Codes and Standards Enhancement Initiative
For PY2004: Title 20 Standards Development

Draft Analysis of Standards Options
For
Commercial Hot Food Holding Cabinets

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1 Introduction

The Pacific Gas and Electric Company (PG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (the Commission) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE Reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE report covers standards and options for commercial hot food holding cabinets.

2 Product Description

Commercial hot food holding cabinets are used in the commercial kitchen industry primarily for keeping food at safe serving temperature, without drying it out or further cooking it. These cabinets can also be used to keep plates warm and to transport food for catering events. There are two primary energy-using components in hot food holding cabinets: the heating element and the fan motor. The heating element is by far the more significant energy user, rated at approximately 1,000 to 2,000 watts, while the fan motor demands approximately 50 watts.

Hot food holding cabinets are freestanding, consisting of a metal cabinet, with internal pan supports for holding food trays, and wheels on the bottom. The cabinets of some models are insulated while others are not. They are available in three size ranges commonly classified as “full-size”, “three-quarter size”, and “half-size”. The inside dimensions for each of these size classes is not formally standardized, and they are only somewhat consistent among manufacturers. The inner dimensions of full-size cabinets appear to range from approximately 52 to 58 inches high; three-quarter-size are approximately 38 to 42 inches high; and, half-size are approximately 20 to 28 inches high. All sizes appear to be approximately 28 inches deep and 22 inches wide. Hot food holding cabinets may include one or two compartments, and a single door or Dutch doors, allowing for more control over food warming. Some units also have a back door opposite the front door(s), and are referred to as “pass-through” models. Units also exist that have glass doors, which may be single-or double-paned.

Hot food holding cabinets are electrically-powered and are equipped to plug into a 120 or 208/240 volt wall outlet in order to power the cabinet and maintain the desired temperature. The heat source can be located on top of or below the cabinet and generally consists of a fan that blows air over an electric resistance element and throughout the cabinet. The heating element cycles on and off, but the fan motor runs continuously. The unit’s controls typically include an on/off switch and a temperature dial with digital or analog readout. While most hot food holding cabinets are heated by convection, at least one major manufacturer’s cabinets are equipped with a network of thermocables in the cabinet walls, warming the cabinet with radiative heat and obviating the need for a fan.

This analysis does not include "cook and hold" cabinets or "proofer" cabinets because these products differ substantially in function from hot food holding cabinets. Cook and hold models are generally used for tasks such as slow roasting overnight, and then keeping food warm for the next business day; proofers heat to a maximum temperature of about 90 degrees F and are used for leavening bread. Hot food holding cabinets typically heat to and maintain a temperature of approximately 150 degrees F.

3 Market Status

3.1 Market Penetration

An estimated 50,000 hot food holding cabinets are in service in California (Bohlig, 2003). The market is dominated by eight manufacturers: Alto Shaam, Bevles Company (Bevles), Carter-Hoffman Corporation (Carter-Hoffman), CresCor, FWE/Food Warming Equipment (FWE), InterMetro Industries Corporation (InterMetro), Servolift Eastern Corporation (Servolift), and Wittco Foodservice Equipment (Wittco) (Lorenzini, 2003). Specific market share information was either unavailable or not provided by these manufacturers.

3.2 Sales Volume

Comprehensive sales data were not readily available, although CresCor, a major manufacturer of hot food holding cabinets, said that in California they sold 418 units in 2003, and 504 in 2002 (Harvey, 2003). Presuming the design life of hot food holding cabinets is 15 years (see Section 5.2), annual sales volume is estimated to be 3,300 units per year.

3.3 Market Penetration of High Efficiency Options

Communications with manufacturers indicate that current hot food holding cabinet sales are predominantly insulated models. Although the manufacturer Bevles states that the company sells about the same number of insulated hot food holding cabinets as non-insulated models, Alto Shaam, Carter-Hoffman, and Wittco only offer insulated models. Although Servolift carries lines of insulated and non-insulated (with the option to insulate) hot food cabinets, Flavian Iovanel, Vice President of Engineering at Servolift, stated that nine out of ten cabinets they sell are insulated (Iovanel, 2003). Iovanel also indicated that most cabinets models now on the market are insulated; he believes this is because they more handily meet the National Sanitation Foundation's requirement that a minimum of 150 degrees F is maintained at three separate points in hot food holding cabinets, in order to ensure that food is safe for consumption.

