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EBTRON comments to the SRVEVR Guidelines

Please see the attached response for comments to the draft guidelines. It is not all encompassing, for example it doesn't make the important note that improved ventilation will likely increase cost for those schools that are currently deficient.

I offer to work with the commission as I have done in the past. I support the interest of the HVAC industry through sharing my 30+ yrs of expertise through active participation and membership in various past and present activities. Including but not limited to SSPC 90.1, SSPC 62.1, SPC 180, SPC 207, GDL 11, TC 7.7, TC 1.4, TC 4.3, WHPA

Additional submitted attachment is included below.

EBTRON®
Thermal Dispersion Airflow Measurement

February 4, 2021

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Re: School Reopening Ventilation and Energy Efficiency Verification and Repair Program Guidelines

Dear CEC Commissioners and Staff:

Thank you for the opportunity to provide comment and insight into the topic of adequate ventilation for the safe operation of CA schools. This is a long overdue need that has existed long before the COVID-19 pandemic. We agree that underserved community LEAs should be a focus, as typically they have the greatest challenges with respect to age and performance of HVAC equipment. It is our hope that this program will result in lasting improvements to the operation of ventilation within CA schools. We would like CA to set an example for the rest of the united states, as many other communities also have under-ventilation problems in schools. We also encourage the LEAs use the ESSER II funds to continue to focus on IAQ and ventilation.

The primary goal of this program is to ensure that systems meet current classroom ventilation requirements. Efforts should be made to ensure that these achievements are not short lived, that they are everlasting. To achieve long term operational success, deficiencies should be addressed sooner rather than later. Performing just assessment and adjustment, may only result in short term acceptable conditions. This attention to system performance was needed long before COVID-19 to ensure that systems were already robust. Action should take place now to ensure every school that is looked at can have the opportunity for update to systems and controls that can have immediate results in monitoring ventilation rates, controlling pressurization, actively changing setpoints when conditions change, and provide true fault detection when adjustments can't be achieved. There are many forces internal and external to the HVAC system that can impact operation. We discus below some limitations of the SRVERV program as well as limitations of Building Energy Efficiency Standard with respect Ventilation, IAQ, and the goals for this program.

The program intends to incorporate CO_2 monitoring and DCV control as a means to ensure, validate, and monitor ongoing ventilation rates after assessment and adjustment has been completed. However, we will discuss why CO_2 monitoring falls short of ensuring the Title 24 part 6 minimum ventilation rates are always provided.

In Chapter 2, part A. HVAC Assessment and Maintenance Requirements, subsection 3) Demand Control Ventilation (DCV). The requirements are to first adjust DCV systems to 800 PPM of less, and only disable the system, when levels below 1100 ppm cannot be maintained. We argue that DCV should be disabled in the start of this program, for DCV operation may result in underventilation during some periods, may impact building pressurization, and in some situation could result in more ventilation than the HVAC system can handle. We understand that this language is direct from AB-841, however, that fact doesn't make it functionally possible or practical, and eliminating this step can eliminate call back and other problems.

DCV's intent is to be an energy saving ventilation reset strategy, not a ventilation enhancement function. Most DCV sequences operate on a limit rather than a modulating control off ambient baseline. Because CO_2 is a lagging indicator, the control may not take action to increase outdoor air off the minimum rate for DCV per Table 120.1-A. The results may look like what is shown in Figure 1. I this example DCV is set to 1000 ppm. The result is the 1st period classroom is under-ventilated until steady state is met. Steady state cannot be achieved until a population has been established, and maintained, within the space. A pre-occupancy purge would clean out by products for the room, however would do nothing to dilute any potential virus generated when the room becomes occupied. If schools open with classrooms having lower than design occupancy, then the result may look more like Figure 2, and there will be under-ventilation for a longer periods.

