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California Schools Healthy Air, Plumbing, and Efficiency Ventilation Program

HVAC Assessment and Maintenance Pathway
HVAC Assessment Report Guide

This guide is made available to help Program participants complete the HVAC Assessment Report Worksheets as part of the California Schools Healthy Air, Plumbing, and Efficiency (CalSHAPE) Ventilation Program Assessment and Maintenance Grant. To comply with grant requirements and be eligible for funding, participants must submit an HVAC Assessment Report for each system and all required supporting documentation.

The CalSHAPE Ventilation Program Guidelines, this guide, worksheets, and other program requirements such as a data reporting and processes are subject to change by the California Energy Commission, including but not limited to any changes to data reporting requirements from the California Public Utilities Commission. It is the participant's responsibility to use the most recent version of these worksheets and otherwise comply with the current requirements of the CalSHAPE Ventilation Program.

Overview

This guide supports completing the **Excel upload tool**, which is designed to report assessment information for each HVAC system (e.g. one complete report per air handler). Carbon Dioxide (CO_2) sensor information is reported separately via the online system. Exhaust-only system measurements (e.g. restroom exhaust) are required by the guidelines but are not being gathered by the upload tool. Exhaust-only system measurements should be reported at the site level by use of an attachment (e.g. PDF of exhaust fan measurements).

The ability of the CEC and its contractors to demonstrate the impact and benefits of CalSHAPE relies on the skilled and thorough work of technicians and complete and accurate reporting. Every ventilation system adjusted to provide adequate outdoor air and every high filtration efficiency filter installed means reduced absence rates, improved student performance, and reduced exposure to harmful outdoor air pollution. The expectation of the CEC is that grantees will make judicious use of the available funding to meet the program guidelines to the greatest extent possible. Completing this program requires extensive access to a school site including building interiors, rooftops, and control systems. **Not completing the work due to lack of access is not acceptable.**

The form collects data "as found," which means the state of the system before any adjustments or changes were made. The form also collects data "as left," which means the state of the system after the adjustments and changes were completed. If system repairs were made during implementation of this program (with CalSHAPE funding or an alternate funding source) please report the final "as left" condition. **When the "as found" and "as left" conditions are the same, enter the same information in both fields.**

The qualified technicians who must conduct these measurements fall into two categories: Qualified Testing Personnel and Qualified Adjusting Personnel. Qualified Testing Personnel are qualified to take the required measurements for the report. Qualified Adjusting Personnel are qualified to take the required measurement and make the necessary adjustments to the equipment. Qualified Testing Personnel can either be an HVAC acceptance test technician or a certified TAB technician. Qualified Adjusting Personnel can either be a certified TAB technician or a skilled and train workforce under the supervision of a TAB technician. In the first table, report the qualified testing technician and, where applicable, the qualified adjusting technician that performed the work on each of the assessment forms.

1. HVAC Equipment Details

1.1. Building Site Information

- Enter the building/site address
- CA climate zone for the address can be found here

1.2. HVAC Equipment Details

- Enter information from equipment nameplate. If nameplate is missing or not legible, look inside the unit for the serial number and model information. It is usually printed in more than one location. Model number information for the indoor unit/air handler is only needed for split systems.
- Determine heating system present. Note that heat pumps often have electric resistance or gas backup. In this case, select all heating types that are present.
- Determine refrigerant type. If not on the name plate, this information is generally printed on the compressor, or is discernable from the maximum operating pressures printed on the compressor.
- Obtain heating input, heating output, and cooling capacity from the equipment nameplate. If nameplate is missing or not legible, use the model number information to obtain this information from the manufacturer or the AHRI database here.

2. Filtration, Airflow Distribution, and Building Pressurization

2.1. Filter Data

- Both the as-found and as-left conditions of the filters need to be documented.
- Use one row for multiple filters of the same dimension, so that in general most systems will have only one row entered. More rows may be added to account for additional filters if necessary.
- A primary objective of this program is to install MERV 13 filters to decrease student exposure to outdoor generated air pollution and indoor generated respiratory aerosols. A careful analysis of the system (including supply airflow, fan power, and pressure drop) is expected to determine if the system can use MERV 13 filters. It's important to note that not all MERV 13 filters will have the same performance. Where possible, use filters with 2" depth and a higher number of pleats per inch to achieve the lowest pressure drop possible. Never stack two 1" deep filters on top of each other - this will more than double the airflow resistance. In general, it's expected that all systems with electrically communicated motors (ECM) (which automatically change speed to provide a constant airflow) will be compatible with MERV 13 filters. The guidelines require that, where possible, the motor speed of variable speed motors, and/or the fan speed of belt driven systems be adjusted to achieve desired supply airflow rates with MERV 13 filters. For general background on filter performance and the impact of filter rating on airflow and pressure drop, please see this video.
- If a minimum of MERV 13 filtration is not feasible, indicate the reasons in section 2.7 and 2.8 regarding remaining deficiencies.

