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MEMO

RE: **Impact of recent ASHRAE 62.1 Standard Committee Interpretations on 2013 Title 24 Code Ventilation Proposals**
BY: Reid Hart, PE, Associate Director, Technical Research, PECI

ASHRAE 62.1 Standard Committee recently made 2 interpretations that are related to recent Title 24 code proposals. While California Title 24 ventilation code is not tied to ASHRAE Standard 62.1, the standard is respected as a consensus document and it is important to review proposals related to these interpretations. The two interpretations (attached) are:

- INTERPRETATION IC 62.1-2010-3 affirms that ventilation fans may be turned off for up to 30 minutes during occupied periods as long as average ventilation rates are maintained.
- INTERPRETATION IC 62.1-2010-4 denies use of an occupancy sensor to turn off ventilation fans or close VAV box dampers completely when the served zones are unoccupied during a period when the building is expected to be occupied. Note that this interpretation applies to a standard that does not have a pre-purge, so occupancy sensor control may result in much higher VOC levels than with the purge cycle required under Title 24.

Relation to Title 24 and proposals.
INTERPRETATION IC 62.1-2010-3 is almost the inverse of Title 24 ventilation requirements that allow ventilation fans to be turned off only 5 minutes every hour, as it acknowledges that adequate ventilation may be provided running the fan 5 minutes every half hour at a high ventilation rate as long as average ventilation is maintained for the space and the space is adequate size for buffering.
INTERPRETATION IC 62.1-2010-4 would not allow occupancy sensors to shut off ventilation as proposed in Title 24 section 120.1 and 120.2 revisions. The interpretation is in conflict with guidance in the current 62.1 user's manual. It has been suggested this represents a shift for the 62.1 standards committee, and that the user's manual will be revised. It should be noted that this interpretation is also in conflict with Standard 90.1-2010, Section 6.4.3.3.4 that requires zone isolation including "isolation devices capable of automatically shutting off the supply of conditioned air and **outdoor air** to and exhaust air from the area." [emphasis added]

Discussion
The use of occupancy sensors for system and zone controls has been applied in progressive buildings. In the CASE analysis, this measure, in conjunction with a slight widening of the thermal deadband is shown to be cost effective. The savings relies on reduction of airflow (fan energy) and reduction of heating and cooling ventilation air when the zone is unoccupied. There are further significant reheat savings for zones in VAV reheat systems. This approach is less costly than standard demand control ventilation based on CO_2 sensors; so many more spaces can receive the benefit of fan and energy reductions. This methodology may be more robust than CO_2 Demand Controlled Ventilation (DCV) in that it is readily apparent when the occupancy control, which is also controlling lights, has failed. A similar signal of CO_2 based DCV failure is not inherently recognizable to occupants. In addition, CO_2 based DCV only works for those systems that have an air side economizer (i.e. an outside air damper than can modulate) whereas the occupancy based outside air and setup control can also control single zone fan systems without economizers simply by cycling the fan. Smaller HVAC systems are not required to have an air side economizer and thus can also reduce energy consumption with occupancy sensor control.

Applicability of the requirements with proposed revisions are summarized in Table 1. Generally, an occupancy sensor control option has been added. This option turns off the unit and fan (or reduces VAV box air to the zone) when spaces are unoccupied during the scheduled period, unless space temperatures fall outside a standby temperature range. The occupancy sensor control approach becomes an option for smaller spaces and allows reasonable cost control for high density rooms down to 150 square feet. In table 1, **new provisions are bold faced**, and provisions that have not changed have a grey background.

Table 1: **Ventilation & temperature control measures as currently proposed**

T24 Section	Space Types, Other Conditions	Space Size, Floor Area	DCV Required	Occupancy Sensor Required	Temperature Standby Required
120.1(c)3 DCV	No outside air economizer	n/a	No	**Yes if 120.2(e)3**	See 120.2(e)3
	Classrooms	<= 750 ft^2	No	No	
	Classrooms	> 750 ft^2	No	**Yes 120.2(e)3**	
	Call centers, continuously occupied office conference rooms, healthcare facilities and medical buildings, public areas of social services buildings	n/a	No (exception 1 to 120.1(c)3)	No	
	>25 people/1000 sf: assembly areas; courtrooms; Hotel function; nurseries; Retail ground floor; grocery; malls, arcades, pool/skating decks	>=1500 ft^2	Yes	No	
		150 – 1500 ft^2	Yes **if no Occupancy Sensor**	**Yes if no DCV control**	
120.2(e)3 Occupancy control	Multipurpose rooms Classrooms	< 1000 ft^2 > 750 ft^2	No	**Yes**	**Yes**
	Conference rooms	751 - 1500 ft^2	No	**Yes**	**Yes**
	Conference rooms	> 1500 ft^2	Yes		

The purpose of including the occupancy sensor as an occupancy control is to reduce the cost of DCV relative to CO_2 based DCV and allow application of unoccupied air control to smaller zones and units without economizers. Occupancy sensor based control is intended to reduce fan and ventilation operation when the space is completely vacant. Occupancy sensors provide more savings than DCV for unoccupied single zones, as the fan would be off and there would be no requirement to heat or cool a base level of ventilation air when the space is unoccupied. For larger zones, CO_2 sensor-based DCV will still be required, and may be preferable, as it allows for adjustment of ventilation to match partial occupancy. Note that in climates where humidity control is required, fan cycling may not be an appropriate solution; however, in California, humidity is not usually a design issue.

In addition, many of the covered occupancies would already be required to have occupancy sensors to save lighting energy: *"**Areas where Occupant Sensing Controls are required to shut OFF All Lighting**. In offices 250 square feet or smaller, multipurpose rooms of less than 1,000 square feet, classrooms of any size, and conference rooms of any size, lighting shall be controlled with occupant sensing controls to automatically shut OFF all of the lighting when the room is unoccupied."* (Proposed Title 24 Section 130.1(c)5).[1] Thus the incremental cost for this measure is only a thermostat that switches between occupied and unoccupied mode based on a signal from an occupancy sensor (that is already required for lighting), and a scheduled pre-purge mode.

[1] Similar requirements currently exist in 2008 Title 24 Section 131(d)4.

While, the use of occupancy sensors is proposed as an occupancy control rather than a DCV control, it looks like the recent ASHRAE INTERPRETATION IC 62.1-2010-4 would not allow it. While Title 24 does not follow ASHRAE Standard 62.1, this consensus standard should be reviewed to determine if there are issues raised by these interpretations that Title 24 should address. The basis of concern in the interpretation is controlling building-based pollution that is not the result of people occupying the space or related activities such as printer or copier use, but rather emission of pollutants on a continuous basis from building materials, furniture etc. As a result, the interpretation would require that building-based pollutants are diluted by some amount during regularly occupied hours regardless of whether someone is actually in the space. However, note that ASHRAE Standard 62.1 does not require a one hour pre-purge of the space in advance of normal occupancy.