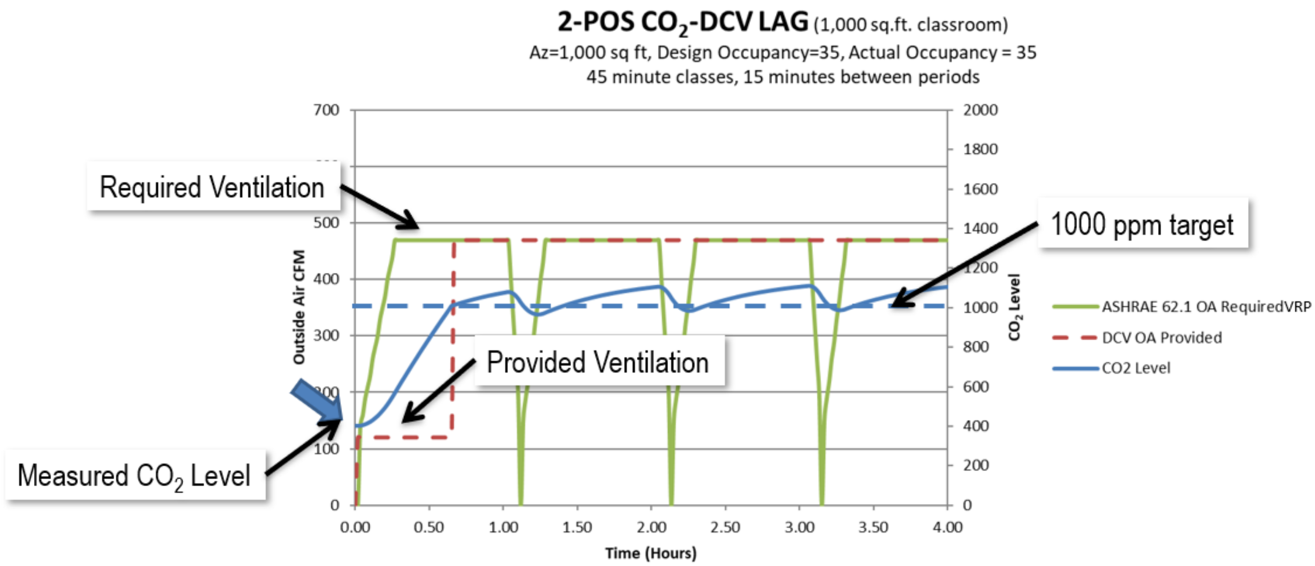

Figure 1

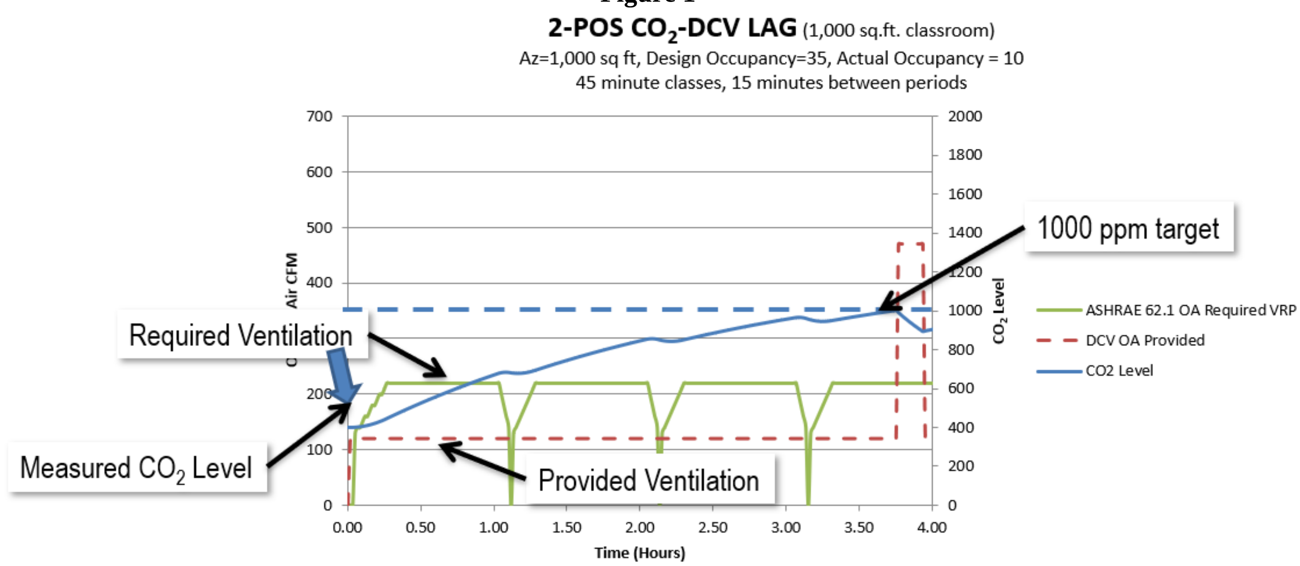

Figure 2

With respect to achieving better than 800 ppm or 1100 ppm, this is dependent on multiple variables. There is an interdependent relationship between space CO_2 level and the ventilation rate. There is also a dependence on the generation rate of the room occupants. This generation rate varies with age, gender, body mass, respiration quotient, basal metabolic rate, and activity level. Based on Carbon dioxide generation rates for building occupants https://doi.org/10.1111/ina.12383, the results for steady state / ventilation rates are different whether you are in elementary school, middle, or high school. Figure 3 shows the mean generation rates per age group for a metabolic activity level of seated. The steady state ppm results for the same population and same room size for elementary, middle, and high school, are shown in Figure 4. In this table, the resultant CO_2 ppm value is compared to the required ventilation rates per Table 120.1-A, as well as the required rates to maintain both 800 ppm and 1100 ppm. Because the interdependency, operating at ventilation rates per 120.1, conflicts with maintaining below 800 