2.2. Supply Fan Motor Nameplate Data

- Enter the information from supply motor nameplate and select whether or not there is a variable speed drive controlling the supply fan motor. Indicate whether the drive assembly is belt or direct drive.

2.3. Fan and Motor Sheave Data

- For belt driven systems, enter the information for the fan and motor sheave for both the as-found and as-left conditions. If the system is not belt driven, do not fill out these fields.

2.4. Summary data for airflow, fan performance, and building pressurization at full airflow

- For this test, disable power exhaust (if applicable) and run the system at full supply airflow.
- Provide an attachment with the supporting data from the technician for as-found and as-left measurements (commonly referred to as a TAB Report).
- If the supply, return, and outside air rate design data are not available, use best practices to obtain the data. Consult the HVAC manufacturer documentation for the unit to determine the appropriate supply airflow rate. If it is not possible to obtain design supply airflow rates, configure the system for 350 to 400 CFM per ton of cooling capacity. Note that the higher flow rate (400 CFM per ton) will generally maximize cooling system efficiency. To determine the outdoor air design rate (to calculate the return air design rate), see section 3.
- Measure the supply airflow and return airflow rates using both the sum terminal method and the pitot traverse method whenever possible to detect duct leakage. Measure the motor speed, fan speed, and actual motor input power (measured with true power meter) reported in units of horsepower (HP). For reference, the single phase and three phase equations to calculate HP from voltage, current, and power factor are as follows:

$$Single\ Phase\ HP = \frac{V \times A \times PF}{746}$$

$$Three\ Phase\ HP = \frac{1.732 \times V \times A \times PF}{746}$$

Where:

V is the measured voltage
A is the measured amps
PF is the power factor of the motor in decimal form (e.g. 0.80)

- Measure the total static pressure across the fan as well as the external static pressure across the ductwork.
- Measure the building pressurization relative to outdoors.

2.5. Summary Data for Powered Exhaust Test

- Note if powered exhaust is present. If present, complete a powered exhaust test and report the supply airflow, exhaust airflow, and building pressurization with the powered exhaust active.
- Provide a complete TAB report as an attachment with the supporting data.

2.6. Minor Repair and Adjustments
- Document any adjustments and minor repairs that were made to the filtration and supply airflow system

2.7. Remaining Deficiencies
- Document any deficiencies that may remain in the filtration and supply airflow system after all the work was completed.

2.8. Remaining Deficiencies Notes

2.9. Measurement Notes
- Provide notes here for any reasons that specific measurements could not be made. For example, a specific supply air grill or pilot traverse that was not accessible.
- Lack of access to the building, rooftop, or control system is not an acceptable reason.

3. Minimum Outside Air

3.1. Minimum Required Outside Air (OSA)
- If design documents are not available, determine the total number of people in the space(s) served by the HVAC system. Request this information from the district and/or school. Alternatively, count seats in classrooms to estimate occupancy. If the number of students in classrooms is not known or available, assume 25 people in elementary classrooms and 32 people in secondary classrooms (middle, junior, and high schools).
- Determine the total floor area served by the space(s) served by the HVAC system.
- Calculate the minimum outside air for the spaces(s) served by the HVAC system, which is the greater of the occupancy or floor area calculation based on Section 120.1 of the 2022 Title 24 California Building Energy Efficiency Standards. A sample calculation for a 900 square foot classroom is shown below; select the larger of the values. If the system uses DCV the minimum outside air requirement is reduced to 0.15 CFM/ft^2 regardless of the number of people. The maximum outside air requirement for DCV is the full ventilation rate calculated for a fixed rate ventilation system. For more information on minimum outside air requirements, please see this video.
- Report the minimum outside air requirement. Note this value should be consistent with supply airflow and return airflow design requirements reported in section 2.
- Note if the system is a single-speed constant air volume system or a multi-speed variable air volume system. For variable air volume systems, the outside air must be adjusted to provide the correct minimum outside air rate at both the high fan speed and the low fan speed.

