CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

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July 13th, 2006 Workshop Report DDC to the Zone Level 3: Hydronic Pressure 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 the reset of hydronic pressure by zone demand.

Energy Benefits

As described in the Methodology section below, we modeled these hydronic supply reset controls on an actual project (a central plant serving two 200,000 ft2 buildings) then ran the build model in each of the 16 Title 24 climate zones. The results of the TDV cost savings are presented in Table 1 below. The TDV savings ranged from $1.0/ft2 to $1.4/ft2 with an average of $1.2/ft2. This measure has both on-peak demand and energy savings as the controls will react to reduce the pump speed even if the pump was oversized or the design pressure was too high.

Table 1 – TDV Cost Savings for Hydronic Pressure Reset

Climate Zone	TDV Savings	TDV Savings/ft2
CZ01	$490,000	$1.2

Table 1 – TDV Cost Savings for Hydronic Pressure Reset

Climate Zone	TDV Savings	TDV Savings/ft2
CZ02	$490,000	$1.2
CZ03	$470,000	$1.2
CZ04	$430,000	$1.1
CZ05	$470,000	$1.2
CZ06	$500,000	$1.3
CZ07	$390,000	$1.0
CZ08	$500,000	$1.3
CZ09	$470,000	$1.2
CZ10	$550,000	$1.4
CZ11	$490,000	$1.2
CZ12	$490,000	$1.2
CZ13	$440,000	$1.1
CZ14	$560,000	$1.4
CZ15	$570,000	$1.4
CZ16	$480,000	$1.2
Minimum	$390,000	$1.0
Maximum	$570,000	$1.4
Average	$490,000	$1.2

Non-energy Benefits

In practice hydronic demand based pressure reset has a number of non-energy benefits that include:

- Reduction of acoustical noise both at the coils and at the pump.
- Improved controllability of the coil valves as the operating pressure is reduced across them.
- Reduction of valve leakage due to over pressurization. Note this can improve space comfort conditions.
- Reduced maintenance and increased life for the pump motor, pump seals, valve actuators and valve seals.

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 coils and pump have DDC controls. The changes to the Title 24 documents are as follows:

Standards

- Revise existing prescriptive requirement 144(j)6
- No change is required for 125 (d) Hydronic System Controls Acceptance.

ACM

- Modify the Standard Design Systems 4 and 5 to have pressure reset by demand
- Modify the existing acceptance test NJ 10.5 Variable Frequency Drives to check the pressure reset.

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

As documented below the existing Title 24 acceptance requirements will be slightly modified to test this proposed requirement.

Analysis Tools

This measure can easily be evaluated using either eQuest or EnergyPro.

Relationship to Other Measures

This measure is an enhancement of the existing hydronic prescriptive measures in 144(j).

Methodology

Energy Model

This measure was evaluated using the eQuest program. The model was based on a real project with two 200,000 ft2 office buildings that were served by a central plant. This model was run in all 16 of the California Climate zones. The TDV energy cost savings 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 1 below.

Figure 1 – EMCS Market by Company in 2001 (BCS 2002)

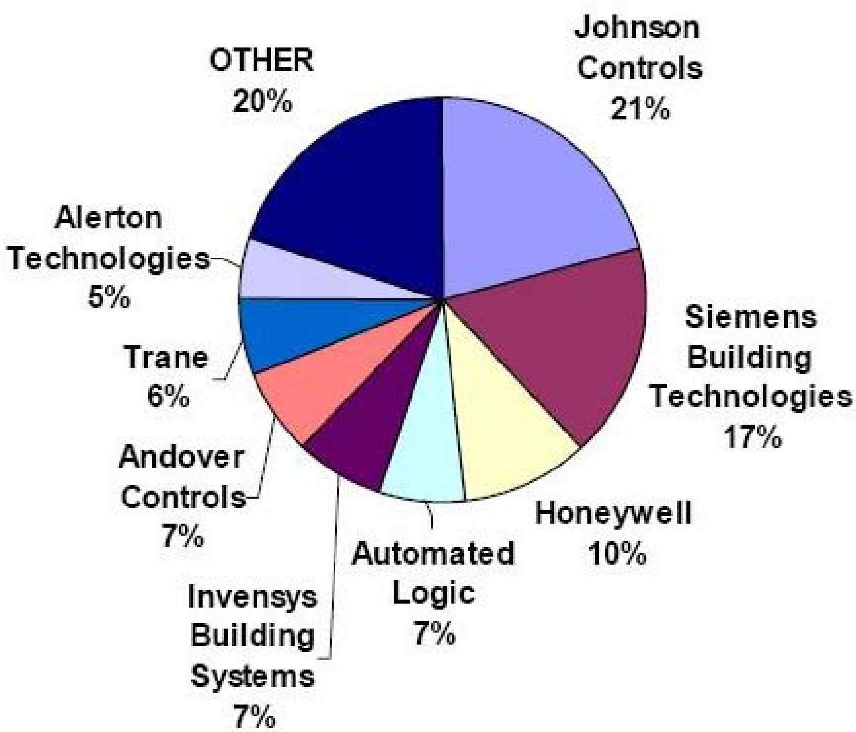
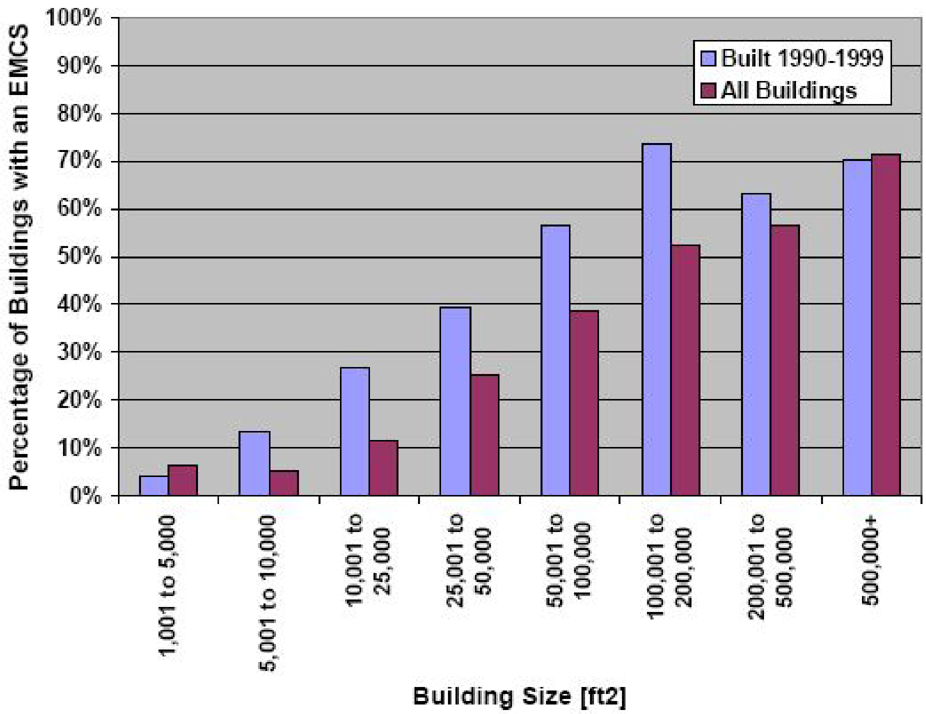