ppm and alarming over 1100 ppm. If we use CO_2 DCV to try and drive more ventilation into the space, it may result in more ventilation than the system can handle. That is, if the controls can even provide more. For these reasons we recommend to disabling DCV.

Age	Sex	RQ Assumed	BMR Calc. Coef. Table D1.2.2.		Mass (kg) Table D1.2.3.1	BMR eq. D1.2.2.2	M Table 1.2.4.1.	G= RQ·BMR·M·*k* L/S	CFM
6 to 10	M	0.85	0.095	2.110	31.9	5.141	1.3	0.003232	0.006848
	F	0.85	0.085	2.033	31.7	4.728	1.3	0.002972	0.006298
50/50 Avg Elementary									0.006573
11 to 13	M	0.85	0.074	2.754	57.6	7.016	1.3	0.004412	0.009347
	F	0.85	0.056	2.898	55.9	6.028	1.3	0.003790	0.008031
50/50 Avg Middle School									0.008689
14 to 18	M	0.85	0.074	2.754	77.3	8.474	1.3	0.005328	0.011290
	F	0.85	0.056	2.898	65.9	6.588	1.3	0.004142	0.008777
50/50 Avg High School									0.010033
30 to 60	M	0.85	0.048	3.653	89.0	7.925	1.5	0.005749	0.012182
	F	0.85	0.034	3.538	77.1	6.159	1.5	0.004468	0.009468
73% Female Teacher 45yrs									0.010201

Figure 3

AB-841 COVID-19 Ventilation Verification Title 24 CO_2 Estimator

Number of Students	30	kids
Area of classroom	1000	ft^2
Outdoor CO2	400	ppm
Table 120.1-A Ventilation R_a	0.38	cfm/ft^2
Room Ventilation	380	cfm

