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PaceController™

A digital controller for a broad range of heating, air conditioning and refrigeration applications that works in conjunction with the thermostat and other controls to operate compressors and burner units for programmed intervals without turning the entire appliance off.

Product

The current versions of the PaceController are the Pace2 and Pace3. Pace3 operates like the Pace2 except it has wireless features. The EXTEND and CUTOUT optional add-on peripherals allow dynamic response to outdoor temperature and/or return air temperature.

Manufacturer

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Distributor

PaceControls does not have distributors by geographic area. PaceControls products can be purchased through energy service companies and HVAC companies that receive wholesale prices.

Product History

The PaceController was originally developed in the 1990s by DIGISTAN, a predecessor company. Beginning in 1998 DIGISTAN distributed the first-generation controller in the Mid-Atlantic states and also supplied the McDonalds Company nationally. PaceControls was formed in late 2004 and acquired the assets of DIGISTAN.

Model PACE2 retrofits with optional return-air sensor kit, installed in package unit control panel. Photo courtesy of PaceControls LLC.

Product Function and Application

The following information was primarily provided by the manufacturer and is not evaluated here. See the section *"Additional Reviewer Comments"* for evaluation of this description. According to the manufacturer, the PaceController is a product line of heating, cooling and refrigeration retrofit solutions and peripherals that establishes maximum run times for compressors and burner units. The PaceController also enforces the minimum off intervals

Product & Technology Reviews (PTR) are developed for Northwest electric utilities. *Energy*Ideas Clearinghouse engineers review published literature for objective, independent test results. No primary testing was conducted by the reviewer for the preparation of this document. PTR factsheets describe the technology, discuss available data, and suggest additional testing needed to verify energy saving claims.
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recommended by equipment manufacturers to avoid short cycling. The PaceController is installed within the existing control lines of heating, ventilating, air-conditioning and refrigeration equipment. If the optional EXTEND or CUTOUT peripherals are installed, the PaceController allows local condition changes to temporarily set new intervals automatically. The EXTEND-85 and EXTEND-90 add-ons allow extension of compressor run time if the outdoor air temperature exceeds 85°F and 90°F, respectively. The CUTOUT add-on allows disabling the PaceController if the return air temperature exceeds 90°F.

Energy Savings Claims

The following information was provided primarily by the manufacturer and is not evaluated in this section. See the section *"Additional Reviewer Comments"* for evaluation of this claim.

The manufacturer claims that the PaceController typically achieves 10% to 20% energy savings and can reduce energy costs by as much as 27%. It is also claimed that customers who pay utility demand charges may save as much as 40%.

Non-Energy Benefits

The following information was provided primarily by the manufacturer and is not evaluated in this section. The manufacturer claims that the PaceController can improve comfort by minimizing overshooting of the temperature called for by the thermostat. The manufacturer also claims the PaceController can contribute both to improved compressor performance and extended life by preventing short-cycling, reducing total compressor runtime, improving lubrication efficiency during compressor operation, allowing compressor electrical windings to cool during the enforced off cycle, reducing frosting and freeze-over, and reducing or eliminating slugging[1].

[1] *Slugging occurs when liquid refrigerant enters the compressor. Slugging can damage compressors because they are designed to compress only vapor.*

Independent Testing Results

Independent testing has been conducted by Intertek Group, Princeton Energy Systems, Renewable Solutions Engineering, Inc. and JP Energy Services.

Performance Testing by Intertek Group

In 2007 Intertek Group (*www.intertek.com*) conducted controlled performance testing of a 4-ton split air conditioner with and without a Pace2 controller. A baseline test without the PaceController operating was run continuously for 90 minutes. In the second test, the PaceController was adjusted such that the compressor cycled on for 6 minutes and off for 3 minutes over a 90 minute period. In the third run, the controller was adjusted to allow the compressor to run for 9 minutes on and 3 minutes off over a 90 minute period. Notably Intertek's test report did not include any measurement of efficiency or output of the system. It did include power and current draw – both average and instantaneous – over the 90 minute intervals. In its sales materials, PaceControls uses the average power, which includes both on and off intervals for Runs 2 and 3.

