

Anti-Sweat Heaters in Refrigerated Display Cases

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Anti-sweat heaters (ASH) are typically applied to low-temperature refrigerated display cases to prevent glass doors from fogging and cold surfaces from forming condensation. Commonly, ASH stay on at full load around the clock. Their contribution to the cooling load and electric power consumption of the refrigeration system can be significant. Using energy-efficient technologies can reduce the power consumption of ASH and the refrigeration system.

This article discusses the laboratory testing results of two commercially available, energy-efficient technologies that can reduce the power and energy requirements of ASH. Tests focused on evaluating the performance of *pulse modulation controls* (PMC) and *special polymer doors* (SPD). All tests were conducted using a three-door frozen food reach-in display case. The installation and operation of the tested technologies followed the manufacturers' recommendations and typical practice used in supermarkets. The impact of these technologies was tested under the following three scenarios, each individually evaluated at 55%, 45%, and 35% indoor relative humidity (RH) conditions:

Scenario 1: Base case — a conventional set up, with ASH on continuously.

Scenario 2: Pulse modulation of ASH — provides proportional control of the cycles of heat per unit of time as a function of indoor RH.

Scenario 3: Retrofit conventional glass doors with SPD—the SPD with high cross-linked thermoset polyurethane door sash eliminates the requirement for heating of the glass doors or door sash.

The evaluation attempts to establish a

correlation between the tested ASH technologies and the following key parameters:

- Anti-sweat heater's power,
- Temperatures on the glass door (glass and frame),
- Fog clearance time,
- Display case total cooling load,
- Discharge air temperature,
- Product temperature,
- Compressor power,
- Refrigerant mass flow rate, and
- Heat gain from ASH.

Southern California Edison's (SCE's) Refrigeration Technology and Test Center (RTTC) was used to conduct tests for this project. The controlled environment chamber of the RTTC was maintained at a fixed dry-bulb temperature of 75°F (24°C), while its RH changed from 35% to 55% in 10% increments, for all three test scenarios. All other operational parameters including suction and discharge pressures remained unchanged for all tests.

Results

Results indicate that the performance of tested technologies directly affect ASH power. *Figure 1* shows that ASH power use stayed constant, in the absence of the subject technologies, regardless of the indoor RH variations. The pulse modulation controller was programmed to provide a maximum output for the heater when indoor RH reached 55%. It used a proportional approach to reduce the frequency of signals per unit of time as RH became less than 55%. In an actual supermarket, each reach-in fixture line up is typically fed by a single ASH circuit, which provides heat to the doorframe, glass and mullions. In this test, the pulse modulation unit was set up to fluctuate

the pulsation to the ASH circuit, which consequently affected the doorframe, glass and the mullions. This unit proportionally controlled the number of electric heat pulses until an indoor RH of 35% was reached, at which point the controller stopped demanding heat (*Figure 1*). The special polymer doors were set up without glass or mullion ASH while the doorframe continued receiving heat.

The changes in indoor RH and dissipation of the anti-sweat heat into the display case impacted the total refrigeration load (*Figure 2*). The highest refrigeration load was reached in the base case where none of the two energy-efficient technologies was used. The slight reduction of 5.3% in total cooling load of the base case under lower RH is due to changes in the latent load. In the case of PMC, reducing the indoor RH from 55% to 35% resulted in a 17.4% drop in the total cooling load. This cooling-load drop is due to lower latent load, as well as reduced anti-sweat heat dissipation into the case. Under the same RH variations for the SPD, the 7% cooling-load reduction can be attributed to less latent load and partial reduction in anti-sweat heat, as well as possibly reduced heat conduction through the glass door. The SPD's non-metallic thermoset polyurethane door sash is expected to reduce the conduction of heat through the door assembly.

Based on test results, when ASH were on at 100%, 664 Btu/h (195 W) or 35% of their connected electrical load ended up as heat inside the case.

Reductions in the total cooling load was directly reflected in compressor power use (*Figure 3*). Lowering the RH from 55% to 35% resulted in 5.1%, 18% and 10.9% reductions in compressor power use for base case, pulse modulating control and special doors, respectively (*Figure 3*).

Refrigeration Applications

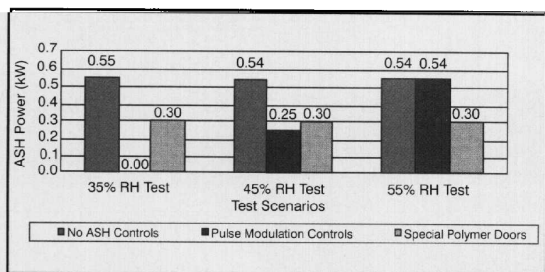


Figure 1: Anti-sweat heater power consumption vs. relative humidity (all three test scenarios).

