Measure Information Template –

Under Floor Air Distribution

2008 California Building Energy Efficiency Standards

PIER Program - EnergySoft, LLC February 2, 2006

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Overview

Description	In recent years, California has seen surge in popularity of the Underfloor Air Distribution (UFAD) systems as a means for space conditioning. A UFAD system is basically a low energy cooling system that delivers warmer cooling supply air through air diffusers located in a floor plenum space. While the UFAD system is still being studied by the CEC's PIER group, and advanced modeling procedures are being developed for use in modeling tools such as EnergyPlus, current ACM modeling procedures are non-specific on modeling guidelines. Based upon work completed as part of the PIER work, this measure template presents more specific language for inclusion in the ACM manual to facilitate modeling these systems with the current tools in use in California.
Type of Change	This measure proposal is a Compliance Options proposal for modeling of Nonresidential buildings in the standards. While the Nonresidential ACM manual now includes some brief language pertaining to modeling of UFAD systems, this proposal suggests more precise language.
Energy Benefits	UFAD systems provide cooling supply air streams at significantly warmer temperatures than conventional system, typically 60°F to 68°F. With the use of higher supply air temperatures comes the ability to operate in economizer mode many more hours each year. When producing the higher supply air temperatures, chilled water systems have the ability to operate at much higher chilled water temperatures, thus resulting in a significant increase in the chiller efficiency when producing chilled water. In addition, for systems that will be requiring reheat, additional heating and cooling energy is saved since they will be reheating air that is cooled to only 65°F versus a conventional system that has cooled the air to 55°F. Since UFAD systems deliver air at lower velocities than conventional system, there is more potential for stratification, since room air is mixed less. Thus, a certain portion of the heat in the space will rise towards the ceiling, where it will be exhausted by the return air register. The overall result is that a portion of the cooling load in the space, including occupant heat gain, lighting and equipment, never appears as a cooling load. Given the fact that at any given point in time, at least some portion of the return air will be exhausted due to outside air requirements, this heat gain will also be exhausted. In fact, because this system runs in economizer mode many more hours of the year dues to the higher supply air temperatures, this effect will be greatly amplified. Although underfloor systems operate at both higher supply air temperatures and flow rates than conventional overhead systems, with careful design, they can consume less energy than a conventional overhead system. Proper design of the system will result in a reduction in air distribution system pressure drop, reducing the overall fan power needed to supply space conditioning needs.

Non-Energy Benefits	One of the most significant benefits of a UFAD system is the flexibility provided to building owners and occupants in space arrangements. Since the UFAD system utilizes an elevated floor system, the plenum space under the floor provides an ideal space for routing wires and cables. This type of system, commonly referred to as an access floor system, has the ability to remove the floor panels so owners and occupants can quickly and easily rearrange space layouts as the need arises. Air delivery in a UFAD system is at a much lower velocity, which results in much less mixing of air. Unlike a conventional overhead system that mixes supply air with space air, the UFAD system relies on a stratification effect to displace warmer air towards return air register located in the ceiling. The net result is that pollutants will stratify towards the ceiling and be carried away, resulting in a significant improvement in indoor air quality. Another benefit is the ability to downsize the mechanical system. Since a large portion of heat gain in the space is simply exhausted out the return air, this heat gain never actually shows up as a load on the mechanical system. This results in a smaller, more efficient system.
Environmental Impact	The only environmental impacts associated with the use of this system are positive benefits such as improved Indoor Air Quality associated with not mixing the air.
Technology Measures	UFAD Systems do not require the use of any particular manufacturer's equipment, nor any special technology that has not been available for years. It is simply the application of currently available cooling systems, designed in a fashion that utilizes the benefits of a stratified, non-mixing cooling system. It is anticipated that the measure life will be improved with this type of system, since it will have higher hours of operation in economizer mode, and a lot less hours of operation of the cooling system.
Performance Verification	This measure is already included in the 2005 ACM Manual. The new Certificate of Acceptance (COA) forms currently encompass the performance verification of the system in the field. Currently, the MECH-2-A, MECH-3-A and MECH-4-A encompass testing procedures that will cover the mechanical system verification necessary for this type of system. It may also be beneficial to extend the COA requirements related to economizer to encompass more extensive testing of this feature due to the energy savings potential with this type of system, although this same testing would also benefit any system that relies on the economizer for savings.
Cost Effectiveness	In several of the reports referenced at the end of this measure template, it is pointed out that the UFAD system will result in a cost increase in the overall building cost, mainly driven by the cost of the access floor system. On a strict energy basis, it will be difficult to demonstrate cost effectiveness. However, these systems are being installed for many other reasons, including the space flexibility issue, more comfortable indoor environment, and indoor air quality benefits. Taken as a whole, and particularly including tenant remodel costs, these systems do show overall cost effectiveness.