There is some inconsistency in the ASHRAE interpretation for single zone systems, as the reason cited, "Section 6.2.7.1.2 [of Standard 62.1] requires that V_{bz} shall be no less than the building component in the DCV zone" applies "whenever the zones served by the system are **occupied**" (see 6.2.6.1 below) and occupancy sensor shutoff of ventilation applies only when the zone is actually **unoccupied**.

> **6.2.6.1 Variable Load Conditions.** Ventilation systems shall be designed to be capable of providing no less than the minimum ventilation rates required in the breathing zone whenever the zones served by the system are occupied, including all full- and part-load conditions.

So ventilation should not be required when all zones served by the system are unoccupied. This should allow occupancy sensor control of single zone systems. Requiring the area component for an unoccupied zone in a multiple zone system is inconsistent, resulting in a different ventilation requirement for unoccupied zones served by single zone systems versus zones served by multiple zone systems. Note that the requirements in both Standard 62.1 and Title 24 relate primarily to design capabilities.

The area ventilation requirement in California Title 24 is generally higher than the ASHRAE requirement, and is intended to provide an absolute minimum outside air rate for an occupied area, and not intended to be the base required for just the building pollution to be combined with a ventilation requirement for people based on occupancy.

Table 2: **Comparison of Title 24 and ASHRAE 62.1 Building Area Outdoor Air Rates for Relevant Spaces**

TYPE OF USE	**CFM per Square Foot of Conditioned Floor Area (Title 24 Table 120.1-A)**	**Area Outdoor Air Rate R_a (cfm/ft^2) ASHRAE 62.1 Table 6-1**
All others	0.15	
Wood Shop classrooms	0.15*	0.18
Daycare	0.15*	0.18
K-12 Classrooms	0.15*	0.12
Lecture Room	0.15*	0.06
Multi-use assembly	0.15*	0.06
Conference/meeting	0.15*	0.06
Break room	0.15*	0.06

* value assigned by the space being listed as "other"

An occupancy sensor is a closed-loop control device that senses actual occupancy. A time schedule is an open-loop device that is, at best, an approximation of when the zone might be occupied. For zones covered by the proposal, occupancy is usually intermittent. An office conference room or a classroom might only be actually occupied 6 hours a day out of a 10 to 14 hour system operating period. The CASE cost effectiveness analysis is based on 2 hours a day when the zone would be scheduled, but actually unoccupied. The concept of "expected to be occupied" or "usually occupied" has not been clearly defined in either Title 24 or ASHRAE Standard 62.1. Certainly an occupancy sensor that senses actual space occupancy will better reflect actual occupancy patterns than a schedule that is unlikely to be adjusted for short term changes that often occur in meeting rooms, classrooms or other intermittently occupied spaces.

A decision about whether to allow occupancy sensor control of ventilation in the code should also be based on whether equivalent operation is allowed under current code. For example, a college classroom served by a single zone HVAC system can be assumed to be "usually occupied" when the class schedule indicates there will be a class in the room. Under careful operation, a classroom might have the time schedule set to operate for three, two-hour periods over the 14 hours daily that the building is open. This type of scheduling would be allowed under the current code. An occupancy sensor would provide the same type of operation, with two improvements. When the classroom was used on an ad-hoc basis outside of the scheduled periods from the class schedule, the HVAC system would be activated and ventilation provided. Alternatively, if the class did not use the room at the scheduled time, either because it was a holiday, the class was on a field trip, or met somewhere else, the HVAC system would move to a standby thermal condition and unnecessary ventilation would be suspended. In both cases the occupancy sensor provides an improvement over careful scheduling, providing ventilation when it was not otherwise scheduled, and eliminating ventilation when it is not needed because there are no occupants.

The occupancy sensor, once properly installed, will respond to actual occupancy indefinitely, and is more likely to continue to provide correct feedback of actual space occupancy that updating a schedule every quarter as class schedules change. An occupancy sensor is also a much simpler device than a CO_2 sensor, resulting in both a simpler sequence of operation and a more reliable operation over time. CO_2 sensor-based DCV has not been required for classrooms in the past, due to concerns over maintenance of CO_2 sensors. Once installed, occupancy sensors do not have ongoing needs for calibration or a high level of maintenance. If the occupancy sensor fails and it is connected to the lighting system, the failure is readily apparent to users and maintenance staff.

The proposal allows fan operation for up to half an hour after occupancy. Typically, 15 minutes of operation after a space is vacated (the default on most occupancy sensors) will allow people-based pollution to be flushed out, so that the space will have acceptable air quality for the next occupied period.

When a space becomes occupied after an unoccupied period, an occupancy sensor will activate the fan or zone and provide outside air based on full design occupancy. This ventilation rate will typically be higher than what a DCV control would require for actual occupancy at the start of an occupancy or meeting. For conference rooms and classrooms, often a single "set-up" person, teacher, or a few attendees or students enter a room several minutes before the full meeting attendance occurs. So this high ventilation rate relative to actual occupancy will typically flush any accumulated building based pollution from the room relatively quickly at the beginning of an occupied period.

While it is true that there are building-based sources of pollution, the ASHRAE and Title 24 area ventilation rates to address building based pollution is founded more on engineering judgment and design experience based on research of occupant acceptability rather than extensive field research identifying specific limits of indoor pollution related to health issues. The research that is available dates from the 1980's and 1990's and there has been significant progress since then reducing VOCs and other pollutants in building construction and finishes. The 2010 California Green Building Standards code that contains both current and future mandatory requirements is an example of progress in this area. Older spaces that might have these provisions applied during a renovation will have had time for off-gassing and consequent reduction in general building-related pollutants.

VOC Concentration Model

A detailed analysis of the impact on VOC concentrations of several DCV control options was completed for CEC in 2003 by NIST.[2] A similar approach using the same VOC emission rates can be applied to simulation of the actual occupancy sensor case and comparison with DCV using CO_2 sensors as prescribed by both Title 24 and ASHRAE standard 62.1. The VOC analysis is based on a minute by minute single space dilution model. This model is simpler than the NIST model in that nodal air exchange with adjacent spaces is not included. The ventilation rates used are shown in Table 3. Four control simulations of interest are modeled:

T24 DCV CO_2 = Modeled based on the CO_2 controlled DCV requirements in the current Title 24, using the higher of the space or people rates based on occupancy and the delay inherent in CO_2 sensor response as CO_2 in a space builds up in response to occupancy. Includes daily purge cycle at full design ventilation rates.

T24 OccSensor= Modeled based on proposed Title 24 language for occupancy sensor control, with full design ventilation provided during a daily purge cycle and when the space is actually occupied, until the space has been vacant for 15 minutes.

62n OccSensor= Modeled based on ASHRAE Standard 62.1-2010 ventilation rates for occupancy sensor control, with full design ventilation provided when the space is actually occupied, until the space has been vacant for 15 minutes. There is no daily purge cycle and INTERPRETATION IC 62.1-2010-4 denies this approach.