		Elementary School			Middle School			HighSchool		
		Title 24 Results	Ventilation Rate needed for CO2 level		Title 24 Results	Ventilation Rate needed for CO2 level		Title 24 Results	Ventilation Rate needed for CO2 level	
Calculated steady state CO2 Table 120.1-A	ppm	946	800	1100	1113	800	1100	1219	800	1100
Calculated cfm/person	cfm	12.3	16.7	9.6	12.3	21.8	12.5	12.3	25.1	14.3
Calculated steady state CO2 15 cfm / person	ppm	846			983			1069		

Disclaimer:

CO_2 rates based on the NIST calculation method as incorporated in proposed addendum to 62.1-2020 and is based on steady state values. Actual CO_2 rate is dependent body mass, gender, age, and metabolic rate and may differ from estimate. These values also assume no error in CO_2 sensor measurement.

Figure 4

Additionally, the goal to monitor spaces to achieve levels below 800 ppm and to alarm above 1100 ppm may have inherent challenges. The challenge of ensuring the location of the space CO_2 is not to close to a source of CO_2 or ventilation and adequately represents the entire space exists. Foremost, there will be an expectation that 800 ppm or better can be achieved, and if they are not, the occupants may be concerned about the safety of the space. As shown in Figure 4 there is great potential that 1100 ppm cannot be achieved, although the rates have been verified to meet Table 120.1-A. This may lead to false alarms generated. The Building standard has this covered with the following exception, however this program does not.

EXCEPTION to Section 120.1(d)4C: The outdoor air ventilation rate is not required to be larger than the design outdoor air ventilation rate required by Section 120.1(c)3 regardless of CO_2 concentration.

Using surrogate measurements can led to more challenges.

The SRVEVR guideline Chapter 2, part A. HVAC Assessment and Maintenance Requirements, subsection 2) Ventilation, has the following goals. Determine the ventilation required per HVAC system, verify it is being brought into the system and to the zone, establish positive pressure, verification of separation distances, verification of exhaust, and make adjusts, if possible, to meet minimums. We intend to address several of these tasks and identify challenges achieving the goals in knowledge sharing effort to impart needed enhancements to this program to achieve healthy indoor environments for students and educational professionals long term.

The intent is to use acceptance tests (e.g. CEC-NRCA-MCH-02-A– Outdoor Air Acceptance) to validate outdoor ventilation rates. The intent of acceptance tests is one we support, however good intentions do not always produce good results. Acceptance Tests in current form were introduced in the 2008 version of the standard, post Evaluation of Title 24 Acceptance Testing Enforcement and Effectiveness report. In the development of the 2013 version, there was a realization that effectiveness of the acceptance tests were not meeting the intention. Therefore, it was determined that other means of controls were needed to ensure quality in the results. This led to the development of the ATTCP program. Unfortunately, it took 7 years for the Mechanical Systems program to meet the threshold to use only certified providers. The launch of the SRVEVR program would be the first test of effectiveness of this certification. It is expected that these certified ATTs will perform better than noncertified professional. The recently released research; Ventilation rates in California classrooms: Why many recent HVAC retrofits are not delivering sufficient ventilation https://doi.org/10.1016/j.buildenv.2019.106426 is an indication of unsatisfactory results of Outdoor Air Acceptance tests up till present. The organization that are ATTCP providers are all well established and qualified organization with training resources. However, we believe there are limitations and omission in the current 2019 and previous acceptance tests, and if the ATTs were not trained for something that wasn't there, then perhaps they do not have the information they need to completely ensure the systems are setup and operating correctly.

It is expected that Outdoor Air acceptance for Variable Air Volume (VAV) systems will have some means of dynamic control, so that as the fan speed changes in response to static pressure as a result of load, that the outdoor air damper will track and adjust to the correct airflow rate. This is required because the fan speed changes has a linear change in pressure across a damper in a fixed position.

