Btu/h higher, at 17,800 Btu/h than the low temperature chemical sanitizing unit with a total convective load of 17,100 Btu/h. The latent loading of the high temperature sanitizing machine with a condensing unit was 200 Btu/h less than the low temperature chemical sanitizing machine because of the condensing unit’s affect. However, the sensible loading of the high temperature sanitizing machine with a condensing unit was 900 Btu/h greater than the low temperature chemical sanitizing machine due to the increased wash tank temperature.

Sensitivity testing found the heat loading from 10 racks of dishes during low temperature chemical sanitizing mode was 3,100 total (310 Btu/h per rack), 1,500 Btu/h sensible, 1,600 Btu/h latent. During high temperature sanitizing mode the heat loading from 10 racks of dishes was 3,200 total (320 Btu/h per rack), 1,000 Btu/h sensible, 2,200 Btu/h latent.
Convective Heat Loads During Idle Conditions

Convective heat loads were measured during idle (ready to wash) condition for the dish machines at typical wash tank temperatures. A sensitivity test was conducted for the high-temperature machine with the wash door open and the door closed. A summary of the test data from the idle testing is shown in Figure 10.

![Convective Heat Loads to Space During Idle Condition](image)

Figure 6. Convective Heat Loads to Space During Idle Condition

Wash tank water temperatures averaged 131°F for the low-temperature machine, and 151°F for the high-temperature machine. The skin temperatures on the door with the doors open were 77°F and 76°F, respectively. The skin temperature on the door of the high-temperature machine with the door closed was 95°F.

For the AM-15T idling with doors open, the total convective heat load for the low temperature machine was 1,900 Btu/h, and 2,800 Btu/h the high temperature machine. The convective load for the high temperature machine with the door closed was 2,000 Btu/h, or 800 Btu/h less than the door open condition. The latent load dropped 700 Btu/h, or 37%, from 1,900 Btu/h to 1,200 Btu/h by closing the doors.
Conclusions

For the Hobart AM15T representative dishwashing operation of 30 racks per hour, the total convective heat load released was determined in prior testing to be 29,400 Btu/h. For the same dishwashing operation utilizing a Condensing Unit, the convective heat load released to the space was reduced by 11,600 Btu/h, or 39%, to 17,800 Btu/h. For comparison, a low temperature dishwashing operation released 17,100 Btu/h. The comparison showed that the high temperature dishwashing operation with a Condensing Unit generated similar convective heat loads (within 4%) as the low temperature chemical operation.
Appendix A – Appliance Specifications

AM SELECT TALL DISHWASHER

STANDARD FEATURES
- .74 gallons per rack final rinse water
- 58 racks per hour – hot water sanitizing
- 65 racks per hour – chemical sanitizing
- NSF pot and pan listed for 2-, 4- & 6- minute cycles
- Timed wash cycles for 1, 2, 4 or 6 minutes
- 27” door opening for 18” x 26” sheet pans or 60 quart mixing bowl
- Solid state, integrated controls with digital status indicators
- Self-draining, high efficiency stainless steel pump and stainless steel impeller
- Stainless steel drawn tank, tank shelf, chamber, trim panels, frame and feet
- Spring counterbalanced chamber with polyethylene guides
- Revolving, interchangeable upper and lower anti-clogging wash arms
- Revolving, interchangeable upper and lower rinse arms
- Slanted, self-locating, one-piece scrap screen and basket system
- Automatic fill
- Door actuated start
- Automatic drain closure
- Vent fan control
- External booster activation
- Delime cycle
- Service diagnostics
- NAFEM Data Protocol capable
- Straight-through or corner installation
- Hot water or chemical sanitation
- Sheet pan rack

OPTIONS AT EXTRA COST
- Gas heat
- Sense-A-Temp™ 70°F rise electric booster heater
- Single point electrical connection for booster equipped machines (3 phase only)

ACCESSORIES
- ¾” pressure regulator valve
- Peg rack
- Combination rack
- Sheet pan rack
- Splash shield for corner installations
- Flanged and seismic feet
- End of cycle audible alarm (field activated)
- Delime notification (field activated)
- Drain water tempering kit

Specifications, Details and Dimensions on Inside and Back.

VOLTAGE
- 208-240/60/1
- 208-240/60/3
- 480/60/3
- 200-240/50/3”
- 380-415/50/3”

*Not submitted for UL/CUL Listing
AM SELECT TALL DISHWASHER

The microcomputer-based control system is built into the AM Select dishwasher. It is available in standard electrical specifications of 208-240/60/1, 208-240/60/3, 480/60/3, 200-240/50/3, 380-415/50/3 and is equipped with a reduced voltage pilot circuit transformer.

*CAUTION: CERTAIN MATERIALS, INCLUDING SILVER, ALUMINUM AND PEWTER ARE ATTACKED BY SODIUM HYPOCHLORITE (LIQUID BLEACH) IN THE CHEMICAL SANITIZING DISHWASHER MODE OF OPERATION. WATER HARDINESS MUST BE CONTROLLED TO 4-6 GRAINS FOR BEST RESULTS.