Standard	Method	15 People	25 People	32 People
California T24 (2022) Occupancy	15 CFM/person	225 CFM	**375 CFM**	**480 CFM**
California T24 (2022) Floor Area	0.38 CFM/ft^2	**342 CFM**	342 CFM	342 CFM

3.2. Outside Air Measurements

- Disable demand control ventilation and economizer for the test and set supply airflow to high speed (full airflow). This high speed, full airflow, test can be done in conjunction with section 2 airflow testing.
- As-Found Measurements: Measure the as-found outside air rate for the system before any adjustments are made. Record the reading and calculate the result as a percentage of the requirement.
- If the outside air is not between 90-110% of the requirement, troubleshoot and adjust the outside air system until the outside air requirement is met. Example types of troubleshooting and adjustments that are expected to be within the scope of this program are: correcting minor problems with control wiring, correcting actuator position settings, changing minimum damper position settings, adjusting the size of a fixed outdoor air intake opening (i.e. making the hole bigger or smaller), removing debris that prevents damper movement, etc.
- After adjustments to meet the outside air requirement (within ±10%), report the as-left measurements.
- If no adjustment can be made, enter the same values in the "as-left" field from the "as-found field" and specify the reason in outside air deficiencies.
- If no adjustment was needed because as-found rate was within specification, enter the same values in the "as-left" field from the "as-found" field.
- Put a physical mark on the system to indicate where the damper was when the minimum damper position was set.
- Repeat this process for the low fan speed for VAV systems where applicable. If not applicable, leave these fields blank.

3.3. Minor Repairs and Adjustments

- Document any minor repairs and adjustments that were made to the outside air system

3.4. Outside Air Deficiencies

- Document any outside air deficiencies that may remain in the system after all the work was completed.

3.5. Remaining Deficiencies Notes

- If deficiencies remain in the outside air system, describe and provide notes to inform future repairs and/or replacements.
- Lack of access to the building, rooftop, or control system is not an acceptable reason to leave the system with a deficiency.

4. Ventilation System Operation

4.1. Economizer and DCV Information

- Check if an economizer is present in the system. If yes, continue the form. If no, consider whether the system should have been installed with an economizer. The 2013 Building Energy Efficiency Standards require an economizer for systems with cooling capacity greater than 54,000 btu/hr.
- For systems greater than 54,000 btu/hr without economizers, determine to the best of your ability whether the system was installed before or after the 2013 Standards took effect (based on likely system age).

4.2. Economizer Configuration and Testing

- For systems with economizers, report the model of the economizer controller. Configure the economizer controller per Title 24 as shown in the table below, and report the settings including the device limit type, high limit setting, and minimum damper position for minimum outside air.

TABLE 140.4-G AIR ECONOMIZER HIGH LIMIT SHUT OFF CONTROL REQUIREMENTS

Device Type[a]	Climate Zones	Required High Limit (Economizer Off When):	
		Equation[b]	Description
Fixed Dry Bulb	1, 3, 5, 11-16	$T_{OA} > 75°F$	Outdoor air temperature exceeds 75°F
	2, 4, 10	$T_{OA} > 73°F$	Outdoor air temperature exceeds 73°F
	6, 8, 9	$T_{OA} > 71°F$	Outdoor air temperature exceeds 71°F
	7	$T_{OA} > 69°F$	Outdoor air temperature exceeds 69°F
Differential Dry Bulb	1, 3, 5, 11-16	$T_{OA} > T_{RA}°F$	Outdoor air temperature exceeds return air temperature
	2, 4, 10	$T_{OA} > T_{RA}-2°F$	Outdoor air temperature exceeds return air temperature minus 2°F
	6, 8, 9	$T_{OA} > T_{RA}-4°F$	Outdoor air temperature exceeds return air temperature minus 4°F
	7	$T_{OA} > T_{RA}-6°F$	Outdoor air temperature exceeds return air temperature minus 6°F
Fixed Enthalpy[c] + Fixed Drybulb	All	$h_{OA} > 28$ Btu/lb[c] or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds 28 Btu/lb of dry air[c] or Outdoor air temperature exceeds 75°F

[a] Only the high limit control devices listed are allowed to be used and at the setpoints listed. Others such as Dew Point, Fixed Enthalpy, Electronic Enthalpy, and Differential Enthalpy Controls, may not be used in any Climate Zone for compliance with Section 140.4(e)1 unless approval for use is provided by the Energy Commission Executive Director.

[b] Devices with selectable (rather than adjustable) setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

[c] At altitudes substantially different than sea level, the Fixed Enthalpy limit value shall be set to the enthalpy value at 75°F and 50% relative humidity. As an example, at approximately 6,000 foot elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

- Perform functional testing of the economizer which includes the following:

