Garage Ventilation Stakeholder Meeting 3

California Statewide Utility Codes and Standards Program

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ASHRAE 8 – Garage Ventilation

2010 CMC

403.8.2 Alternative Exhaust Ventilation for Enclosed Parking Garages. Mechanical ventilation systems used for enclosed parking garages shall be permitted to operate intermittently where the system is arranged to operate automatically upon detection of vehicle operation or the presence of occupants by approved automatic detection devices.

403.8.2.1 Minimum Exhaust Rate. Ventilation systems shall be capable of providing 14,000 cfm (6608 L/s) of exhaust air for each operating vehicle. Number of operating vehicles shall be determined based on 2.5 percent of all parking spaces (and not less than one vehicle).

403.8.2.2 Automatic Carbon Monoxide Sensing Devices. Automatic carbon monoxide sensing devices may be employed to modulate the ventilation system to maintain a maximum average concentration of carbon monoxide of 50 parts per million during any eight-hour period, with a maximum concentration not greater than 200 parts per million for a period not exceeding one hour. Automatic carbon monoxide sensing devices employed to modulate parking garage ventilation systems shall be approved pursuant to the requirements in Section 302.1.

Proposed Code Change – Title 24

Enclosed Parking Garages. Mechanical ventilation systems for enclosed parking garages where the total design exhaust rate for the garage is greater than or equal to 10,000 cfm shall conform to all of the following:

1. Automatically detect contaminant levels and stage fans or modulate fan airflow rates to 50% or less of design capacity provided acceptable contaminant levels are maintained
2. Have controls and/or devices that will result in fan motor demand of no more than 30 percent of design wattage at 50% of design airflow
3. CO shall be monitored with at least one sensor per 5,000 ft2, with the sensor located in the highest expected concentration locations, with at least two sensors per proximity zone. A proximity zone is defined as an area that is isolated from other areas either by floor or other impenetrable obstruction.
4. CO concentration at all sensors is maintained ≤ 25 ppm at all times.
5. The ventilation rate shall be at least 0.15 cfm/ft2 when the garage is scheduled to be occupied.
6. The system shall maintain the garage at negative or neutral pressure relative to other occupiable spaces when the garage is scheduled to be occupied.

Proposed Code Change – Title 24

7. CO sensors shall be:

1. Certified by the manufacturer to be accurate within plus or minus 5% of measurement.
2. Factory calibrated.
3. Certified by the manufacturer to drift no more than 5% per year.
4. Certified by the manufacturer to require calibration no more frequently than once a year.
5. Monitored by a control system. The system shall have logic that automatically checks for sensor failure by the following means. Upon detection of a failure, the system shall reset to design ventilation rates and transmit an alarm to the facility operators.
   a. If any sensor has not been calibrated according to the manufacturer's recommendations within the specified calibration period, the sensor has failed.
   b. During unoccupied periods the systems compares the readings of all sensors. If any sensor is more than 30% above or below the average reading for a period of longer than 4 hours, the sensor has failed.
   c. During occupied periods the system compares the readings of sensors in the same proximity zone. If any sensor in a proximity zone is more than 30% above or below the average reading for a period of longer than 4 hours, the sensor has failed.

Exception: Any garage, or portion of a garage, where more than 20% of the vehicles expected to be stored have nongasoline combustion engines.

Other Energy Codes

- Oregon Energy Code (goes into effect July 2011)
  - Requires CO control for garages > 30,000 design cfm
  - Control CO to < 50 ppm during any 8-hour period, < 200 ppm for a period not exceeding 1 hour
  - System must be capable of ventilating at 1.5 cfm/sqft
  - Failure of devices causes the exhaust fans to operate in the ON position
    - No criteria about what qualifies as a failure
- Washington Energy Code (2009)
  - Requires CO control, time clocks, and occupancy sensors for garages > 8,000 design cfm
  - Control CO to < 35 ppm. Spacing and location of sensors per manufacturer's recommendations
  - For garages with >20% nongasoline vehicles, fuel-appropriate sensors are required. Concentration level setpoint must be no less than the standard used by OSHA for 8-hour exposure

