Minority Report

On Proposed State Amendment 15-E070 to the 2015 International Energy Conservation Code Section 403.2.6.1 "Dedicated Outdoor Air Systems (DOAS)"

Submitted to the Washington State Building Code Council

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Submitted by the following members of the Washington State Energy Code Technical Advisory Group, and members of the Mechanical Engineering/Contracting Community:

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1. Introduction

Dedicated Outside Air Systems (DOAS) combined with zonal heating/cooling systems provide a solution to building HVAC that result in easily verifiable and controllable quantities of ventilation air to the building without requiring large building fans to run whenever the building is occupied. The zonal heating and cooling systems can be configured to operate only upon a demand for heating or cooling.

There is little argument that when compared to conventional VAV systems, DOAS with zonal heating/cooling will save energy. However, the results presented in the proponent's backup documentation are limited in scope and represent ideal, best-case scenarios.

The proposed modification to the Code represents a significant change to the HVAC design and construction community. It would be irresponsible for the State Building Code Council to adopt a sweeping change to the energy code without fully evaluating the economic impacts doing so will have on the building and construction industry. Therefore, this Minority Report recommends rejection of proposed amendment 15-E070 to the 2015 State Energy Code.

2. Argument against adoption

Limited data to substantiate significant change

DOAS alone does not guarantee energy savings which will vary greatly depending on the systems selected for providing heating and cooling. For example, systems utilizing electric resistance heat and minimum Code efficiency heating equipment will show substantially less energy savings than those claimed in the proponent's documentation. For some projects, this could merely be a loophole to avoid air economizers.

ASHRAE publishes a set of design guides with a goal of 50% energy savings over ASHRAE 90.1-2004. For Small Office Buildings, the guide discusses the positive benefits of DOAS. DOAS is recommended in all climates for zonal systems. VAV systems are also discussed, and recommended for use in these energy efficient buildings. There are specific recommendations for efficiency and controls to optimize the VAV system. The efficiency levels for packaged DX systems are higher than our current Code minimums. Low temperature design supply air temperatures combined with a supply air temperature reset, economizer controls, energy recovery, and demand control ventilation are all recommended, and are mostly covered by provisions in our current Code. Proposal 15-E070 does not make any mention of the fact that VAV systems are recommended for high performance buildings by ASHRAE.

For this proposal to move forward, a more comprehensive study by a nationally respected organization such as ASHRAE must be a prerequisite. An example of a comprehensive study can be found in the December 2012 ASHRAE Journal article "Dual Maximum VAV Box Control Logic". In that article by Taylor Engineers, the authors describe the data collected for a study of a large office complex that was part of ASHRAE Research Project 1515; the research study included real-world energy savings, airflow and temperature trend data, and a thermal comfort satisfaction survey. The outcome of the ASHRAE Research Project work led to amendments to ASHRAE 90.1 modifying the requirements for VAV Box Control Logic.

The proponent's for amendment 15-E070 provided only anecdotal information on which to support their case for energy savings resulting from DOAS systems. The three examples, designed by their firm, are small (<55,000 ft²) public buildings with somewhat different operational characteristics than most other commercial buildings. For example, schools have a very short cooling season compared to that of an office building. Occupancy schedules for privately owned office buildings will differ from how long occupants are working in a public building such as the KC Housing Authority cited in the supporting documents to the proposed amendment. Furthermore, the three projects cited by the proponents are within a 30-mile radius of each other in the Puget Sound Region. They propose this amendment be enforced state-wide yet provide no evidence or data supporting the improved performance of DOAS systems in other regions around the State. Providing only three example projects comparing as-designed vs modeled alternatives does not necessarily lead to the conclusion that there are enormous energy savings to be had; the building and construction community requires more rigorous studies with a larger database of buildings before making such a significant prescriptive code change. Additionally, measured data of actual operation of facilities should be included as the basis for changing the code not simply modeled data. This is especially true since the proponents of this proposal submitted the change based on perceived operational issues with economizer based systems.

Too open ended

Not all DOAS systems are created equal. Although there is a growing body of data showing that DOAS with VRF is an energy efficient system, VRF is only one type of zonal heating/cooling system that can be coupled with DOAS. The proposed amendment does not prescribe the type of zonal heating/cooling system that must be paired with the DOAS system. Would ALL other systems installed in conjunction with DOAS also be as efficient? Is a 4 pipe fan coil with condensing boilers and chillers more efficient than a central system with economizer? The proposed language leaves open the possibility of systems installed that use more energy than systems with outdoor economizer. In their article, "VAV Reheat Versus Active Chilled Beams & DOAS" (May 2013 AHSRAE Journal) authors Steve Taylor and Jeff Stein summarize the results of a design competition between three separate design firms in the Bay Area comparing Active Chilled Beams & DOAS with a traditional overhead VAV system with reheat and air economizer. The results found that the VAV systems with reheat and outdoor air economizer have the lowest energy costs as well as lowest first costs. In the article the authors note that the results will vary by region but that in areas where outdoor climate conditions support air-economizer (most of Washington State for example), overhead VAV with economizer systems provide efficient performance at lower first costs

One argument against air economizer is that they often fail over time. Eliminating air economizer language in reaction is rather like throwing the baby out with the bathwater. Instead, the code should include stronger language regarding Existing Building Commissioning. Air-side economizers are a proven method of saving energy; this is why air economizer is required under most codes throughout the United States. As with most mechanical systems, they fail over time. Proper maintenance is required and existing building commissioning is a cost effective way to keep systems operating as designed. Given the limited data currently supporting DOAS, it would be rash to exclude prescriptive language for air-economizer due to lack of maintenance.

