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July 13th, 2006 Workshop Report DDC to the Zone Level Measure 5: Supply Air Temperature Reset

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Overview

Description

This CASE report addresses one of five separate measures that extend the control requirements of the standard. All five of these requirements are possible at a very small cost if the installed control system is direct-digital control (DDC) to the zone level. This initiative does not seek to require installation of DDC to the zone level, rather it extends the current philosophy of the prescriptive requirements such as supply static pressure reset (Section 144(c)2D) that state a functional requirement of the control system if it is designed for DDC to the zone level.

The measures covered by this proposal are as follows:

1. Modification of the existing prescriptive measure 144(d) (Space-conditioning Zone Controls) to allow for “dual maximum” control of VAV boxes
2. A new mandatory measure for global demand shed controls that can automatically reset the temperature set-points of all non-critical zones by 1 to 4°F from a single central command in the building energy management and control system (EMCS).
3. Modification of the existing prescriptive measure 144(j)6 (Hydronic System Measures: Variable Speed Drives) to require demand based reset of the pressure setpoint for pumps serving variable flow systems based on valve demand. This measure is the hydronic analog of the existing prescriptive measure for supply air pressure reset in (Section 144(c)2D).
4. Modification of the existing mandatory demand controlled ventilation (DCV) requirements 121(c)3 (Required Demand Control Ventilation) to include high occupant density zones served by multiple zone systems.
5. Modification of the existing prescriptive measure 144(f) (Supply Air Temperature Reset Controls) for demand based supply air temperature reset for variable air volume (VAV) systems that operate when the system is on 100% free cooling from the air-side economizer.

As each of these measures is simply a matter of programming, the cost for implementing them is quite low. However, as described below each of these measures has a significant potential for energy and demand savings.

This specific report covers measure 5, supply air temperature reset controls.

Energy Benefits

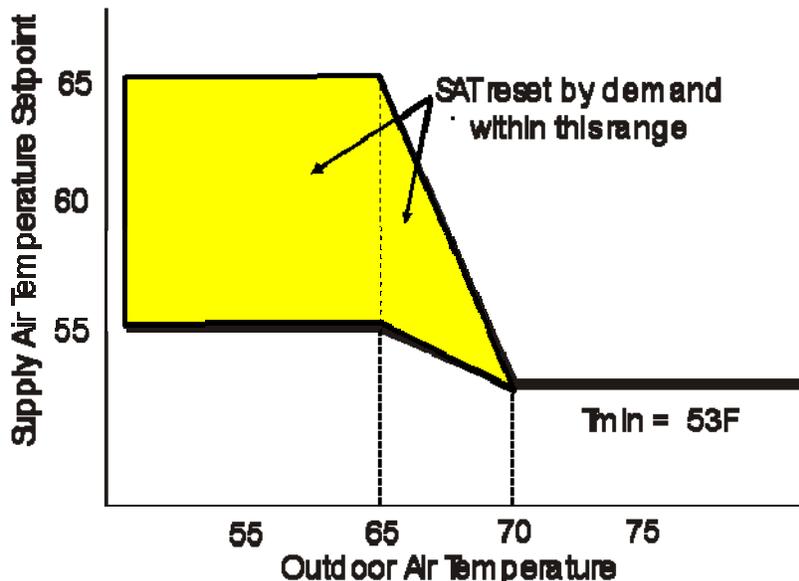
This measure was derived from the Integrated Energy Systems — Productivity and Building Science project, a Public Interest Energy Research (PIER) program administered by the California Energy Commission under contract No. 400-99-013, and managed by the New Buildings Institute. This project focused on large VAV systems and has guidance on both system selection and controls. As part of this project, the researchers simulated seven different supply air temperature control schemes in the climates of Sacramento and San Francisco (see Table 1 below). In both of these climates the same control scheme produced the lowest source energy usage. Methods 5 and 6 produced significantly lower energy usage than the other 5 methods. These schemes do supply air temperature reset by zone demand until the outside air temperature reaches a threshold. The threshold for both of these climates was between 65°F and 70°F.