Typical Practice

- Most new garages have DCV with CO
  - Generally sold with a maintenance program
  - Some sensors turn themselves off after 2 years if not calibrated
- Many existing garages are constant volume
  - Many of these have arbitrary fan schedules
    - e.g. fans operate from 7am to 9am and from 4pm to 6pm
  - Note that when garage fans are turned off stack effect sucks garage air into the building above

Findings

- Sensor Accuracy
  - CO sensors use electrochemical and solid state sensors that have been used in critical life safety and industrial applications for over 60 years (e.g. mines)
  - Not same technology as CO_2 sensors
  - Recent studies:
    - 26 sensors in garages showed ~5% drift/yr after 2 years
    - Taylor Engineering study shown later
  - UL conducted a study on residential sensors over a period of four years. Overall they found the sensors to be very reliable (residential sensors must meet UL Std 2034)
  - Garages use an array of sensors and control to the highest signal so failure of a single sensor has little risk

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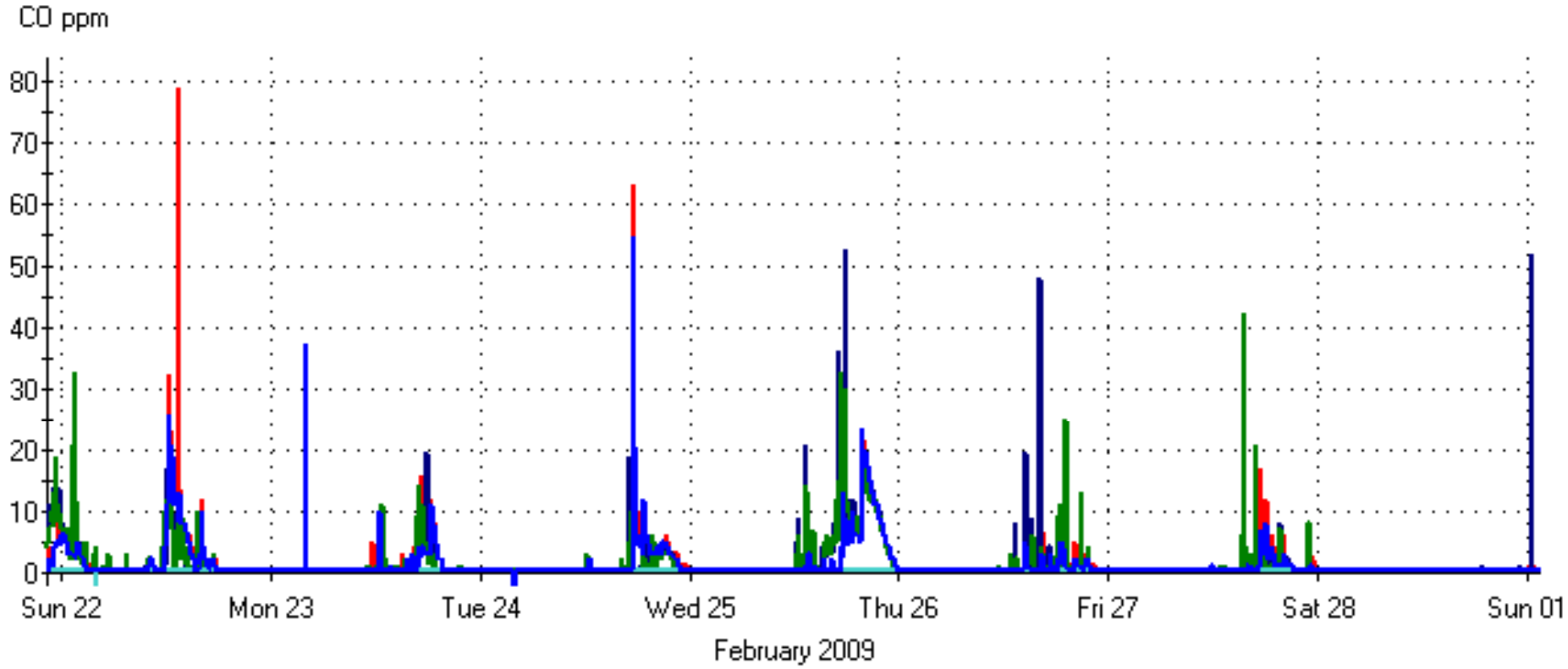
Estimated Energy Savings