What about non VAV systems, or as noted in the Outdoor Air Acceptance as Constant Air Volume (CAV) systems. CAV is not defined in the standard, but is defined in the Nonresidential Compliance Manual ***Constant Volume System*** *is a space-conditioning system that delivers a fixed amount of air to each space. The volume of air is set during the system commissioning.* VAV is likewise defined and is associated with zones that use single duct or dual duct box terminals. The requirements of the Outdoor Air Acceptance is clear, CAV systems are to be set to a fixed minimum outdoor air. It can be assumed that since 2013 any unit >54,000 Btu/hr will have an economizer with low leak modulating dampers, and before that >75,000 Btu/hr with standard modulating dampers. It can also be assumed that units smaller than the economizer threshold will either have barometric or 2 position actuation, due to the requirement to close upon fan shut down.

Something that has never been accounted for is the change in 2013 adding 140.4(m) Fan Control, with the Table 140.4-D Effective Dates – Figure 5. Any system that falls under this requirement, is no longer a CAV unit. If the damper is set to a fixed position, then ventilation rates will not be achieved when fan speed is reduced, unless controls are in place similar to VAV. Some units are being manufactured with more than 2 speeds, to match the minimum number of mechanical stages required.

TABLE 140.4-D EFFECTIVE DATES FOR FAN CONTROL SYSTEMS

Cooling System Type	Fan Motor Size	Cooling Capacity	Effective Date
DX Cooling	any	≥ 110,000 Btu/hr	1/1/2012
		≥ 75,000 Btu/hr	1/1/2014
		≥ 65,000 Btu/hr	1/1/2016
Chilled Water and Evaporative	≥ 5 HP	any	1/1/2010
	≥ 1 HP	any	1/1/2014
	≥ 1/4 HP	any	1/1/2016

Figure 5

Many economizer systems on were manufactured in the past with not only leaky dampers, but excessive slop in the actuated drivetrain gear or linkage assembly. The result is an actuator may rotate, but the damper may not. This causes the inability to be reliant on actuator position to always position the damper in the same location. Therefore, the field measured outdoor air at one moment in time may not be reproducible the next time. You can have the best ATT or TAB, and they can't resolve this inherent problem with measurement and adjustment alone. ASHRAE Standard 111 puts it this way, "certification that airflow rates meet specification is the most difficult field measurement that a TAB engineer has to perform" The inability to hit the same position exists whether moving from closed position to minimum or from economizer mode to minimum. In economizer mode, and DCV, there is closed loop logic that will continue to adjust until the desired sensor value is achieved. In minimum ventilation mode however, the actuator is driven to a position without verification that this position has been achieved. Actuator feedback only provide actuator internal motor position and not damper positions. Damper curves are not linear and change from unit to unit based on conditions and damper authority Belimo Damper Application Guide.

In 2013 when the requirement for low leak economizer dampers and economizer cycle testing was incorporated, there was a reduction of mechanical slop, however the seals that give a damper low leakage rating, also generate increase hysteresis, the tendency to arrive at different positions for the same signal input when moving in different directions. Figures 6 Illustrates hysteresis, Figure 7 is actual data of a low leak damper, where 100% equals minimum position setpoint. It shows when going from closed to minimum position that the minimum position is never achieved and the mean is 82% of the target. Regardless of the damper curve that is already greater than 10% below minimum ventilation. This is without considering other impacts such as wind, increased filter pressure drop, and more. Position by itself is not an repeatable validation of airflow rate.