It is worth describing the test in order to understand what was measured and what was not. The test apparatus and air conditions were in accordance with ARI Standard 210/240. ARI 210/240 requires air entering the indoor and outdoor coils be maintained at specific conditions and flow rate. Dry bulb and wet bulb temperatures entering the indoor coil and the outdoor coil are maintained by separate room conditioning apparatuses – not by the unit being tested. An indoor space is not conditioned by the unit. The unit is required to be run continuously for a minimum of one hour without interruption for any reason. Note that only the baseline test met ARI 210/240 specifications because in Runs 2 and 3 the unit was cycled on and off by the PaceController. Thus, the unit was not subjected to the controlled conditions over the same period of time in these runs as in the baseline. Cycling on and off, the unit will naturally use less energy on average over the 90 minute period than if running continuously when operating under the same

conditions. In comparing energy use then, the average values are not relevant and we should only examine power requirements when the unit was operating and exclude the intervals when it was off.

Power required in all three runs during the on intervals – with and without the PaceController – was essentially the same (within 1%) at 4.5 kW. Since the cooling capacity provided by the system was not measured, these results do not show that the PaceController increased efficiency of the system.

Power Monitoring by Renewable Solutions Engineering

Renewable Solutions Engineering monitored power of a 15-ton New York chiller unit that provides cooling for an office building located in Mayaguez, Puerto Rico. The equipment was operated for two days without the PaceController installed (Baseline), for two days with the PaceController cycling the unit on and off at 6 minute and 3 minute intervals (Run 1) and for two days cycling the unit on and off at 12 minute and 3 minute intervals (Run 2). In the baseline test, the chiller ran almost continuously during the day, suggesting the unit was undersized. Outdoor and indoor temperatures were monitored.

Even with EXTEND-85 and CUTOUT add-ons installed, indoor temperatures were significantly higher with the PaceController operating on both days of each test compared to the baseline test: 6°F higher when operating at intervals of 6 minutes on and 3 minutes off and 3°F higher when operating for periods of 12 minutes on and 3 minutes off. This was in spite of lower average outdoor air temperatures during the Baseline run without the PaceController. These temperature differences were discounted in the report because discomfort was noticed on only one day of testing. The manufacturer noted the test was imperfectly designed due to the undersized unit and poor placement of the thermostat.

Energy use was decreased in the runs with the PaceController operating and the report states that results were normalized to account for differences in outside humidity and temperature. However, they do not indicate that results were adjusted to account for the change in indoor temperature.

Results indicate that the system did not meet cooling requirements during periods when the PaceController was installed. The test therefore does not confirm that the same cooling requirements can be met and indoor comfort conditions achieved with less compressor run time. That the test was imperfectly designed does not change this conclusion.

Energy Use Monitoring by Princeton Energy Systems and JP Energy Services

Princeton Energy Systems and JP Energy Services conducted separate studies to monitor energy use of several existing buildings. We found all these studies to be lacking in some respect with regard to measurement and/or documentation of indoor temperature conditions. In all but one of Princeton Energy System's summary reports, indoor air temperature data is not summarized quantitatively. In one, it is noted that the building management system gave them the "ability to determine if the interior space requirements were being satisfied." Whether or not it was satisfied was not mentioned. In another, the only reference to indoor conditions was that "it is observed from the M&V data that the PaceController does not appear to over-ride the operation of the thermostat." In three of the studies, it is stated "the temperature requirements within these areas remained within acceptable levels" without discussion of what they mean by acceptable levels. In the one report that did quantify indoor temperature, the test period was only four hours total and outdoor temperature data was not provided. Regardless, indoor temperature was measured for only a one-hour period prior to installation of the PaceController and for two hours following installation at half hour intervals (7 data points.) We question the significance of field testing over such a short interval. In JP Energy Services' report, an indoor temperature setpoint is stated in their description of equipment, but measured indoor temperature is not included in their summary

of results. The two test intervals in JP Energy Services' study were only 2.5 hours long and so also are of questionable value regardless.