- Energy savings based on trend reviews of actual garages with CO monitoring systems



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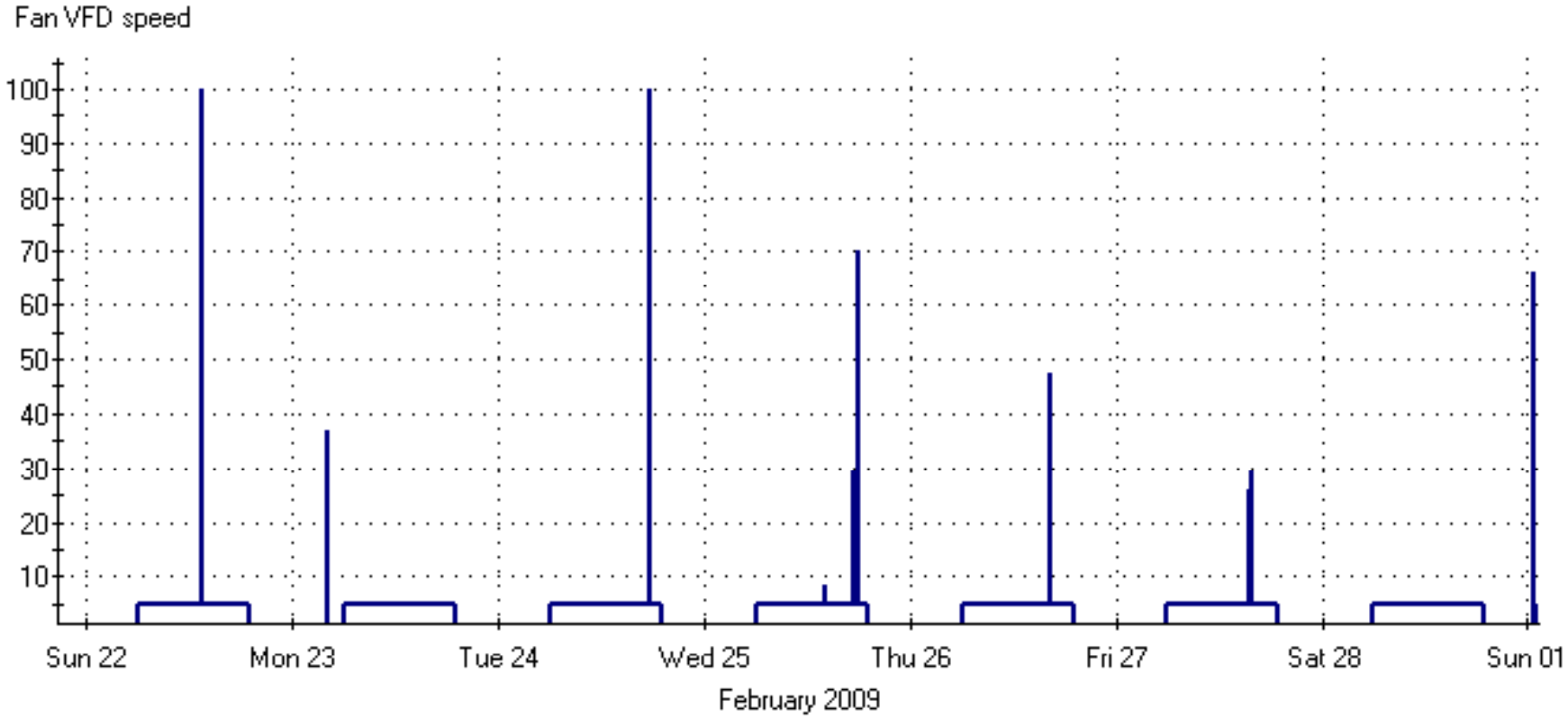
Estimated Energy Savings

- Trend reviews done on two garages with systems installed.
- Result: 80 – 90% fan energy savings