4 Savings Potential

4.1 Baseline Energy Use

The following steps were taken in the process of calculating baseline energy use:

First, the relative proportion of full-size, ¾-size and ½-size hot food cabinets had to be estimated. Because manufacturers often focus their sales on particular industries (e.g., restaurant, hospital, schools, etc.), each of which has its own preferences for cabinet size and style, there is considerable variation among manufacturers in relative proportion of sales of different sized cabinets. Interpreting individual manufacturer comments in lieu of more specific, market-wide data, we estimated that the California stock and sales consist of roughly 50% full-size units, 25% ¾-size units, and 25% ½-size units.[1]

Second, we developed an estimate of the ratio of insulated versus non-insulated cabinets because energy use for each type differs markedly. As mentioned above, Alto Shaam, Carter-Hoffman, and Wittco only offer insulated models. CresCor and Servolift indicate that they sell more insulated then non-insulated (CresCor, 2003; Iovanel, 2003); however Bevles states that they sell roughly the same proportion of insulated and non-insulated cabinets. Without knowing specific market share for any of these manufacturers, the sales and stock are assumed to be 75% insulated and 25% non-insulated cabinets. We apply these proportions equally to all three size categories.

Last, each manufacturer was asked for energy consumption data, but no information was available beyond what manufacturers had already provided to the US Environmental Protection Agency's (US EPA) ENERGY STAR program. At the time this analysis was developed, data for only two manufacturers were available on the ENERGY STAR Web site. Due to the dearth of energy use data for this appliance, baseline energy use was calculated based on information from three sources:

- Food Service Technology Center (FSTC) Report "CresCor Models H-137-UA-12B & 131-1816B Hot Food Holding Cabinet Performance Test" (commissioned by PG&E in 2000). This report provides results from testing one full-size insulated cabinet and one full-size non-insulated cabinet, including pre-heat times and heating system duty cycles.
- US EPA's listing of Energy Star Qualified Commercial Hot Food Holding Cabinets, all of which were manufactured by either CresCor or Alto Shaam[2].

[1] According to one manufacturer, Carter-Hoffman, the company sells more full-size cabinets, than ¾-size cabinets, and more ¾-size cabinets than ½-size cabinets (Palmy, 2003). An Alto Shaam customer service representative estimates that they sell more full- and ¾-size cabinets than ½ -size cabinets, by a ratio of three to one. Lastly, Wittco indicates that 40 to 50% of their sales are full-size cabinets, and of the ¾- and ½-sizes, more ½-size is sold than ¾-size (Wittco, 2003). CresCor indicated that 70% of the hot food holding cabinets sold in their most popular model line are full size, and that they sell "very few" of the ½ size, implying that 25 to 30% of sales in that product line are ¾ size cabinets (Delau, 2003).

[2] Once a manufacturer lists a qualifying product with Energy Star, the manufacturer may list additional "models represented" from within the same product line. These are larger volume models within the same product line and they can be listed without actually being tested because, due to a lower surface-to-volume ratio, they are more efficient than smaller products. However, although they are technically listed with Energy Star, exact energy use data and volumes are not provided for these "models represented".

- Manufacturer specifications sheets, which provide power ratings for the electrical heating systems.