Documentation of outdoor temperature is similarly qualitative (e.g. "relatively low ambient temperature conditions") in all but two of the reports, but this is of less concern because it is stated that their energy savings results were adjusted to account for outdoor conditions. Importantly, it does not appear results were adjusted for any change in indoor conditions. Because of insufficient quantitative indoor temperature data and the lack of adjustment for variation in indoor conditions, these studies do not confirm that savings were achieved while still meeting indoor comfort requirements. This is especially of concern because comfort conditions were not maintained in the study conducted by Renewable Solutions Engineering.

Case Studies

We did not find other case studies reported in journals or press releases that included any comments on energy use or comfort except those made by PaceControls representatives. From 2005 to 2007, PaceControls conducted a number of case studies in a variety of facility types in which energy use before and after installation of the PaceController was metered. These studies documented indoor conditions better than studies conducted by independent parties. Nevertheless, we are concerned by many of the explanations of that data. In one study of heating energy use it is reported, "After colder weather resulted in unacceptably low interior temperatures, however, header pressure was reset, the PaceController taken offline and burner runtime returned to a 20-30 minute cycle." In a study of air conditioning energy use, "slight lowering of inside temperatures when the PACE2 was taken offline" was noted, indicating the setpoint may not have been achieved with the PaceController installed. In a heating study, it is noted, "Temperatures were initially controlled well around the setpoint during relatively mild weather" but dropped "when outside temperatures dropped steeply." Also, what is interpreted as "good" or "reasonable" control of indoor conditions is not clear. For example, in one study it is noted that "space temperatures were controlled reasonably well throughout the office" for indoor temperatures that ranged between 58°F and 71°F. No setpoint information was provided that might have explained this large variation.

Cost

Hardware price from the manufacturer is $750. Distributors may receive a 20% discount for small orders and a volume discount of as much as 40% for large orders. Typically an hour is required for installation of each unit. PaceControls' retail pricing for most of its peripherals is less than $150 each.

Alternative Products and Strategies

Direct digital control (DDC) energy management systems in general can be programmed to operate equipment for specified on and off intervals if desired when space conditioning is called for. In addition, we found two commercial products that, like the PaceController, are described by their manufacturers as achieving energy savings by dynamically modifying the system cycling pattern in conjunction with the system's thermostat and enforcing a sufficiently long off interval to prevent compressor short cycling.

One of these alternative products uses a different strategy in modifying cycling than the PaceController and this strategy is more consistent with conventional understanding of start-up efficiencies of HVAC equipment. The alternative product operates by delaying start up when there is a call for heating or cooling. This essentially increases the deadband and results in longer off intervals, which will in turn result in longer run times and reduced cycling. Reduced cycling should reduce the energy use associated with start up inefficiencies that according to conventional understanding are inherent to both air conditioning systems and fossil-fuel fired heating systems. This contrasts with the strategy used by the PaceController. The PaceController imposes a maximum on interval, based on the argument that efficiency is greatest at start up, which can reduce the length of run times and increase the number

of cycles with high loads, as was observed in testing by Renewable Solutions Engineering.