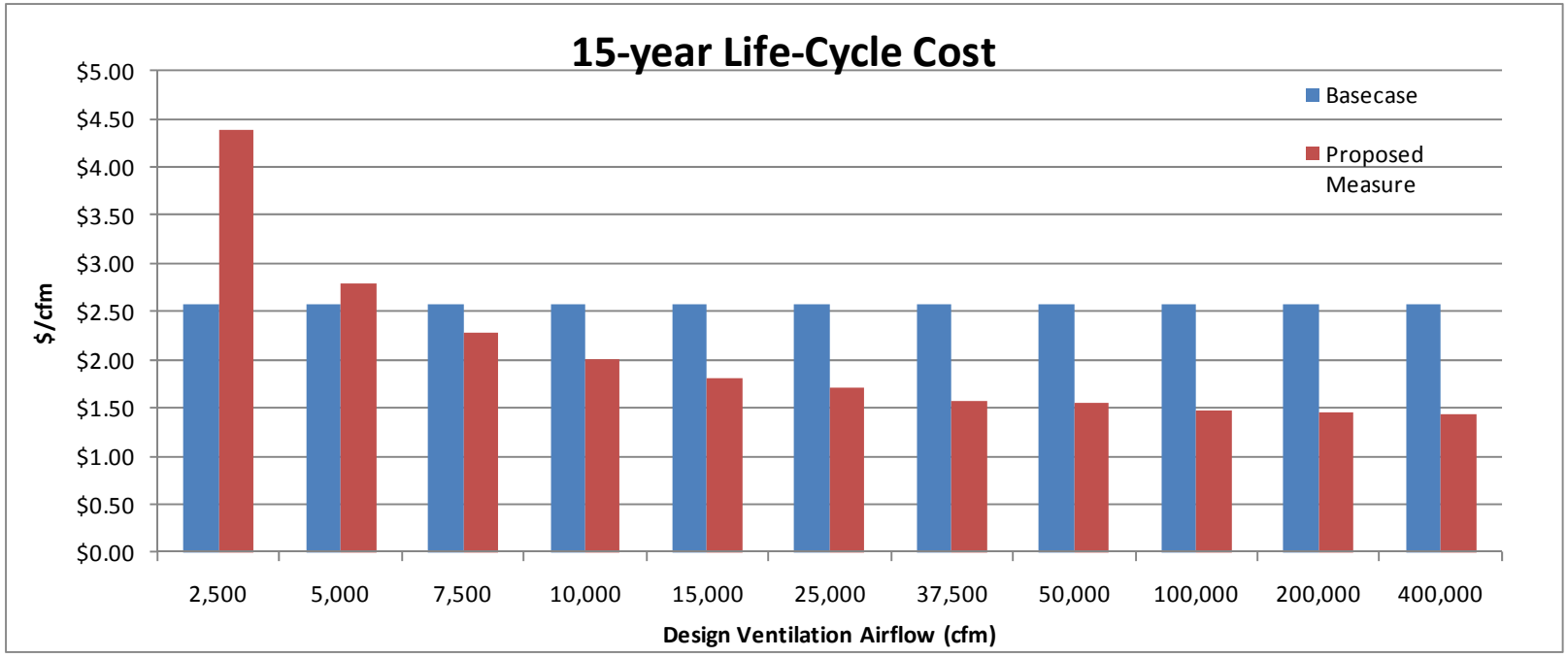
Estimated Cost

- Product, installation, and maintenance costs from manufacturers (with markup)

Product Costs		
CO sensor	$250	$/CO sensor
Controller (<32 sensors)	$3,000	$/controller
Controller (> 32 sensors)	$4,000	$/controller
VFD	$2,568	$/VFD (assume 1 per 10,000 cfm)
Installation costs		
Total sensor installation	$1,200	$/sensor for system installation
VFD	$545	$/VFD (assume 1 per 10,000 cfm)
Maintenance costs		
Replace CO sensor	$50	$/sensor/year
Labor to calibrate CO sensor	$50	$/sensor/year
Materials for CO calibration	$38	average

Cost Effectiveness

- Calculated for CZ03
- Cost-effective for all garages greater than 6,000 cfm (15-year life).