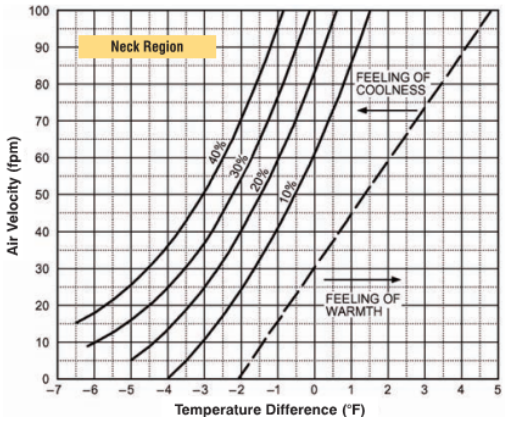
Cost Impacts

The cost data provided by the proponents is limited to the initial capital costs (i.e., first costs) for the three project examples cited in the supporting documentation. Other costs that comprise the total cost of ownership were not considered. For example, the churn rate in private office buildings will be higher than the public buildings examples cited in the proposal (i.e., fire station, school building, public housing authority office). DOAS is less flexible for tenant improvements because the main duct system is providing the ventilation air. If a conference room moves from one side of the tenant space to the other, this can be an issue. If a more dense occupancy moves in, the whole DOAS may have to be replaced/enlarged. Depending on the system types used for heating/cooling, DOAS could result in higher tenant improvement costs than with traditional overhead VAV systems or other systems.

More problematic are the cost implications on larger projects. The three projects cited are all under 55,000 ft^2 and limited to one to two levels. The results of such a limited body of data cannot be applied to larger scale projects such as multi-floor high-rise office buildings with floor areas of 500,000 ft^2 – 1,000,000 ft^2. The capital costs and churn cost impacts alone could be substantial compared with traditional overhead VAV systems. Using the cost metrics cited by the proponents for an office building occupancy (i.e., \$1/ft^2 - \$4/ft^2, the cost impact on larger projects could range from \$500,000 to \$4,000,000; the costs can potentially be higher depending on the size and complexity of the buildings and system types installed.

Reduced Room Air Circulation

The proponents of the DOAS proposal mentioned that no thermal comfort issues are present with this system, but with the small quantity of projects presented and the lack of any comprehensive thermal comfort surveys, this is an untested statement.



The proposed Code amendment requires that zonal heating and cooling fan systems operate only when a demand for heating or cooling exists. This will result in a large quantity of hours throughout the year where the zone temperature is satisfied and only the DOAS is providing airflow to the space. The DOAS must be sized to a maximum of 150% of the minimum ventilation rates of the IMC. With this reduced airflow, stagnant air can be a problem. The figure to the right (from 2009 ASHRAE Fundamentals) graphically depicts the impact of air velocity and the difference between local temperature (i.e., supply air temperature) and average room temperature have on occupant comfort. During periods of the year when the supply air temperature matches the average room temperature (Temperature Difference = 0°F on the graph), a minimum 30 fpm air velocity is required to avoid the sensation of stagnant room air.

Reduced Annual Ventilation

The majority of today's buildings require airside economizer, which for more than 50% of the year provides 100% of the supply flow as outside air. During mild weather conditions, the outside air is used as the primary source of cooling and provides a flush of fresh air to the building. Under these new Code provisions, airside economizer is not required and would come at a significant additional cost to implement with a DOAS.

Operating at minimum ventilation rates year round increases the risk of sick building syndrome and exposes building owners to potential liability.

Acoustical Issues

Cycling of zonal fans on/off with demand is an acoustical issue that can be disruptive to building occupants.

Scaling Issues

It is difficult to measure/balance very low airflows in small offices where a single occupant requires only 20 CFM outdoor air. Flow measurement instruments are less accurate at these low airflows resulting in either inadequate airflow or substantially over-design airflow to individual spaces.

Limits Design Flexibility and Creativity

A one size fits all energy code restricts the available options open to architectural/engineering teams and therefore substantially limits the flexibility and creativity of the design team to implement the right balance between first cost, total cost of ownership, suitability to the building type, architectural considerations, tenant needs, etc. Selecting the appropriate mechanical system type should be left to the design and construction team to evaluate and make appropriate recommendations to respective owners/developers; it should not be mandated by code, particularly when the proposed amendment is based on extraordinarily limited data.

Code Enforcement

Building code officials are not required to be experts in mechanical systems. Outside of larger municipalities, building code officials may not be able to interpret impracticalities to the extent needed.

Impracticality Clause

Difficult to get approval from code official w/o a good definition of impractical

3. Recommendations

As an alternative to the proposed amendment, rather than requiring all systems be DOAS, the proposed language can be adopted as an exception to the requirement of outdoor air economizer. This gives the design team the option of selecting DOAS with a parallel heating/cooling system in lieu of meeting the full economizer prescriptive requirements currently enforced in the Energy Code.

Alternatively, the new Code section C403.2.6 could be made mandatory after July 1, 2019 (effective date of 2018 Code) but remain as an option for those projects that are interested in using DOAS. This would serve as advanced notice to the building community of the coming change and give building owners, contractors, and designers the opportunity to adjust for the change throughout the next Code cycle.