62n DCV CO_2 = Modeled based on ASHRAE Standard 62.1-2010 ventilation rates for area and person using a CO_2 controlled DCV approach similar to the T24_DCV CO_2 method. In the ASHRAE method, the ventilation required is the area ventilation rate plus the per person rate. There is no daily purge cycle.

Table 3. **Outdoor Air Rates Used**

Standard	General Method	Conference Room & Office				Classroom		
		Area Rate cfm/sf	Person Rate cfm/person	Conf. Rm. Design* Ventilation cfm/sf	Office Design* Ventilation cfm/sf	Area Rate cfm/sf	Person Rate cfm/person	Design* Ventilation cfm/sf
ASHRAE Std. 62.1	Sum	0.06	5	0.228	0.085	0.12	10	0.370
California Title 24	Higher	0.15	15	0.503	0.15	0.15	15	0.375

*Design basis from 2008 Title 24 compliance manual: 33.5 people/1000 square feet in Conference room, 5 people/1000 square feet in office, and 25 people/1000 square feet in Classroom

To look at the relative impact on VOC concentration for high density spaces using the four control options, both a conference room and a classroom were analyzed. To maintain consistency, the peak ventilation rate for all four control options is based on half the default CBC occupant density value as shown in the 2008 T24 code compliance manual, or 33.5 people per 1000 square feet in the conference room and 25 people per 1000 square feet in the classroom. Schedules and occupancy profiles that were slightly different than the original NIST study were used, to test the occupancy sensor protocol with more of a worst case scenario. The same VOC emission rate of 0.25 mg per m^2 was used, and the original study provides background for that selection. The same low infiltration rate of 0.1 air changes per hour was used when fans were not operating, and VOC emission was doubled when the spaces were actually occupied. (The original NIST study included double the emission rate during the scheduled period.) The concentration rates produced by the model at the end of the overnight unoccupied period were similar to the NIST results, indicating good model alignment with the original NIST study. The NIST study did not include a pre-purge.

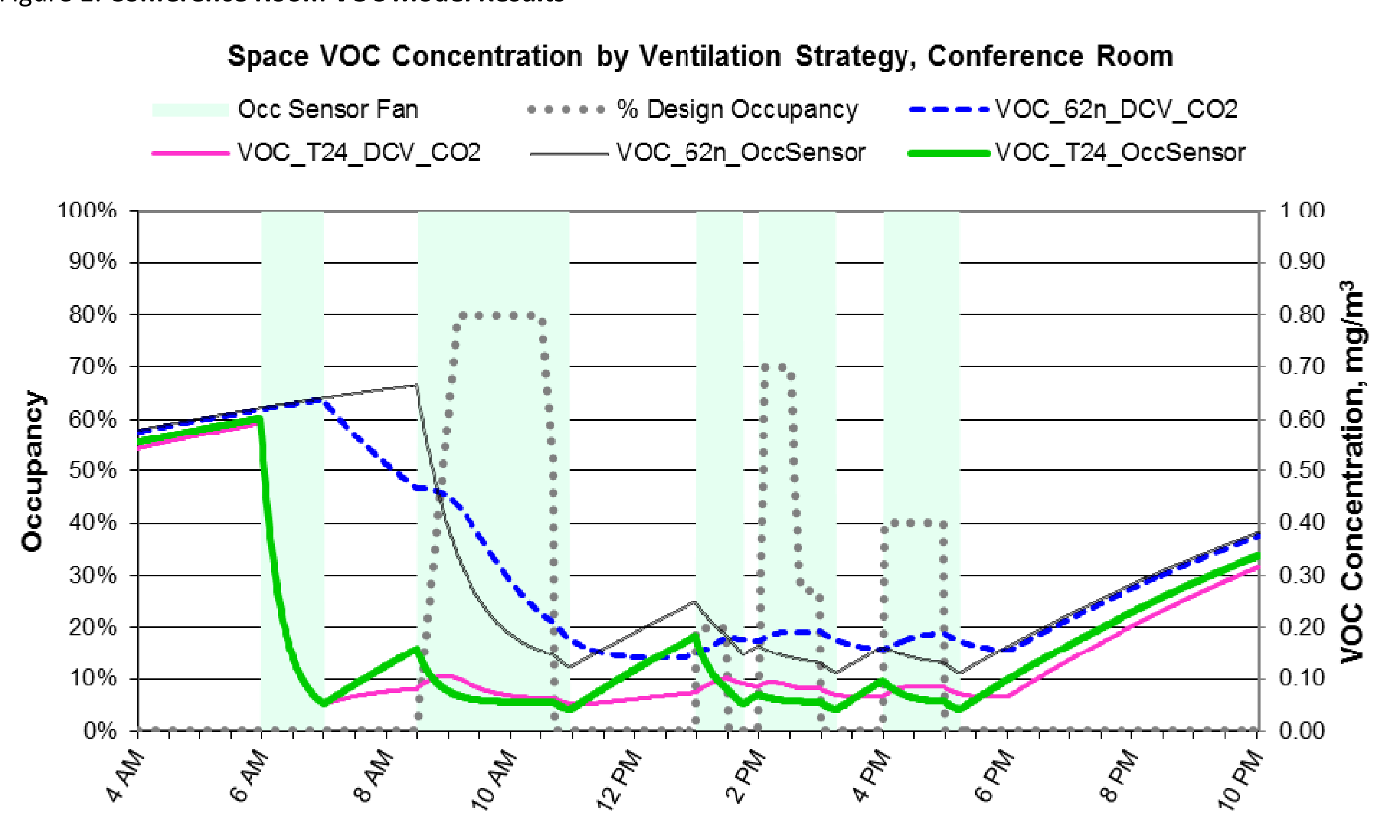
[2] A.K. Persily et al., *Simulations of indoor air quality and ventilation impacts of demand controlled ventilation in commercial and institutional buildings* (National Institute of Standards and Technology, Gaithersburg MD, 2003), http://fire.nist.gov/bfrlpubs/build03/PDF/b03074.pdf.

For both the T24_DCV_CO_2 model and the T24_OccSensor model, the required building purge at full design ventilation rates one hour prior to occupancy was simulated. For the 62n_DCV_CO_2, the fan starts an hour later, as ASHRAE standard 62.1 does not require a purge. For the 62n_OccSensor model, fan start is delayed until the space is actually occupied, a conservative estimate as the fan would usually operate at the start of the schedule for thermal response. The T24 control protocols result in a VOC concentration after purge below the 0.2 mg/m^3 low occupancy equilibrium level for both conference rooms and classrooms. The concentration at the start of the scheduled period under the 62.1 protocols is higher, around 0.6 mg/m^3. General fan schedules after purge are 7:00 am to 6:00 pm for the conference room and 8:00 am to 9:00 pm for the classroom, with T24 occupancy sensor fan operation shown on the figures.