CONSTRUCTION: Drawn tank, tank shelf and feet constructed of 16 gauge stainless steel. Wash chamber and front trim panel above motor compartment are polished, satin finish. Frame is 12 gauge stainless steel, chamber is 18 gauge, and removable trim panels are 20 gauge.

CHAMBER: Stainless steel chamber with large 20½" W x 27" H opening will accommodate 18" x 26" sheet pans or a 60-quart mixing bowl.

CHAMBER LIFT: Chamber coupled by stainless steel handle, spring counterbalanced. Chamber guides for ease of operation and long life.


MOTOR: Built for Hobart, 2 H.P., with inherent thermal protection, grease-packed ball bearings, splash-proof design, ventilated. Single-phase is capacitor-start, induction-run type. Three-phase is squarer-cage, induction type.

MICROCOMPUTER CONTROL SYSTEM: Hobart microcomputer controls, assembled within water-resistant enclosure, provide built-in performance and reliability.

The microcomputer control, relays and contactors are housed behind a stainless steel enclosure, hinged to provide easy access for servicing. The line voltage electrical components are completely wired with 105°C, 600 volt thermoplastic insulated wire with stranded conductors and routed through listed electrical conduit. Electrical components are wired with type ST cord. Line disconnect switch NOT furnished.

CYCLE OPERATION: The microcomputer-timing program is started by closing the doors, which actuates the door cycle switch. The microcomputer energizes the wash pump motor contractor during the wash portion of the program. After the wash, a dwell permits the upper wash manifold to drain. At the end of the dwell, the final rinse solenoid valve is energized. After the final rinse valve closes, Sani-Dwell (Hot Water Mode) only permits sanitization to continue. The Rinse display remains on during this period, completing the program. If the microcomputer is interrupted during a cycle by the door-cycle switch, the microcomputer is reset to the beginning of the program. Hot Water Sanitizing (56 racks per hour) - 57 seconds: 38 Seconds Wash, 2 Seconds Dwell, 10 Second Rinse, 7 Second Chemical Sanitizing (65 racks per hour) - 50 Seconds: 38 Seconds Wash, 2 Seconds Dwell, 10 Second Rinse. Other programs can be pre-selected by your Hobart service technician.

Manual wash cycle selector also provides selection of 2-, 4-, or 6-minute wash cycles for heavier washing applications.

WASH: Hobart revolving stainless steel wash arms with unrestricted openings above and below provide thorough distribution of water jets to all dishwasher surfaces. Arms are easily removable for cleaning and are interchangeable. Stainless steel tubing manifold connects upper and lower spray system.

RINSE: Rotating rinse arms, both upper and lower, feature 14 rinse nozzles. The stainless steel upper and lower rinse arms are easily removable without tools for inspection and are interchangeable. Diaphragm-type rinse control solenoid valve mounted outside machine. Machine is equipped with special hot water vacuum breaker on both sides of rinse valve mounted 6" above uppermost rinse opening. Easy open brass line strainer furnished.

FILL: Microcomputer controlled fill valve installed on upstream side of rinse vacuum breaker. Ratio fill method is used giving the correct fill at any flowing water pressure. (20 PSI minimum necessary for proper rinsing.)

DRAIN AND OVERFLOW: Large bell type automatic overflow and drain valve controlled from inside of machine. Drain automatically closed by lowering chamber. Drain seal is large diameter, high temperature "O" ring. Cover for overflow is integral part of the stand pipe.

STRAINER SYSTEM: Equipped with large, exclusive self-jettisoning, easily removable perforated stainless steel, one-piece strainer and large capacity scrap basket. Submerged scrap basket minimizes frequent removal and cleaning.

HEATING EQUIPMENT: Standard tank heat is SKW electric immersion heating element. Regulated power infrared gas immersion tube system is optional at extra cost. A solid-state igniter board controls the gas valve and provides flame ignition. A transformer steps the control circuit voltage down to 24 volts to power the igniter board and gas valves.

Gas Heated Dishwasher: For natural gas, gas pressure (customer connection) not to exceed 7" W.C. For liquefied petroleum, gas pressure to burner (customer connection) not to exceed 11" W.C. If gas pressure is higher than 7" W.C. natural or 11" W.C. LP, a pressure regulating valve must be supplied by others, in the gas line to the dishwasher. Water temperature regulation is controlled by thermistor sensor in combination with microcomputer controls. The tank heat and positive low water protection microcomputer circuits are automatically activated when the main power switch is turned "on." If tank is accidentally drained, low water protection device automatically turns heat off. Gas immersion tube is additionally protected by a high limit device mounted on the surface of the tube. These features are standard with the Hobart Microcomputer Control System.

OPTIONAL EQUIPMENT AT EXTRA COST – ELECTRIC BOOSTER HEATER: Electric booster with Sense-A-Temp technology adequately sized to raise 110°F inlet water to 180°F (not available on gas heat models).

ACCESSORIES: 19% x 19% peg and combination dish racks. Sheet pan rack. Splash shield for corner installations. End of cycle audible alarm (field activated). Delime notification (field activated). Desirable functional accessories can be furnished at added cost. See listed options and accessories on this specification sheet. Write to the factory for special requirements not listed above.