Analysis Tools	The current reference method, DOE-2.1E, as well as derivatives such as DOE-2.2 are not well suited to modeling these types of systems. Simplifications can be made in the modeling to approximate the energy benefits, however, these approximations will underestimate the energy savings of this system. Newer programs such as EnergyPlus are being enhanced through work by the PIER group to more accurately represent the performance of the UFAD systems. However, since EnergyPlus is not scheduled to be implemented as the reference method in the 2008 Standards, this measure template has been written in a more general format to encompass the current modeling tools, as well as future products like EnergyPlus.
Relationship to Other Measures	No other measures are impacted by this compliance option.

Methodology

This measure change proposal does not propose to make any changes to the standard system comparison flowchart for this system. Instead, it proposes to modify the language pertaining to optional system types in Section 3.3.5 of the Nonresidential ACM manual. Based upon modeling procedures developed by the PIER team and outlined in the report, this measure change proposes that more precise language be included in the ACM manual to allow the correct modeling of these systems. However, it should be noted that different software tool vendors may approach this modeling issue from a different perspective, as outlined in the materials. Therefore, rather than describing the more detailed EnergyPlus modeling that has been developed, which would preclude the use of the simplified models, this template provides latitude for modeling with the tools currently in the marketplace.

Analysis and Results

Data at the Center for the Built Environment (CBE) website shows 244 UFAD systems registered as being under construction or built as of March 2005. Many, many more projects have been built using the UFAD system that have not been registered on this site. Ultimately, this system has become quite popular, and is being built despite the fact that we do not have prescribed procedures and tools to quantify precisely the energy savings benefits. As a move towards facilitating more accurate modeling of these systems, the language below has been developed to provide more guidance in the ACM manual for software vendors on how to address these systems.

Recommendations

This is proposed as a compliance option, so only changes to the Nonresidential ACM manual are proposed.

Material for Compliance Manuals

In Chapter 2, it is suggested that the supply air temperatures for conventional systems be fixed at 55 degrees. In tables N2-11 through N2-14, the following would be changed:

Min Supply Temp: ~~$50 \le T \le 60$ DEFAULT:~~ 55

In Chapter 3 of the Nonresidential ACM Manual under optional systems the following language is suggested based upon the referenced studies:

3.3.17 Underfloor Air Distribution Systems.

Description:

A central system provides air (typically 60°F to 68°F) to an underfloor plenum. It is distributed to the space using either passive or active grilles (cooling), across reheat coils or through fan-powered boxes (typically variable speed with reheat coils). Although this system uses warmer supply air temperatures it usually has a similar airflow to a conventional overhead system as it provides displacement of some of the thermal loads.

The ACM shall automatically assign the portion of heat gain from occupants, lighting and equipment to the plenum zone, or some other zone defined to represent the stratification effect of the DV system. Default assignment fractions for the portion of heat to the space versus the portion to the plenum shall be as follows:

Load Component	Percent to Space	Percent to Plenum
People	75%	25%
Lights	67%	33%
Equipment	67%	33%

The ACM shall allow the use of a higher supply air temperature, as well as the application of supply temperature reset by either demand or outdoor dry-bulb temperature. Additionally, the ACM may also optionally accommodate higher chilled water temperatures on systems that utilized chilled water coils.

The ACM shall make an entry in the special features and remarks section of the PERF-1 report noting the use of an underfloor air distribution system.

DOE Keyword: LIGHTING-W/SQFT
EQUIPMENT-W/SQFT
AREA/PERSON
MIN-SUPPLY-T
CHILL-WTR-T

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design:	The ACM shall model all optional underfloor air distribution system features as input by the user according to the construction documents for the building.
Modeling Rules for Standard Design (New):	The ACM shall model the standard design according to the requirements of the Required Systems and Plant Capabilities.
Modeling Rules for Standard Design (Existing Unchanged & Altered Existing):	ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

Bibliography and Other Research

Information for this measure template has been taken from the PIER research project number 500-03-097-A9 report and the Energy Design Resource work. This PIER report is available from the California Energy Commission's PIER group as an Adobe Acrobat file, and includes the detailed background and research related to this measure template proposal.

One PIER report which is almost 8 MB is available at:

http://www.energy.ca.gov/reports/2003-11-20_500-03-097F-A09.PDF

Additional work sponsored by PIER on this topic can be found at:

http://www.cbe.berkeley.edu/underfloorair/

An additional PIER report which documents the modeling is available at:

http://www.energy.ca.gov/reports/2003-11-20_500-03-097F-A07.PDF

In addition, work done for the Energy Design Resources (EDR) group was also the basis of the change proposal. The EDR report which includes case studies is available at the following link:

http://www.energydesignresources.com/docs/db-02-underfloordistro.pdf

An additional report produced by the EDR group which describes similar modeling techniques is available at:

http://www.energydesignresources.com/docs/hg-underfloor.pdf