Step	Economizer Functional Test
1	Disable demand control ventilation systems, if applicable
2.0	Enable the economizer and simulate a cooling demand large enough to drive the bypass to fully open position. Maintain this status for all of Step 2.
2.1	Verify outdoor air intake is 100 percent open, and return is 100 percent closed.
2.2	Verify that all applicable fans and dampers operate as intended to maintain building pressure.
2.3	Verify that the economizer heating is disabled (if unit has heating capability).
3.0	Disable the economizer and simulate a cooling demand. Maintain this status for all of Step 3.
3.1	Verify that the economizer damper closes to its minimum position.
3.2	Verify that all applicable fans and dampers operate as intended to maintain building pressure.
3.3	Verify that the unit heating is disabled (if unit has heating capability).
4.0	If unit has heating capability, simulate a heating demand and set economizer system so that it is capable of operating (i.e., actual outdoor air conditions are below lockout setpoint). Maintain this status for all of Step 4.
4.1	Verify that the economizer damper is at minimum position.
4.2	Verify that the return air damper opens.
5	Turn off the unit and verify that the economizer damper closes completely.
6	Restore demand control ventilation systems, if applicable, and remove all system overrides initiated.
7	Record "Pass" if functional test complies with all requirements. Record "Fail" if functional test does not comply with all requirements.

Report if the economizer was fully functional and configured correctly both as you found it and as you left it. Restoring proper functioning of economizers is critical to reducing cooling energy use in classrooms and should be a priority for contingency funds when repairs that exceed the assessment/adjustment budget are needed.

4.3. Demand Controlled Ventilation

- Check if the system is configured to use demand control ventilation. If yes, continue the form.

- Configure and report the carbon dioxide setpoint. The "setpoint" can vary based on the controller configuration but is generally 1,000 ppm (or 600 ppm above outdoor CO_2 concentration) for true setpoint controllers and is 800 ppm or lower for activation limits.
- Perform functional testing of demand control ventilation which includes the following:

Step	DCV Functional Test
1	Disable economizer controls.
2.0	Simulate a signal for the DCV at the CO_2 sensor slightly above the CO_2 concentration setpoint and Verify either Steps 2.1 or 2.2.
2.1 or	For single zone units, verify that the outdoor air damper modulates open to satisfy the total ventilation air called for.
2.2	For multiple zone units, verify that the zone damper (or outdoor air damper when applicable) modulates open to satisfy the zone ventilation requirements.
3.0	Simulate a signal for the CO_2 sensor well below the CO_2 concentration setpoint. Verify either Steps 3.1 or 3.2.
3.1 or	For single zone units, verify that the outdoor air damper modulates to the design minimum value.
3.2	For multiple zone units, verify that the zone damper (or outdoor air damper when applicable) modulates to satisfy the reduced zone ventilation requirements.
4	Restore economizer controls and remove all system overrides initiated during the test.
5	With all controls restored, apply CO2 calibration gas at a concentration slightly above the setpoint to the CO2 sensor. Verify that the outdoor air damper modulates open to satisfy the total ventilation air called for.
6	Record "Pass" if the Functional Test complies with all requirements in Steps 1-5.

- Report if DCV system was fully functional and configured correctly both as you found it and as you left it.

4.4. Minor Repairs and Adjustments

- Document any adjustments or minor repairs that were made to the economizer and/or DCV system.

4.5. Remaining Deficiencies

- Document any deficiencies that remain with the economizer and/or DCV system after all the work is completed.

4.6. Remaining Deficiencies Notes

- If deficiencies remain in the economizer and/or DCV system, describe and

provide notes to inform future repairs and/or replacements.
    - Lack of access to the building, rooftop, or control system is not an acceptable reason to leave the system with a deficiency.
5. Operational Controls
    5.1. Operational Controls
        - Report the control system type and system heating and cooling setpoints.
        - Configure the control system to operate the supply air fan for ventilation and filtration 1 hour prior to and during scheduled occupancy. Occupants should not be able to override the fan to off. Report the ventilation start time and end time for a typical occupied day.
    5.2. Minor Repairs and Adjustments
        - Document any minor repairs and adjustments that were made to the system for operational controls.
    5.3. Remaining Deficiencies
        - Document any operational controls deficiencies that remain in the system
    5.4. Remaining Deficiencies Notes
        - If deficiencies remaining, describe and provide notes to inform future repairs and/or replacements.
        - Lack of access to the building, rooftop, or control system is not an acceptable reason to leave the system with a deficiency.
6. General Maintenance
    6.1. General Maintenance
        - Perform basic maintenance including measuring and reporting the air temperature splits for heating and cooling. Where needed and where possible within the budget, cap service ports with gasketed gaps to prevent refrigerant leaks, clean coils, and inspect and repair condensate drainage systems.
    6.2. Minor Repairs and Adjustments
        - Document any minor repairs and adjustments that were made to the system in the general maintenance category.
    6.3. Remaining Deficiencies
        - Document any general maintenance deficiencies that remain in the system
    6.4. Remaining Deficiencies Notes
        - If deficiencies remaining, describe and provide notes to inform future repairs and/or replacements.
        - Lack of access to the building, rooftop, or control system is not an acceptable reason to leave the system with a deficiency.