VOC Concentration Model Results

Figure 1 shows the modeled results of VOC concentration for a conference room with typical occupancy schedules comparing the proposed Title 24 occupancy sensor controls (VOC_T24_OccSensor) with CO_2 DCV control (VOC_62n_DCV) and occupancy sensor control (VOC_62n_OccSensor) methods of ASHRAE Standard 62.1-2010 and the 2008 California Title 24 (VOC_T24_DCV) ventilation requirements. Note that the occupancy control method without pre-purge under ASHRAE Standard 62.1 has been declared non-compliant under the recent ASHRAE INTERPRETATION IC 62.1-2010-4 even though it is included in the current users manual.

Figure 1: **Conference Room VOC Model Results**



Average VOC concentrations for the occupied periods are summarized in Table 4. The average VOC concentration during actually occupied periods for the occupancy sensor control is below the average VOC concentration of both CO_2 DCV control methods under either the 62.1 method and the Title 24 method.

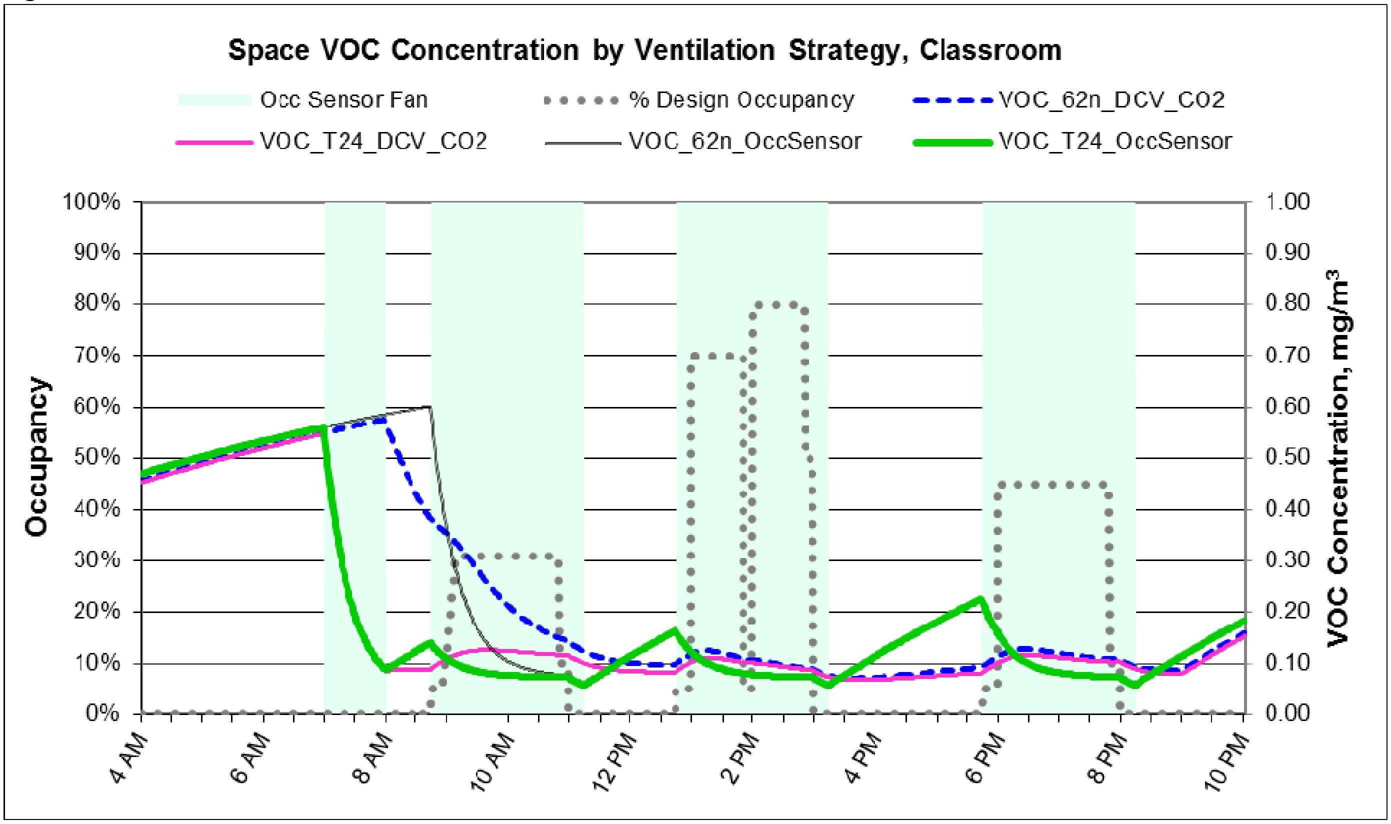
Table 4. **Average VOC Concentrations during Actual Occupied Periods**

	Conference Room		Classroom	
Control Method	Average VOC mg/m^3	% of 62.1 DCV	Average VOC mg/m^3	% of 62.1 DCV
62.1 CO_2 DCV	0.261	100%	0.156	100%
T24 CO_2 DCV	0.083	32%	0.108	69%
T24 Occupancy Sensor	0.072	28%	0.092	59%
62.1 Occupancy Sensor	0.218	84%	0.123	79%

While there is not a set or recommended limit for indoor VOC concentration at this time, the use of a VOC concentration model can show the relative impact on VOC concentration of different ventilation control methods. With the occupancy sensor method The VOC level does increase during vacant periods when the fan is off; however, for both the classroom and the conference room, the VOC level with occupancy sensor control remains close to or below a T24 area only equilibrium level of about 0.2 mg/m^3 during all occupied times, even with a 2.5 hour vacancy for the conference room simulation and a 3 hour vacancy for the class room model. With the pre-purge, the VOC level with T24 occupancy sensor control remains well below the VOC level for the ASHRAE standard 62.1 method at the start of the scheduled period and the beginning of the first actual occupied period.

Figure 2 shows the modeled results of VOC concentration for a classroom with typical occupancy schedules including evening classes and compares the control options as the classroom. Relative average VOC concentrations for the T24 modeled classroom occupancy are similar to the conference room, as seen in Table 4.

Figure 2: **Classroom VOC Model Results**



The conclusion, based on VOC concentration model results for high-density occupancies, is that when coupled with a pre-purge cycle, the occupancy sensor method of ventilation control performs well for VOC concentration management as compared to the CO_2 DCV control methods allowed under either the ASHRAE Standard 62.1-2010 or the 2008 California Title 24 ventilation requirements.

Application to Low density Occupancies

Under Title 24 an office space will have outside air provided at the same level for DCV and standard ventilation, as the higher "area" outdoor air rate is always in effect due to the low density of occupants. Hence, applying CO_2 DCV to general office occupancies provides no savings. Unoccupied occupancy sensor control can be applied to offices or other low density spaces where intermittent occupancy is expected and provides savings, although it is not required in the proposed language.