Table 1 – Source Energy Savings for Supply Air Temperature Reset Controls
 Table 30 from PIER VAV Guide (CEC Oct. 2003)

	Cooling	Fans	Total kWh	Heating	Total Source
SAT Control Method	kWh/ft2	kWh/ft2	kWh/ft2	kBtu/ft2	kBtu/ft2
San Francisco Climate					
1. Constant 55	2.43	0.38	2.81	5.23	33.9
2. Reset by zone demand	1.75	0.47	2.22	4.45	27.2
3. Switch to T-min when chiller runs	1.82	0.4	2.22	4.64	27.3
4. Switch to T-min when OAT > 60	1.88	0.4	2.28	4.58	27.9
5. Switch to T-min when OAT > 65	1.76	0.43	2.19	4.49	26.9
6. Switch to T-min when OAT > 70	1.75	0.45	2.2	4.46	27
7. Switch to T-min when OAT > 75	1.75	0.46	2.21	4.45	27.1
Sacramento Climate					
1. Constant 55	2.76	0.52	3.28	7.38	41
2. Reset by zone demand	2.3	0.63	2.93	6.55	36.5
3. Switch to T-min when chiller runs	2.33	0.52	2.85	6.8	36
4. Switch to T-min when OAT > 60	2.39	0.52	2.91	6.79	36.6
5. Switch to T-min when OAT > 65	2.3	0.54	2.84	6.6	35.7
6. Switch to T-min when OAT > 70	2.29	0.55	2.84	6.56	35.7
7. Switch to T-min when OAT > 75	2.29	0.57	2.86	6.55	35.9

The recommended control scheme in the guide is depicted in Figure 1 below. It has the controls resetting the supply air temperature between 55°F and 65°F when the outdoor air temperature is less than 70°F and fixed at the design temperature (shown as 53°F in Figure 1 below) when it is hot outside.

Figure 1 – Recommended SAT Reset Sequence from PIER VAV Design Guide (CEC Oct 2003)



Non-energy Benefits

The major non-energy benefit of SAT reset is that it reduces the number of hours of compressor cooling. It also reduces the reheat energy. On the down side it increases fan energy.

Environmental Impact

This measure has no adverse environmental impacts.

Type of Change

This measure is proposed as a modification of an existing prescriptive requirement. It applies to either new construction or retrofit where the zones have DDC controls. The changes to the Title 24 documents are summarized in the following paragraphs. The complete proposed changes with underlines and strikeouts are in the section Proposed Standard Language below:

Standards

- Strike out exception 4 to the existing prescriptive requirement 144(f)

ACM

- No changes are proposed.

Technology Measures

This measure only applies to systems with DDC to the zone level. As presented in our industry survey below, this represents between 90% to 95% of the new construction market.

Measure Availability and Cost

EMCS systems with DDC to the zone level are prevalent in the current building market. Our experience and surveys of the major EMCS vendors indicate that all of the major vendors are capable of meeting these proposed requirements. Data on the major market players and the surveys are presented below.

Useful Life, Persistence and Maintenance

This measure will be tested through the Title 24 acceptance testing requirements. These proposed control sequences (like all controls) will need to be reviewed and the sensors recalibrated as part of the routine maintenance of the EMCS. For this requirement, the sensor calibration is part of both the base case and proposed requirements.

Performance Verification

None is proposed.

Analysis Tools

This measure can be evaluated using either eQuest or EnergyPro.

Relationship to Other Measures

This measure is an enhancement of the existing supply air reset control measure in 144(f).



Methodology

Energy Model

This measure was evaluated as part of a PIER project. The results of the simulation are presented in Table 1 above.

EMCS Market Share

The authors did a literature search and surveyed the major EMCS vendors to determine the market share of EMCS vendors in the HVAC controls market nationwide. The results follow:

1. Johnson 16%-25%
2. Siemens 15%-17%
3. Trane 6%-15%
4. Honeywell 7%-10%
5. Alerton 5%-10%
6. Automated Logics 7%-10%
7. Andover 7%-10%
8. Invensys 7%
9. All others 10%-20%

Graphical data from one of the market research sources is presented in Figure 2 below.

Figure 2 – EMCS Market by Company in 2001 (BCS 2002)