Of the eight manufacturers contacted, only CresCor, Alto Shaam, Servolift, and Wittco confirmed that they had tested at least one of their models of insulated hot food cabinets for "idle energy rate".[3] CresCor and Alto-Sham's results were posted on the ENERGY STAR Web site, and Wittco's data was unavailable. Servolift's results were determined to be unusable in this analysis because Servolift's testing methodology and results were inconsistent with the test method used by the others.[4] FSTC found a duty cycle of 20% for the insulated CresCor cabinet they tested and 67% for the non-insulated cabinet. These cycle times were presumed to be typical for the purposes of this analysis

Baseline idle energy rate and annual energy use estimates were then calculated for six prototypical models: three sizes with an insulated and non-insulated version of each. Product research suggested the following heating element wattage assumptions were representative: full-, ¾-, and ½-size cabinets use 1,800, 1,400, and 1,000 watt heating elements, respectively. Idle energy rate (essentially average power demand) was then calculated by multiplying the heating element rating by cycle time fraction plus a constant fan load of 50 watts. These values were then multiplied by 12 hours per day and 363 operating days per year to arrive at annual energy use estimates shown in Table 1.

Table 1. Idle Energy Rate for Insulated versus Non-insulated Cabinets

Cabinet Type	Cabinet Size	Idle Energy Rate (W/cu ft)	Volume (cubic feet)	Idle Energy Rate (watts)	Annual Energy Consumption (kWh/y)
Insulated	**Full-size**	20	22	445	1,938
	¾-size	24	15	357	1,555
	½-size	34	8	269	1,173
Non-insulated	**Full-size**	58	22	1,273	5,544
	¾-size	67	15	1,001	4,361
	½-size	91	8	729	3,177

[3] The "idle energy rate" is the industry term used by ASTM and US EPA to describe the rate of energy consumed (kW) by the hot food holding cabinet to maintain the holding cavity at the control set point (temperature), once the holding cavity has been heated to the control set point.

[4] Servolift's calculation for a full-sized insulated cabinet was based on the pre-heat time and subsequent cycling of the heater over the first hour of operation. Actual energy consumption was not recorded and the test was not run over multiple hours. The idle energy rate we extrapolated from this data was significantly larger than CresCor's and Alto Sham's results for similar products. This is due to Servolift's indication that the heater had a duty cycle of 50%, much larger than CresCor's 20% for a similar product.

As presented in Section 7, the metrics for the standards recommendation is expressed in watts per cubic foot. The average power demand for non-insulated hot food holding cabinets, normalized for volume, is 68 watts/ft^3 versus 24 watts/ft^3 for insulated models. These two values represent weighted averages of full-, ¾-, and ½-size cabinets currently being sold in the market. When weighted to also reflect the high percentage of insulated hot food holding cabinets being sold today, the overall baseline average power demand amounts to 35 watts/$ft^{3.}$

The projected statewide annual energy consumption and peak demand for hot food holding cabinets is summarized in Table 2. Stock performance in California was assumed to mirror that of current sales. The energy use estimates of the six prototypical models were weighted for both the assumed ratio of insulated versus non-insulated cabinets and the mix of cabinet sizes currently entering the market. Peak demand assumes that hot food holding cabinets are in use 100% of the time during peak hours.

Table 2. Baseline Energy Use

Category	Stock	UEC (kWh/y)	AEC (GWh/y)	Peak Demand (MW)
Hot Food Holding Cabinets	50,000	2,402	120	28

4.2 Proposed Test Method

ASTM International has developed ASTM F2140-01, *Standard Test Method of Hot Food Holding Cabinets*, which evaluates the preheat energy consumption and idle energy consumption of hot food holding cabinets. During the test, the hot food holding cabinet is connected to the appropriate metered energy source, and the following data points are recorded:

- Voltage while elements are energized
- Ambient temperature
- Energy input rate during or immediately prior to each test run
- Confirmation that the peak input rate is within ± 5% of the rated nameplate input

The test includes detailed procedures for calculating the energy input rate, calibrating temperature, determining the preheat energy consumption and time, and calculating the idle energy consumption (under dry and humid conditions). The energy input rate is calculated using the following formula:

$$q_{input} = \frac{E \times 60}{t}$$

Where q_{input} = measured peak energy input rate, kW,

E = energy consumed during period of peak energy input, kWh, and

t = period of peak energy input, min.