While the proposed language requires DCV with an occupancy sensor option only in high density spaces, specifically conference rooms, multipurpose rooms, and classrooms; the new language clearly allows occupancy sensor control in low density occupancies like offices. Prior interpretations of Title 24 could validly hold that a space is "usually occupied" when an occupancy sensor indicates it is actually occupied, allowing use of occupancy sensor fan or VAV box outside air control. Clarifying the language allows this popular approach to space ventilation control to be clearly acknowledged as allowable on a statewide basis.

To look at the relative impact on VOC concentration for low density spaces using the four control options, an office with a typical schedule and an office with late occupant arrival were both analyzed. To maintain consistency, the peak ventilation rate for all four control options is based on half the default CBC occupant density value as shown in the 2008 T24 code compliance manual, or 5 people per 1000 square feet in the office. Schedules and occupancy profiles that were different from the original NIST study were used to test the occupancy sensor protocol for both a typical occupancy profile and a late arrival profile. Other assumptions were the same as the classroom and conference room cases.

For both the T24_DCV_CO_2 model and the T24_OccSensor model, the required building purge at full design ventilation rates one hour prior to occupancy was simulated. For the 62n_DCV_CO_2, the fan starts an hour later, as ASHRAE standard 62.1 does not require a purge. For the 62n_OccSensor model, fan start is delayed until the space is actually occupied, a conservative assumption, as the fan would usually operate at the beginning of the scheduled time for thermal response. The T24 control protocols result in a VOC concentration after purge at about 0.3 mg/m^3. The concentration at the start of the scheduled period under the 62.1 protocols is higher, around 0.7 mg/m^3. General fan schedules after purge are 8:00 am to 5:00 pm for both office occupancy scenarios. To illustrate one difference with occupancy sensors, occupancy was intentionally extended past the scheduled period for one hour from 5:00 pm to 6:00 pm. During this end of day period, the DCV cases resulted in an increase in VOC concentration relative to the T24 occupancy sensor case, as the fan was off for the DCV cases and on for the occupancy sensor cases. The results of the VOC concentration analysis are shown in Table 5. VOC levels are generally higher in the low density occupancies than in the high density occupancies where per-person based ventilation results in higher outside air delivery.

Table 5. **Average VOC Concentrations during Actual Occupied Periods for Offices**

	Private Office, Typical Occupancy		Private Office, Late Occupancy	
Control Method	Average VOC mg/m^3	% of 62.1 DCV	Average VOC mg/m^3	% of 62.1 DCV
62.1 CO_2 DCV	0.420	100%	0.360	100%
T24 CO_2 DCV	0.179	43%	0.170	47%
T24 Occupancy Sensor	0.205	49%	0.267	74%
62.1 Occupancy Sensor	0.401	95%	0.490	136%

Figure 3 shows that with a pre-purge and occupancy sensor control in an office, VOC levels are maintained well below the results of the 62.1 DCV strategy. Even the 62.1 occupancy sensor option without a pre-purge result in VOC concentrations close to the 62.1 DCV strategy. The occupancy sensor control also provides ventilation and maintains lower VOC levels in an after-hours occupancy that is not provided with ventilation controlled by a fixed schedule. Figure 3 also illustrates the low-density space VOC equilibrium that occurs for Title 24 area rate of 0.15 cfm/ft^2 at about 0.18 mg/m^3 late in the day. The 62.1 equilibrium rate for design ventilation in low density spaces is around 0.33 mg/m^3, which is close to the late-in-the-day level provided by the 62n_OccSensor method.