Suggestions for Further Research and Testing

Performance testing under controlled conditions should include measurements of heating or cooling output, as well as energy use, to enable calculation of efficiency. Field tests that monitor energy use in actual installations should include both indoor and outdoor relative humidity and temperatures, in addition to energy use of the HVAC system. Indoor setpoint temperatures should also be recorded to enable comparison of actual temperatures to the setpoint. In general, credibility of results increases with the length of test intervals and the similarity of conditions during the test intervals to the baseline conditions. Test intervals on the order of two weeks for the baseline and two weeks with the controller installed – provided the two intervals have similar weather conditions – would be considered acceptable by many energy professionals. Note actual testing may need to be conducted over longer periods to obtain intervals having similar weather conditions. Even with similar conditions, energy use should be adjusted using standard engineering methods to account for any differences in both indoor and outdoor conditions. Performance testing should include measurements of heating or cooling capacity as well as energy use to enable calculation of efficiency. Test intervals of less than a day are not meaningful except in controlled performance testing conducted in accordance with applicable standards.

Additional Reviewer Comments and Analysis

We do not question that energy savings are achieved by operating HVAC equipment for less time and this is what was shown in the studies and testing summarized in the Sections "Independent Testing" and "Case Studies." Our concern is the claim that the same heating or cooling requirements can be met with less run time using the PaceController and we did not find evidence of that. We note that this concern applies to both heating and cooling equipment.

Central to the manufacturer's explanation of their air conditioning energy savings claims is their assertion that compressor volumetric efficiency[2] is greatest when the compressor first starts up and declines after several minutes. However, an increase in volumetric efficiency does not necessarily result in an increase in the COP due to other influencing factors, as observed by Regola, et al. and Arthur, et al. (2001). In performance testing, cooling performance is typically reduced at start-up and increases with run time. In NIST Publication No. 270, which summarizes the development of heating and cooling system performance testing requirements, it is noted that "[d]uring the start-up and shut-down periods, most of the equipment experienced nontrivial energy losses or inefficiencies associated with warm-up, cool-down, and/or migration of refrigerant." Fossil-fuel heating equipment also is less efficient at start up due to the purge cycle, initial flame instability and lower radiation transfer between heat transfer surfaces.

Like air conditioning equipment, reducing cycling should therefore increase boiler efficiency over time. It is important to understand that the PaceController will turn a unit off either at the set maximum "on" interval or when heating or cooling is no longer called for by the thermostat, whichever comes first. Thus, "on" intervals will not be increased for the case of an over-sized unit.

HVAC manufacturer comments provided to us by PaceControls notably do not include comments on efficiency improvements attributable to the PaceController. Carrier Corporation is quoted as supporting the claim that the PaceController helps "reduce peak kW distribution." This could often be true. However, as shown in the study by Renewable Solutions Engineering, demand may be reduced at the expense of comfort under high load conditions. On the issue of comfort conditions, a Lennox representative is quoted as saying he "would not expect the customer to be aware of

[2] *The volumetric efficiency is the ratio of the volume of refrigerant actually admitted to the full piston displacement volume, measured at a specified temperature and pressure,*

the difference unless some other variable was involved such as marginal capacity at design or when actual conditions cause a greater than design load." The suggestion here is that there may be differences in indoor conditions but these are usually not noticeable.

A non-energy benefit claimed by PaceControls is prolonged equipment life due to reduced run times and prevention of short-cycling. However, the detrimental effects of short cycling are due primarily to the number of start-ups, as described in Copeland's *Engineering Application Bulletin AE-1262*. As was observed in the study by Renewable Solutions Engineering, the PaceController can increase the number of start-ups, especially at high loads.

Conclusion

We did not find independent monitoring and testing results nor performance data conducted under controlled conditions that documented sufficient data to confirm that efficiency was improved by the PaceController or that energy savings were achieved while maintaining comfort conditions. We question the energy savings claims by PaceControls and would like to see results of field monitoring and performance testing conducted by independent parties in which all important parameters necessary for evaluating system performance are measured and well documented. We suggest the manufacturer commission such studies.

Additional Information

Northwest businesses and electric utilities can contact the EnergyIdeas Clearinghouse for additional information on this or other energy technologies or products. Contact:

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The EnergyIdeas Clearinghouse is a technical assistance service managed by the WSU Extension Energy Program with support from the Northwest Energy Efficiency Alliance.

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