Figure 2 – Buildings with EMCS (EIA 1999)



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.

The results of our simulation indicate an average TDV cost savings of $1.2/ft2. The programming of this measure is 2 to 3 man-days (depending on the system size) representing an installed cost of $800 to $2,500. Using a conservative estimate of $2,500 for the installed costs this measure becomes cost effective on all buildings over 2,000 ft2. If adopted this measure would likely only be applied to buildings of 10,000 ft2 or larger.

Statewide Energy Savings

[To be developed later]

Recommendations

Proposed Standards Language

Modification of Existing Prescriptive Requirement 144(j)6

144(j)6. **Variable Speed Drives.** Individual pumps serving variable flow systems and having a motor horsepower exceeding 5 hp shall have controls and/or devices (such as variable speed control) that will result in pump motor demand of no more than 30% of design wattage at 50% of design water flow. The controls or devices shall be controlled as a function of desired flow or to maintain a minimum required differential pressure as follows:~~.~~

A. Variable flow systems with direct digital control of individual coils reporting to the central control panel, static pressure set point shall be reset based on the valve requiring the most pressure; i.e., the set point is reset lower until one valve is nearly wide open.

B. On all other variable flow systems d~~D~~ifferential pressure shall be measured at or near the most remote heat exchanger or the heat exchanger requiring the greatest differential pressure.

EXCEPTION 1 to Section 144 (j) 6: Heating hot water systems.

EXCEPTION 2 to Section 144 (j) 6: Condenser water systems serving only water-cooled chillers.

Alternate Calculation Manual

2.5.2.4 Standard Design Systems

2.5.2.4 Standard Design Systems

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Table N2-13 System #4 Description

System Description: Chilled Water VAV With Reheat

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Chilled Water Pumping System: Variable flow (2-way valves) with a VSD on the pump if three or more fan coils or air handlers. Constant volume flow with water temperature reset control if less than three fan coils or air handlers. Reset supply pressure by demand if proposed system has DDC controls.

…

Hot Water Pumping System: Variable flow (2-way valves) riding the pump curve if three or more fan coils or air handlers. Constant volume flow with water temperature reset control if less than three fan coils or air handlers. Reset supply pressure by demand if proposed system has DDC controls.

…

Table N2-14 System #5 Description

System Description: Four-Pipe Fan Coil With Central Plant

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Chilled Water Pumping System: Variable flow (2-way valves) with a VSD on the pump if three or more fan coils or air handlers. Constant volume flow with water temperature reset control if less than three fan coils. Reset supply pressure by demand if proposed system has DDC controls.

…

Hot Water Pumping System: Variable flow (2-way valves) riding the pump curve if three or more fan coils or air handlers. Constant volume flow with water temperature reset control if less than three fan coils. Reset supply pressure by demand if proposed system has DDC controls.

NJ 10.5 Variable Frequency Drive Controls

NJ.10.5.2 Equipment Testing

Step 1: Open all control valves. Verify and document the following:

· System operation achieves design conditions +/- 5%.

· VFD operates at 100% speed at full flow conditions.

- Hydronic pressure setpoint is at design (DDC controls only)

Step 2: Modulate control valves closed. Verify and document the following:

· Ensure all valves operate correctly at system operating pressure conditions.

· Witness proper response from VFD (speed decreases as valves close).

· System operation stabilizes within 5 minutes after test procedures are initiated (no hunting).

- Hydronic pressure setpoint has reduced to minimum (DDC controls only)

Step 3: Adjust system operation to achieve 50% flow. Verify and document the following:

· VFD input power less than 30% of design.

Step 4: Adjust system operation to achieve a flow rate that would result in the VFD operating below minimum speed setpoint. Verify and document the following:

· Ensure VFD maintains minimum speed setpoint regardless of system flow operating point.

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Appendices

None.