The idle energy consumption rate (for dry and humid conditions) is calculated as follows:

$$q_{idle} = \frac{E \times 60}{t}$$

Where q_{idle} = energy consumption (idle energy rate), kW,

E = energy consumed during the test period, kWh, and

t = test period, minutes.

4.3 Efficiency Measures

The only measure that significantly increases the energy-efficiency of hot food holding cabinets is the addition of insulation to the cabinet. Less significant measures include the use of magnetic door gaskets, auto-door closers and Dutch doors (i.e., split doors that allow access to the top or bottom half of the cabinet only, so that heat can be retained in the other half of the cabinet).

As noted, in 2000 the FSTC compared an insulated hot food holding cabinet and a non-insulated cabinet made by one manufacturer. The cabinets have the same interior dimensions and voltage requirements (120 volts), and are both made of aluminum. The insulated unit has self-closing Dutch doors with latches and magnetic door gaskets, while the non-insulated unit has a single door with gravity latches only. FSTC found that the insulated cabinet had an idle energy rate of 925 fewer watts than the non-insulated cabinet (410 watts versus 1,335 watts) (Bohlig, 2000).

In addition to saving energy, insulated cabinets:

- Have faster preheat times
- Are less susceptible to ambient air temperature changes
- Have less temperature stratification, and a more uniform cabinet temperature
- Radiate less heat into the kitchen, reducing kitchen cooling loads

4.4 Standards Options

The spread between the performance of insulated and non-insulated cabinets is significant, as shown in the Table 1, above. As presented in Section 4.1, current shipment weighted average idle energy rate for hot food holding cabinets, normalized for volume, is 35 watts/ft^3. This value represents a weighted average of full-, ¾-, and ½-size cabinets, as well as insulated and non-insulated models currently being sold in the market.

We propose a maximum volume-normalized idle energy rate of 42 watts/ft^3, which falls between the insulated and non-insulated idle energy rates shown in the Table 1 above and provides ample margin at the smallest size category of insulated cabinets. We note that this value is also somewhat less stringent than the Energy Star performance level (40 watts/ft^3).

4.5 Energy Savings

Projected energy savings resulting from the proposed standard are shown in the table below. All insulated units are believed to currently meet or exceed the proposed standard. The Per Unit Annual Saving associated with non-insulated units that are brought into compliance with the standard is calculated to be 1,856 kWh/year. Because an estimated 75% of units sold today appear to be insulated and thus would not be impacted by the standard, the overall weighted average per unit savings due to the proposed standard (shown in Table 3) would be only 454 kWh per year. First year savings are estimated to be 1.5 GWh and 0.4 MW of peak demand reduction

Table 3. Estimated Savings for Proposed Standard

Standard	Per Unit Annual Savings (kWh/yr)	Projected Savings (%)	Projected Annual Savings of Stock (GWh/yr)	Projected Peak Demand Savings (MW)
42 watts/ ft^3	454	19%	23	5.2

5 Economic Analysis

5.1 Incremental Cost

The use of insulation in hot food holding cabinets is by far the most significant energy saving measure. The incremental cost associated with this measure is estimated to be $453 based on information from the FSTC, as well as Servolift and Bevles, both of which manufacture full-size insulated and non-insulated hot food holding cabinets that are otherwise comparable (Bevles, 2003; Iovanel, 2003).

Generally, insulated models are made of stainless steel, a fact that is reflected in a price difference of closer to $1,500 between non-insulated aluminum cabinets and insulated stainless steel cabinets. According to David Zabrowski of the FSTC, insulated cabinets also often include other upgrades, such as higher quality controls (Zabrowski, 2003).

Per Charles Bohlig of the FSTC, the incremental cost to customer (i.e. incremental "street" price) is $850 for the two CresCor models he tested in 2000. The incremental "list" price was $1600.

Bevles' full-size, aluminum, non-insulated hot food holding cabinet (model number HC70MP12) lists for $3,994; whereas their full-size, aluminum, insulated hot food

holding cabinet (model number HC70MP12 INS) lists for $4,485, only $490 more. Per the FSTC, "street" price is generally about half of "list" price, making the incremental street price of the Bevles unit $245 (Zabrowski, 2003).