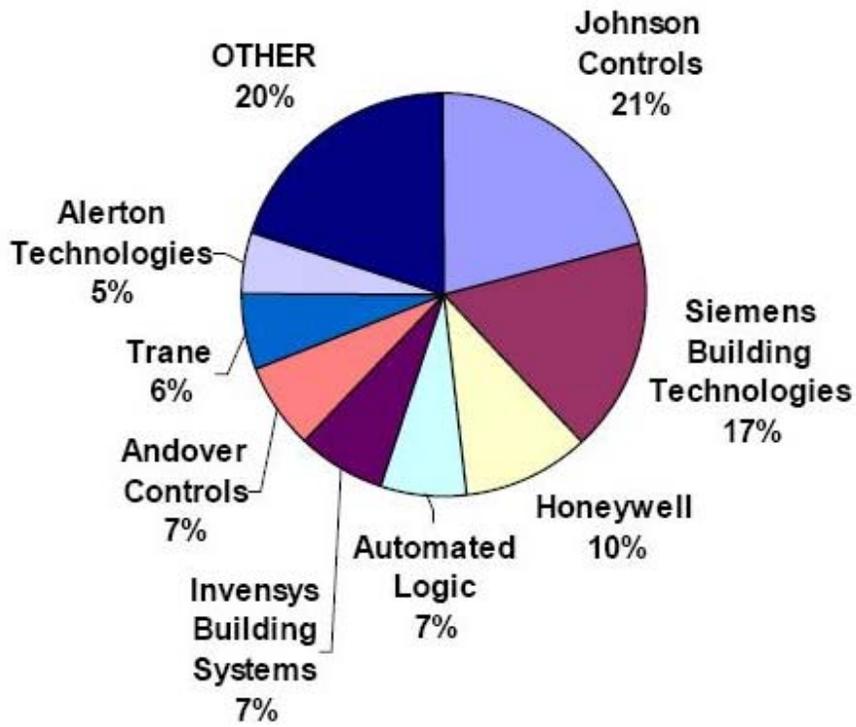
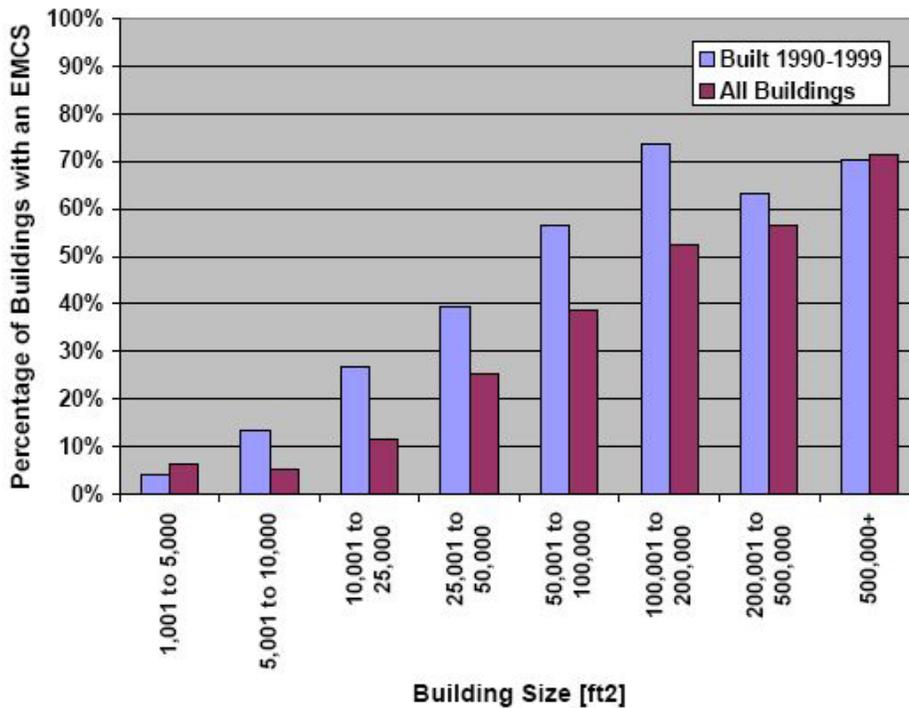


Figure 3 – Buildings with EMCS (EIA 1999)



Survey of EMCS Manufacturers on the Proposed Requirements

An email survey was sent to EMCS vendors to get their reaction to the proposed requirements. The survey was sent to Trane, Honeywell, Invensys, Alerton, Johnson, Automatic Logic Corporation and Siemens. At the time of this report, responses were received from Alerton, Automated Logic Corporation and Siemens. The survey that was sent follows:

Dear [Insert Name],

We are working on the development of the 2008 update of California's building energy code, Title 24. We are preparing for a workshop on July 13th and would appreciate your response by July 1st if possible. One of the issues we are researching relates to DDC controls. We are investigating a code change to specify control requirements on systems that have DDC to the zone level. In order to determine the feasibility of these ideas, we are surveying vendors and contractors for their opinions on the viability of these proposed measures and the make-up of the BMS market in California. To assist our deliberations, we would like you to answer the following questions:

- 1. In your opinion, for new construction in commercial buildings what percentage of the controls marketplace (based on \$ spent by owners) belongs to the following classes of control products:
 - a) Fully DDC (including the zone controls)?*
 - b) Hybrid DDC and pneumatic systems?*
 - c) Fully pneumatic?*
 - d) Other (please elaborate)?**

In considering your answer to this question exclude the single zone units that are controlled by programmable thermostats

- 2. In your experience what are the most important (top 3 to 5) factors that drive a customer to purchase DDC controls? Consider the following list but feel free to list other major factors:*
 - a) First cost*
 - b) Energy savings*
 - c) Alarming*
 - d) Improved comfort and control*
 - e) Trending*
 - f) Tenant submetering*
 - g) Tenant after hours management*
 - h) Facility management*
 - i) Web based access*
 - j) Other factors (please list)*

3. *What are the relative installed costs of DDC and pneumatic systems for typical office and retail buildings?*
 - a) *On a \$/sf basis (or relative % cost basis) if you have the data*
 - b) *Qualitatively, are they about the same or is one significantly more expensive?*
4. *Do you have any data on comparative maintenance costs for DDC and pneumatic systems?*
5. *Would you support a code change requiring DDC controls to the zone level for new control systems serving multiple zone systems and equipment?*
 - a) *What are some questions or concerns you might have about such a code change?*
 - b) *Are there systems or applications where this would not be appropriate?*
6. *The following are specific control requirements that we are considering. Please provide feedback (positive or negative about each). For each control requirement please address the following issues:*
 - *whether your existing systems (hardware and software) will be able to support these requirements*
 - *what exceptions should be included*
 - *the added effort to program and tune these control algorithms*

Here are the proposed new control requirements

- a) *Hydronic pump pressure reset by demand (either directly by valve demand or through a "trim and respond" algorithm)*
- b) *Ability to globally reset cooling set points on zone thermostats on "non critical" zones by 1 to 4°F for central demand shed.*
- c) *Supply air temperature reset on VAV systems that is only enabled when the system is on 100% economizer cooling*
- d) *Demand controlled ventilation for multiple zone units serving one or more densely occupied zones. The control logic is likely to cascade with the first step controlling the zone box minimum and the second step controlling the minimum OSA damper position.*

Please contact us if you need any clarifications on the above questions. We thank you in advance for your time and we welcome your comments and feedback.

A summary of the survey results follow:

Question 1, EMCS market place: All three respondents indicated that DDC to the zone level was between 90% to 95% of the new construction market.

Question 2, Top Factors for DDC Purchases:

- Facility Management - 3 Votes
- Improved Comfort and Controls – 3 Votes



- Tenant After Hours Management – 2 Votes
- Alarming – 2 Votes
- Energy Savings – 2 Votes
- First Cost – 2 Votes
- Web Based Access – 1 Vote

Question 3, Relative First Cost of DDC and Pneumatic Controls: The consensus of the respondents is that pneumatic controls generally have a slightly smaller first cost. This cost depends on the number of points in the system as the pneumatic control system incurs a large first cost penalty for the compressor and associated equipment (like air dryers and filters). For small control systems DDC is actually less expensive. For medium and large control systems DDC is likely to be a slight cost premium.

Question 4, Relative Maintenance Cost of DDC and Pneumatic Controls: The consensus of the respondents is that pneumatic controls have a significantly higher maintenance cost (on the order of 20%-40%).

Question 5, Support for the Proposed Requirements: All respondents support the proposed requirements.

Results

The results of our investigations indicate that this measure is both cost effective and would be embraced by the industry.

Statewide Energy Savings

[To be developed later]

Recommendations

Proposed Standards Language

Modification of Existing Prescriptive Requirement 144(f)

(f) Supply Air Temperature Reset Controls. Mechanical space-conditioning systems supplying heated or cooled air to multiple zones shall include controls that automatically reset supply-air temperatures:

1. In response to representative building loads or to outdoor air temperature; and
2. By at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

Air distribution to zones that are likely to have constant loads, such as interior zones, shall be designed for the fully reset supply temperature.

EXCEPTION 1 to Section 144 (f): Systems that meet the requirements of Section 144 (d), without using Exception 1 or 2 to that section.

EXCEPTION 2 to Section 144 (f): Where supply-air temperature reset would increase overall building energy use.

EXCEPTION 3 to Section 144 (f): Zones in which specific humidity levels are required to satisfy process needs.

~~EXCEPTION 4 to Section 144 (f): Variable air volume space conditioning systems with variable speed drives.~~

Alternate Calculation Manual

No proposed changes

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Appendices

None.