Figure 3: **Office with Typical Occupancy VOC Model Results**

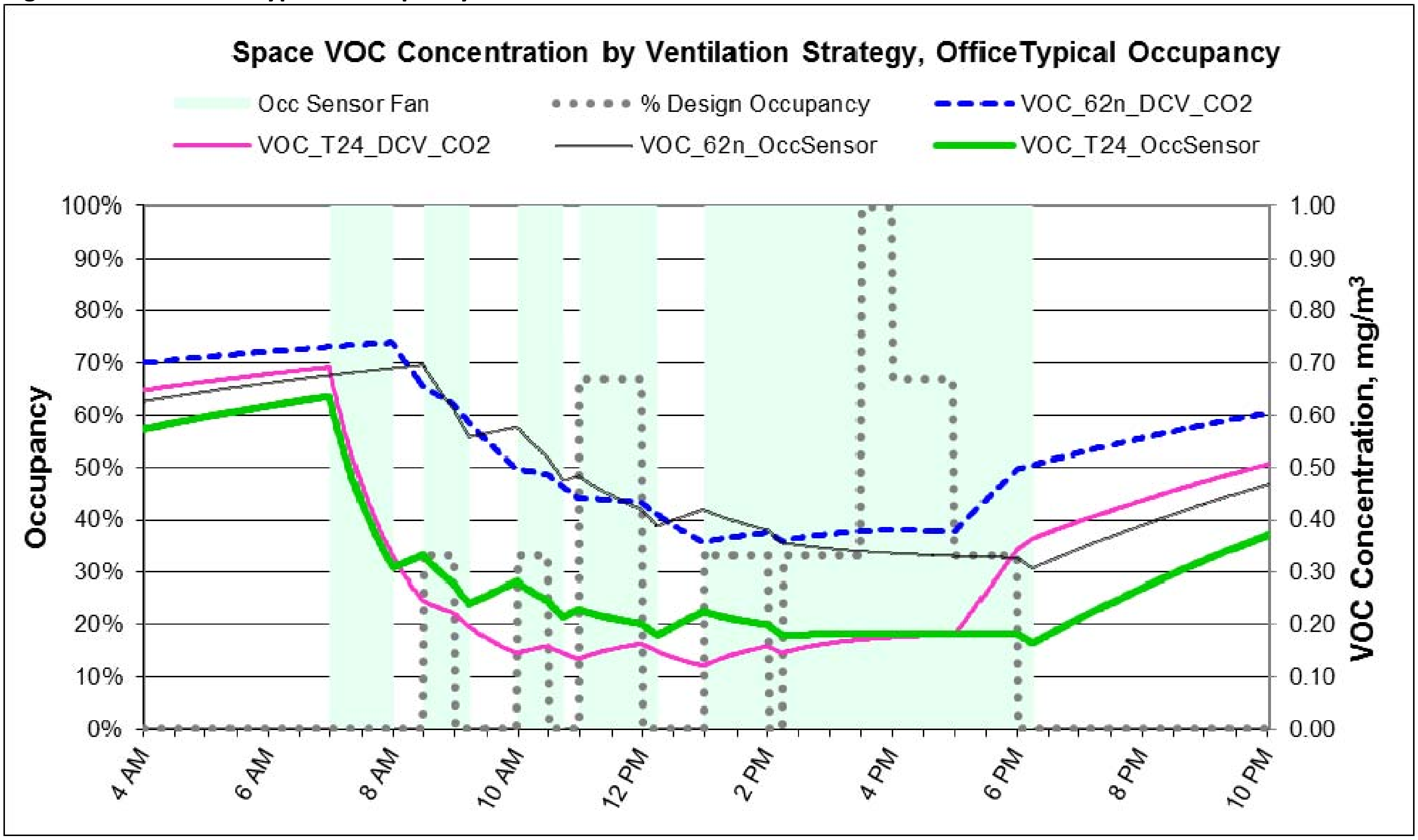
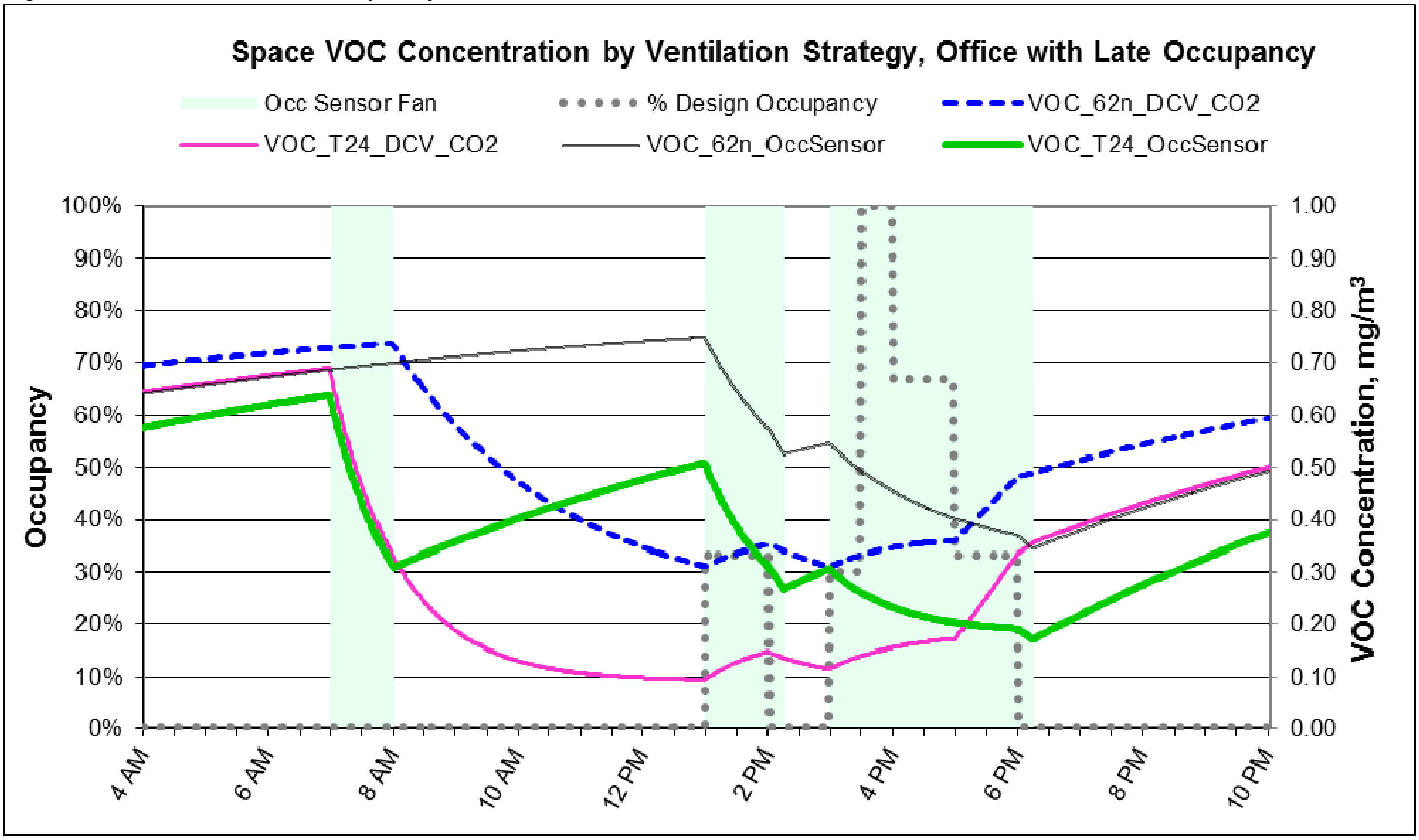


Figure 4 shows what happens when the first occupancy occurs five hours after the purge is complete. In the T24 Occupancy Sensor scenario, VOC levels are reasonable and the average VOC concentration during occupancy is less than the Title 24 DCV method. The VOC levels for the VOC_62n_OccSensor option without a pre-purge does result in higher VOC maximum concentrations and a higher average concentration, indicating that a daily pre-purge is desirable. The benefit of after-hours occupancy sensor control is again shown in Figure 4 between 5:00 pm and 6:00 pm.