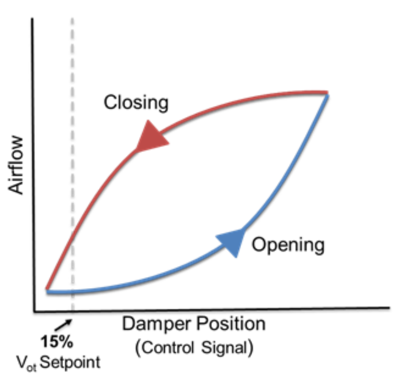

Figure 6

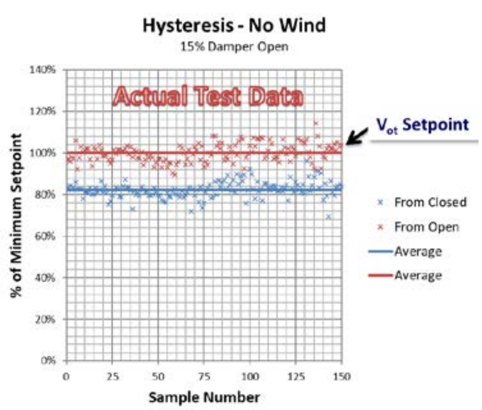

Figure 7

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Dilution ventilation is based on the mass flow of air. Neither 120.1 nor the acceptance tests account for the effect of seasonal or elevation density impact. It may balance out over the year, however if there could as situation where this impact is additive to acceptance of 90% of design airflow rates, then ventilation rates are unacceptable. We would recommend that the acceptance tests should be no be certified with no less than 100% of minimum air requirements. Furthermore, many parts of CA are subjected to Katabatic winds during periods of schools in session. These winds can have negative effect on ventilation intakes or pressurization control, especially on systems with open loop ventilation control, or external pressure sensors used to maintain building pressurization.

Building pressurization is a function of supplying more ventilation than is relieved and exhausted. This extra ventilation can be defined as the pressurization flow. The amount of pressurization flow required is depending on the leakiness of the building. This leakiness can be impacted by seasonal changes, winds, malfunctioning building components (e.g doors not closing tight), and deterioration. Malfunctioning or incorrectly controlled or operated HVAC equipment has direct impact on maintaining building pressure. This highlights importance on flow tracking and verification of control sequences and ensuring equipment is in good functioning condition. The standard has minimal requirements for building pressurization. There is the requirement of120.1(f), that outdoor should at least be the rate to make up exhaust, and 140.1(e) relief during economizing to prevent over pressurization. The only acceptance tests verification in place is economizer controls acceptance. There is some guidance in the compliance manual on three potential options to relief air during economizer operation, however there is no other guidance or verification for this program's requirement to ensure positive pressure differential. The same goes for exhaust airflow verification, this has not been addressed by the standard or acceptance tests, even though it should be. These two things go hand in hand and are interdependent on ventilation. As mentioned above as an impact to ventilation, 140.4(m) requirement fan control also can lead to buildings to be negatively pressured during those turndown periods, since there is no metric in place.

Verification that ventilation is reaching all zones will be a challenging if not impossible part of the assessment. This could be possible with DOAS direct to the space and tracer gas, otherwise we are not sure how commission expects this be achieved.

TAB and Commissioning of new buildings to determine systems and controls are tuned and functioning correctly is hard enough on new buildings and systems, it is asking quite a bit to try and assess schools in various states. Control sequences on paper may not correspond with those in the BAS. There will be cases when not all systems are connected or functioning. There will be schools without BAS and schools with hybrid mechanical and natural ventilation. One step to getting to not only verification, but also long term delivery of minimum ventilation is to require the integration of airflow measuring device (AMD). A factory calibrated and traceable AMD is already an advantage over field measurement. Not only does an AMD provide the rates, but it also closes the control loop. It can automatically command for an increase in flow with fan speed changes, filter loading, compensation for wind impact and seasonal or density changes. They are much easier to adjust to enhanced pandemic ventilation rates and readjust when things are normal. Additionally, logic can be added to increase outdoor air rates above minimum when the outdoor temperature is more neutral and doesn't impact load capabilities of the HVAC system. They could also more easily be setup to reduce air in times when the outdoor PM is unsatisfactory. Further inclusion of AMDs would also make pressurization control an easier to achieve under varying operating conditions.

Respectfully Submitted,
Darryl DeAngelis

Additional resources: School Ventilation COVID-19 Ventilation.pdf CO2-DCV.pdf