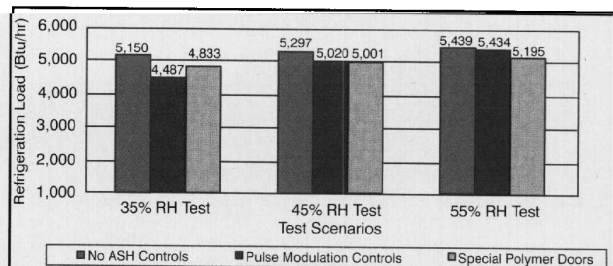


Figure 2: Comparison of refrigeration load (case cooling load) vs. relative humidity (all three test scenarios).

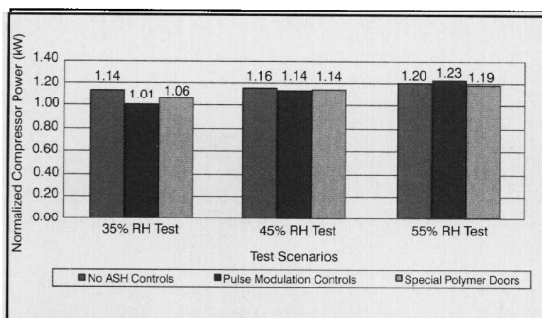


Figure 3: Comparison of normalized compressor power vs. relative humidity (all three test scenarios).

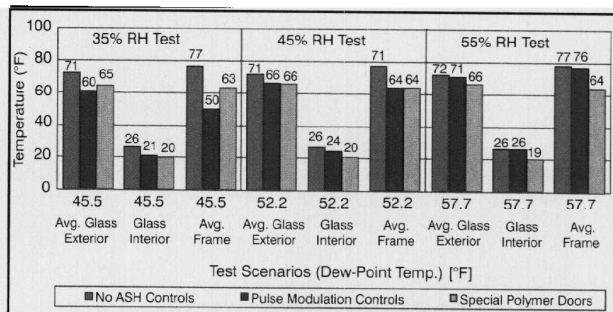


Figure 4: Average glass exterior, glass interior, and average frame temperature vs. dew-point temperature (all three test scenarios).

Figure 4 compares the average temperature of exterior glass, interior glass and door frame with the corresponding room dew point temperature for each test scenario. For all three test scenarios, the temperature of the exterior glass and doorframe remained above the room dew-point temperature, while the interior glass temperature remained below the room dew-point temperature. This indicates that both technologies, the PMC and SPD, prevented condensation from taking place at the exterior surface of glass. Interior heat mirror film of SPD, and possibly door frame heating, provided a high temperature air gap between the film and the outer glass pane. This resulted in 5°F (2.8°C) higher exterior glass temperature than PMC at 35% RH test (Figure 4).

Figure 5 depicts the fog recovery time for all three test scenarios under various dew-point temperatures. As the dew-point temperature decreased from 57.7°F to 45.5°F (14°C to 7.5°C), the fog recovery time decreased as well for all three test scenarios. This reduction in fog recovery time is more noticeable in Scenario 3, and less noticeable in Scenario 1. SPD had the longest fog recovery time under more humid conditions. Their recovery time increased by 70% as room dew point was raised from 45.5°F to 57.7°F (7.5°C to 14°C). As for PMC, fog recovery time increased by 16% when indoor dew point was raised from 45.5°F to 57.7°F (14°C to 7.5°C).

Conclusions

The performance of the tested technologies proved to be beneficial under all indoor relative humidity conditions. Both

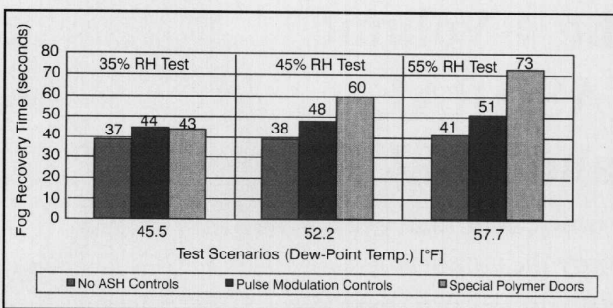


Figure 5: Fog recovery time vs. dew-point temperature (all three test scenarios).

technologies reduced anti-sweat heater power use, cooling load, as well as refrigerant mass flow rate and compressor energy.

The use of both energy-efficient technologies in this project reduced the electric consumption of the refrigeration's system. Additionally, they provided lower average product temperature. The main drawback of these technologies was observed in the increased fog recovery time. The trade off between lower electric energy use and product temperature, and longer fog recovery time is an issue to be closely evaluated by supermarket operators.

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