Servolift manufactures a line of insulated, aluminum cabinets (the 2600 series), as well as non-insulated, aluminum cabinets (the 1500 series). According Servolift, the 1500 series can be special-ordered to have insulation added for an incremental list price of about $900[5], but the incremental "street" price that a consumer would actually pay is about $400 (Iovanel, 2003).

The average of the three incremental "street" prices is about $500, which was then weighted for full-, ¾- and ½-size cabinets. Servolift estimates that the incremental cost of insulation in ½-size cab is about 75% of full size (Iovanel, 2003). The resulting incremental price is therefore estimated at $453.

5.2 Design Life

When asked about expected lifetimes of typical hot food holding cabinets, manufacturer representatives estimated that the metal housing that makes up the cabinet itself is expected to last 15 or more years; though the heating element may fail sooner if exposed to water (Alto Shaam, 2003; Bevles Co., 2003; Palmy, 2003; CresCor, 2003; InterMetro, 2003).

5.3 Life Cycle Cost

Total savings due to the proposed standard over the lifetime of a hot food holding cabinet is estimated at $1,369 per unit.

Table 4. Life Cycle Cost

Proposed Standard	Design Life (years)	Annual Energy Savings[6] (kWh/yr)	Present Value of Energy Savings* ($)	Incremental Cost, Retail ($)	Customer Net Present Value** ($)
42 W/ft^3	15	1,815	$1,782	$453	$1,329

* Present value of energy savings calculated using a life cycle cost of $0.982/kWh (CEC, 2001)
** Positive value indicates a reduced total cost of ownership over the life of the appliance.

[5] The difference between a 1500 series cabinet with insulation and a 2600 series cabinet, which comes standard with insulation, is in the rack system. The 1500 rack system in the 1500 is more versatile than that in the 2600, and some customers prefer the 1500 but want an insulated cabinet.
[6] Based on savings associated with a cabinet that previously did not meet the standard (i.e., non-insulated model).

6 Acceptance Issues

6.1 Infrastructure Issues

Insulated models are currently available and very cost-effective for consumers. Market research indicates that, in fact, insulated models dominate the current market, which shows that distribution channels can readily accommodate these products. Additionally, providing more specific evidence that efficient (insulated) hot food holding cabinets can satisfactorily address efficiency and other product utility requirements, in the FSTC Report 5011.00.89, *CresCor Models H-137-UA12B & 131-1816B Hot Food Holding Cabinet Performance Test*, the FSTC found in a product test that the manufacturer had "successfully developed an insulated hot food holding cabinet that combines quick preheats, energy efficiency, and temperature uniformity" (Bohlig, 2000).

6.2 Existing Standards

US EPA has recently established a voluntary ENERGY STAR standard. The following is the energy-efficiency specification for qualifying products:

Maximum idle energy rate = 40 watts/ft^3

where the maximum idle energy rate is based on the "idle energy rate—dry test" in ASTM F2140-01. Guidelines for measuring interior volume are also provided.

In the Appliance Efficiency Regulation's (Title 20), Sections 1602, 1604, and 1606, respectively, the Commission defines hot food holding cabinets, identifies ANSI/ASTM F2140-01 as the appropriate test procedure, and includes listing requirements in Table U. The Commission does not however set any performance or prescriptive standards for this product category.

7 Recommended Standard

In view of the substantive, cost-effective savings opportunity and dominant market share of high efficiency models, the Commission should require that hot food holding cabinets have a maximum, volume-normalized idle energy rate of 42 watts/ft^3. The Commission should maintain its Section 1606 reporting requirement for this product category, as well.

The following standard language is proposed:

The commercial hot food holding cabinet shall have an idle energy rate equal to or less than 42 watts/ft^3 when tested in accordance with the "idle energy rate—dry test" in ASTM F2140-01 and volume is determined according to US EPA's Energy Star guidelines, "Measuring Interior Volume".

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