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CO Sensor Field Study

- Testing sensors already installed in garages to see how they perform at various CO concentration levels.
- Garage 1: 5/5 sensors failed

	0 ppm		35 ppm		50 ppm		100 ppm		200 ppm		
	volts	ppm	volts	ppm	volts	ppm	volts	ppm	volts	ppm	Conclusion
Sensor 1	0.45	9	2.29	45.8	1.2 - 0	-	0.99 - 0	-	0.6 - 0	-	failed
Sensor 2	0.39	7.8	0.24	4.8	0.24	4.8	0.23	4.6	0.23	4.6	failed
Sensor 3	0.44	8.8	0.24	4.8	0.24	4.8	0.24	4.8	0.25	5	failed
Sensor 4	0.49	9.8	2.28	45.6	2.29	45.8	2.29	45.8	2.29	45.8	failed
Sensor 5	0.42	8.4	0.23	4.6	0.23	4.6	0.23	4.6	0.23	4.6	failed

- Garage 2: 4/5 sensors failed

	0 ppm		35 ppm		50 ppm		100 ppm		200 ppm		
	volts	ppm	volts	ppm	volts	ppm	volts	ppm	volts	ppm	Conclusion
Sensor 1	0.98	0.63	0.98	1	0.98	1	0.98	1	0.98	1	failed
Sensor 2	0.98	0.62	2.33	85	2.67	106	3.02	128	3.28	144	operating but out of calibration
Sensor 3	0.98	0.00	0.98	0	0.98	0	0.98	0	0.98	0	failed
Sensor 4	0.99	0.00	0.99	0	0.99	0	0.99	0	0.99	0	failed
Sensor 5	0.98	0.00	0.98	0	0.98	0	0.98	0	0.98	0	failed

CO Sensor Field Study

- Garage 3: 5/5 sensors performing well

	0 ppm	35 ppm		50 ppm		100 ppm		200 ppm	
	ppm	measured ppm	% Diff of Full Scale	measured ppm	% Diff of Full Scale	measured ppm	% Diff of Full Scale	measured ppm	% Diff of Full Scale
Sensor 1	0	31	-2%	49	0%	104	2%	200	0%
Sensor 2	0	30	-2%	46	-2%	102	1%	210	4%
Sensor 3	0	33	-1%	47	-1%	250	60%	248	19%
Sensor 4	0	35	0%	53	1%	114	6%	206	2%
Sensor 5	0	40	2%	62	5%	139	16%	241	16%

  - All sensors are responsive. The readings that are more than a few % off are reading too high (err on the side of safety).

Acceptance Tests

- With all sensors active and all sensors reading below 25 ppm, observe that fans are at minimum speed and fan motor demand is no more than 30 percent of design wattage
- Apply CO span gas with a concentration of 30 ppm, and a concentration accuracy of +/- 2%, one by one to at least 50% of sensors or 10 sensors per garage and to at least one sensor per proximity zone.
- For each sensor observe that:
  - CO reading is between 25 and 35 ppm
  - Ventilation system ramps to full speed when span gas is applied
  - Ventilation system ramps to minimum speed when span gas is removed.
- Temporarily override the programmed sensor calibration/replacement period to 5 minutes. Wait 5 minutes and observe that fans ramp to full speed and an alarm is received by the facility operators. Restore calibration/replacement period.
- Temporarily place the system in unoccupied mode and override the programmed unoccupied sensor alarm differential from 30% for 4 hours to 1% for 5 minutes. Wait 5 minutes and observe that fans ramp to full speed and an alarm is received by the facility operators. Restore programming.
- Temporarily override the programmed occupied sensor proximity zone alarm differential from 30% for 4 hours to 1% for 5 minutes. Wait 5 minutes and observe that fans ramp to full speed and an alarm is received by the facility operators. Restore programming.

ACM Simulation Baseline

- Garage fan schedule follow building schedule
- If the proposed garage < 10,000 cfm or if the garage is expected to serve more than 20% diesel vehicles then basecase garage fan power = 0.35 W/cfm
  - based on 1.5" total static and 50% fan efficiency
- If proposed garage > 10,000 cfm and less than 20% diesel then basecase fan power is fixed at 0.044 W/cfm
  - based on 1.5" total static, 50% fan efficiency and an average fan speed of 50%

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QUESTIONS & COMMENTS

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