Figure 4: **Office with Late Occupancy VOC Model Results**



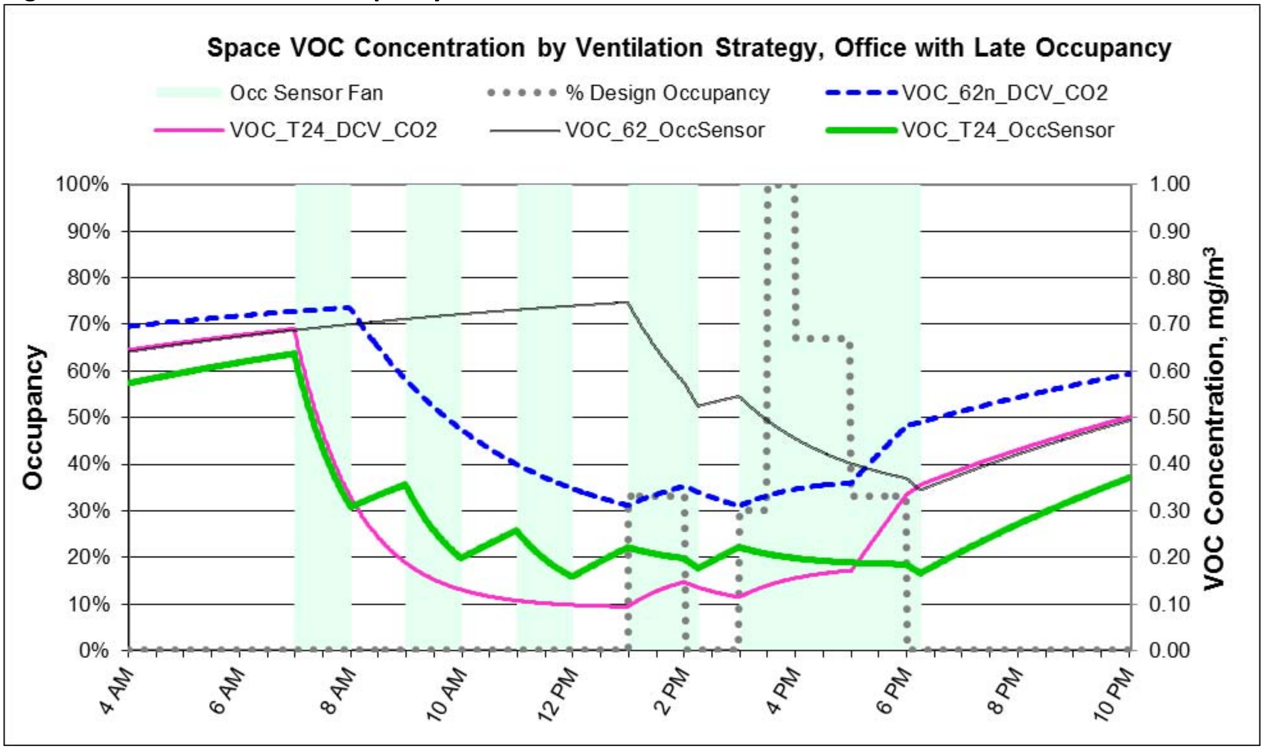
The VOC levels for the Title 24 Occupancy Sensor (solid green line) remain below the start-of-day 62n DCV method (dotted blue line) and also far below an occupancy sensor method applied to 62.1 rates without a purge (thin grey line) that is no longer allowed according to ASHRAE interpretation. Following the end of the purge cycle, after 2.5 hours the Title 24 Occupancy Sensor (solid green line) VOC concentration does rise above the 62n DCV method (dotted blue line). Since actual occupancy in intermittently occupied spaces can occur several hours after the end of a daily purge cycle, an interim ventilation process is recommended to maintain a high level of indoor air quality. The NIST study[3] used double the VOC emission rate for occupied spaces, so half of the Title 24 area rate is highly likely to deal with building generated pollution when spaces are actually unoccupied during times of expected occupancy. Note that half the Title 24 floor area rate is higher than the ASHRAE floor area rate for most occupancies. Selecting half the rate is easy to implement with a 50% duty cycle in offices and other low density occupancies that have the ventilation rate determined by floor area rather than occupant density. High occupant density spaces reduce accumulated VOCs at a much faster rate under occupancy sensor control due to higher design outside air rates.

Figure 5 demonstrates the impact of using a 50% area ventilation rate in low-density occupancies for the Title 24 (green line). Note that VOC levels are maintained at a much lower level than in Figure 4 by requiring an average ventilation rate of half the Title 24 area rate. This approach provides a good balance between energy efficiency and ventilation control. It is recommended that language be updated to include a provision that provides average ventilation equal to half the Title 24 area rate when spaces are actually unoccupied during times of expected occupancy. This sequence would be applied uniformly to all space types that utilize occupancy sensors. In spaces with higher design ventilation rates, fan

[3] Ibid.

operation required would be less. For instance in conference rooms, the vacant ventilation requirements can be met with 18 minutes of design ventilation rate operation every two hours.

Figure 5: **Office with Late Occupancy & Maintenance Ventilation VOC Model Results**



Additional Discussion

The spaces the proposed occupancy sensor provisions apply to (Assembly areas including classrooms, conference rooms, and multi-purpose rooms) do not typically have active printing or copying activity when unoccupied, one of the largest remaining sources of indoor pollution. They also do not have significant sources of building based pollution, and any space that has identified sources of contaminants (generate dusts, fumes, mists, vapors or gasses and are not provided with local exhaust ventilation) are exempted. To be crystal clear on this point, we suggest the language around occupancy sensor control (120.2(e)3) include such an exception so that art classrooms or shops are clearly excluded.

Single zone systems with electro-mechanical controls often have the fan in the 'Auto' position in actual practice, resulting in no ventilation when there is no thermal load. Including an occupancy sensor that forces fan operation whenever the space is occupied will reliably improve ventilation for these systems.

On a personal note, I have had experience implementing occupancy sensor control of VAV boxes for a public meeting room complex with variable scheduling, under ASHRAE standard 62.1 with a similar sequence to the VOC_62n_OccSensor option. I worked with the DDC control upgrade and facility management and worked in the affected building. We received no complaints about air quality during five years of operation using this method.

The complete proposed language related to occupancy sensors ventilation control is attached, with specific recommended changes to the 45-day language shown below.

Recommendation

Based on the discussion above, the spaces where occupancy sensors would be applied do not have significant building-based pollution in new construction and modeled VOC concentrations are moderate for an occupancy sensor control method. It is recommended that the 45-day language in 120.2(e)3 be retained with the following modification.

3. Multipurpose rooms less than 1000 ft^2, classrooms greater than 750 ft^2 and conference rooms greater than 750 ft^2 that do not have processes or operations that generate dusts, fumes, mists, vapors or gasses (such as auto shop classrooms, wood shop classrooms, and art classrooms) shall be equipped with occupant sensor(s) to accomplish the following during unoccupied periods:

   A. Automatically setup the operating cooling temperature set point by 2°F or more and setback the operating heating temperature set point by 2˚F or more; and

   B. Automatically reset the minimum required ventilation rate with an occupant sensor ventilation control device according to Section 120.1(c)5.

Further, in response to ASHRAE INTERPRETATION IC 62.1-2010-4, to avoid build-up of building based pollutants during times when occupancy is expected, when vacant periods detected by occupancy sensors exceed an hour, the following addition will maintain an area ventilation rate by amending 120.1(c)5. There is also a reference correction required.

(c) **Operation and Control Requirements for Minimum Quantities of Outdoor Air.**

. . .

5. **Occupant Sensor Ventilation Control Devices.** When occupancy sensor ventilation devices are required by Section 120.**2**(**e**)3 or EXCEPTION 5 to Section 120.1(c)3, occupant sensors shall be used to reduce the rate of outdoor air flow when occupants are not present in accordance with the following:

. . .

   E. **If spaces equipped with an occupant sensor remain without mechanical outside air ventilation for more than 60 minutes during hours of expected occupancy, then the system or zone controls shall cycle or operate to maintain the average outdoor air rate over an averaging period of 120 minutes equal to or greater than half the rate listed in TABLE 120.1-A.**

Further, based on ASHRAE INTERPRETATION IC 62.1-2010-3 the use of fan cycling for significant fan energy savings should be allowed (but not required for this code change cycle) with the following changes to 120.1(c)1:

EXCEPTION 2 to Section 120.1(c)1: Temporary reduction. The rate of outdoor air provided to a space may be reduced below the level required by Section 120.1(b)2 for up to ~~5~~ **30** minutes ~~each hour~~ **at a time** if the average rate for each hour is equal to or greater than the required ventilation rate.

Respectfully submitted,

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Proposed Occupancy Sensing HVAC Control Language for 2013 Title 24, Part 6

SECTION 120.1 – REQUIREMENTS FOR VENTILATION

All nonresidential, high-rise residential, and hotel/motel occupancies shall comply with the requirements of Section 120.1(a) through 120.1(e).

(c) **Operation and Control Requirements for Minimum Quantities of Outdoor Air.**

1. **Times of occupancy.** The minimum rate of outdoor air required by Section 120.1(b)2 shall be supplied to each space at all times when the space is usually occupied.

   EXCEPTION 1 to Section 120.1(c)1: Demand control ventilation. In intermittently occupied spaces that do not have processes or operations that generate dusts, fumes, mists, vapors or gasses and are not provided with local exhaust ventilation (such as indoor operation of internal combustion engines or areas designated for unvented food service preparation), the rate of outdoor air may be reduced if the ventilation system serving the space is controlled by a demand control ventilation device complying with Section 120.1(c)4 or by an occupant sensor ventilation control device complying with Section 120.1(c)5.

   EXCEPTION 2 to Section 120.1(c)1: Temporary reduction. The rate of outdoor air provided to a space may be reduced below the level required by Section 120.1(b)2 for up to ~~5~~ **30** minutes ~~each hour~~ **at a time** if the average rate for each hour is equal to or greater than the required ventilation rate.

2. **Pre-occupancy.** The lesser of the minimum rate of outdoor air required by Section 120.1(b)2 or 3 complete air changes shall be supplied to the entire building during the 1-hour period immediately before the building is normally occupied.

3. **Required Demand Control Ventilation.** HVAC systems with the following characteristics shall have demand ventilation controls complying with 120.1(c)4:

   A. They have an air economizer; and

   B. They serve a space with a design occupant density, or a maximum occupant load factor for egress purposes in the CBC, greater than or equal to 25 people per 1000 ft² (40 square foot or less per person); and

   C. They are either:

      i. Single zone systems with any controls; or

      ii. Multiple zone systems with Direct Digital Controls (DDC) to the zone level.

   EXCEPTION 1 to Section 120.1(c)3: Classrooms, call centers, office spaces served by multiple zone systems that are continuously occupied during normal business hours with occupant density greater than 25 people per 1000 ft² per Section 120.1(b)2B, healthcare facilities and medical buildings, and public areas of social services buildings are not required to have demand control ventilation.

   EXCEPTION 2 to Section 120.1(c)3: Where space exhaust is greater than the design ventilation rate specified in Section 120.1(b)2B minus 0.2 cfm per ft² of conditioned area.

   EXCEPTION 3 to Section 120.1(c)3: Spaces that have processes or operations that generate dusts, fumes, mists, vapors, or gases and are not provided with local exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, or beauty salons shall not install demand control ventilation.

   EXCEPTION 4 to Section 120.1(c)3: Spaces with an area of less than 150 square feet, or a design occupancy of less than 10 people per Section 120.1(b)2B.

   EXCEPTION 5 to Section 120.1(c)3: Spaces with an area of less than 1,500 square feet complying with 120.1(c)5.

5. **Occupant Sensor Ventilation Control Devices.** When occupancy sensor ventilation devices are required by Section 120.**2(e)**3 or EXCEPTION 5 to Section 120.1(c)3, occupant sensors shall be used to reduce the rate of outdoor air flow when occupants are not present in accordance with the following:

A. Occupant sensors shall meet requirements in Section 110.9(b)4 and shall have suitable coverage and placement to detect occupants in the entire space ventilated. Occupant sensors controlling lighting may be used for ventilation as long as the ventilation signal is independent of daylighting, manual lighting overrides or manual control of lighting. When a single zone damper or a single zone system serves multiple rooms, there shall be an occupancy sensor in each room and the zone is not considered vacant until all rooms in the zone are vacant.

B. One hour prior to normal scheduled occupancy, the occupancy sensor ventilation control shall allow pre-occupancy purge as described in Section 120.1(c)2.

C. Within 30 minutes of vacancy in all rooms served by a zone damper on a multiple zone system, and there is no call for cooling or heating, then no outside air is required and supply air shall be zero.

D. Within 30 minutes of vacancy in all rooms served by a single zone system, the single zone system shall cycle off the supply fan when there is no call for cooling or heating.

E. **If spaces equipped with an occupant sensor remain without mechanical outside air ventilation for more than 60 minutes during hours of expected occupancy, then the system or zone controls shall cycle or operate to maintain the average outdoor air rate over an averaging period of 120 minutes equal to or greater than half the rate listed in TABLE 120.1-A.**

SECTION 120.2 – REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS

Space-conditioning systems shall be installed with controls that comply with the applicable requirements of Subsections (a) through (i).

(e) **Shut-off and Reset Controls for Space-conditioning Systems.** Each space-conditioning system shall be installed with controls that comply with the following:

1. The control shall be capable of automatically shutting off the system during periods of nonuse and shall have:

A. An automatic time switch control device complying with Section 110.9, with an accessible manual override that allows operation of the system for up to 4 hours; or

B. An occupancy sensor; or

C. A 4-hour timer that can be manually operated.

EXCEPTION to Section 120.2(e)1: Mechanical systems serving retail stores and associated malls, restaurants, grocery stores, churches, and theaters equipped with 7-day programmable timers.

2. The control shall automatically restart and temporarily operate the system as required to maintain:

A. A setback heating thermostat setpoint if the system provides mechanical heating; and

EXCEPTION to Section 120.2(e)2A: Thermostat setback controls are not required in nonresidential buildings in areas where the Winter Median of Extremes outdoor air temperature determined in accordance with Section 140.4(b)4 is greater than 32°F.

B. A setup cooling thermostat setpoint if the system provides mechanical cooling.

EXCEPTION to Section 120.2(e)2B: Thermostat setup controls are not required in nonresidential buildings in areas where the Summer Design Dry Bulb 0.5 percent temperature determined in accordance with Section 140.4(b)4 is less than 100°F.

3. Multipurpose rooms less than 1000 ft^2, classrooms greater than 750 ft^2 and conference rooms greater than 750 ft^2 that do not have processes or operations that generate dusts, fumes, mists, vapors or gasses (such as auto shop classrooms, wood shop classrooms, and art classrooms) shall be equipped with occupant sensor(s) to accomplish the following during unoccupied periods:

A. Automatically setup the operating cooling temperature set point by 2°F or more and setback the operating heating temperature set point by 2˚F or more; and

B. Automatically reset the minimum required ventilation rate with an occupant sensor ventilation control device according to Section 120.1(c)5.

EXCEPTION 1 to Section 120.2(e): Where it can be demonstrated to the satisfaction of the enforcing agency that the system serves an area that must operate continuously.

EXCEPTION 2 to Section 120.2(e): Where it can be demonstrated to the satisfaction of the enforcing agency that shutdown, setback, and setup will not result in a decrease in overall building source energy use.

EXCEPTION 3 to Section 120.2(e): Systems with full load demands of 2 kW or less, if they have a readily accessible manual shut-off switch.

EXCEPTION 4 to Section 120.2(e): Systems serving hotel/motel guest rooms, if they have a readily accessible manual shut-off switch.