Industry Standard Practice Study
SCE-ISP-14-004
Revision 2

CO Demand Control Ventilation for Enclosed Parking Structures - VFD Airflow Modulation

Report

Presented by ASWB Engineering
To Southern California Edison Company

June 30, 2014

REVISION HISTORY

Revision #	MM/DD/YYYY	Author/Affiliation	Summary of Changes
1	06/30/2014	Scott Bailey/ASWB & David Wylie/ASWB & Salvador Heredia/ASWB	Original Draft Report

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Date: June 30, 2014

To: The SCE ISP Evaluation Team
Southern California Edison (SCE)

From: David Wylie, P.E., Scott Bailey, EIT, and Salvador Heredia, EIT
ASWB Engineering

Re: Investigations of Industry Standard Practice (ISP)
[SCE-ISP-14-004 CO Demand Control Ventilation for Enclosed Parking Structures - VFD Airflow Modulation]

After reviewing the project documents, expert opinions, and research, ASWB recommends that SCE consider Variable Frequency Drives (VFD) to be Industry Standard Practice for airflow modulation in CO Demand Control Ventilation systems used in enclosed parking structures for new construction projects.

THE PURPOSE OF ISP STUDIES (LOW-RIGOR)

The purpose of an Industry Standard Practice (ISP) study is to recommend the appropriate baseline for calculating the potential energy savings; it is not to assess the potential energy savings that a proposed custom measure can achieve when compared to the existing old equipment. The intent is to collect enough data to make informed decisions regarding SCE's incentive and rebate programs and to substantiate its energy savings claims for the Energy Division's impact evaluation studies. The methodology is not intended to provide statistically significant measurements of market penetration rates. (For further discussion, see "Addendum: About ISP Studies" at the end of this report.)

PROJECT DISCUSSION

In enclosed parking structures, the operation of gasoline and diesel powered vehicles can result in the buildup of hazardous carbon monoxide (CO) gas within the structure. Given the toxic effects of CO gas, exposure to occupants must be limited. Therefore, institutions, societies, organizations and government agencies charged with human safety and building standards have established codes and regulations that address the maximum levels of CO concentration and prescribe the elimination of CO gas in enclosed parking structures.

A CO Demand Control Ventilation (DCV) system for enclosed parking structures is a ventilation system that provides for the automatic venting of CO gas to acceptable levels by modulating airflow between the interior and exterior via fans based on CO concentrations. A key component of such systems is the carbon monoxide sensor which, when strategically placed in the parking structure, will sense the parts per million concentration of carbon monoxide in the air that the occupants are exposed to. When CO concentrations are above acceptable levels, the CO Demand Control Ventilation system will increase the flow rate resulting in reduced CO concentrations.

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METHODOLOGY

ASWB Engineering analyzed the documentation that is associated with this ISP study. The documentation stated that although previous studies indicate that "most new enclosed parking garages are already being designed with CO-monitoring systems," they do not specify the type of airflow modulation that is typical for these CO sensing-based ventilation systems. Research into CO DCV technology for enclosed parking structures revealed that airflow modulation can be achieved by various technologies, specifically fan cycling, 2-speed motors and VFDs. However, CPUC staff has indicated that airflow modulation via Variable Frequency Drives (VFDs) is the most economic and practical method and should be considered ISP. The goal of this study is to establish the Industry Standard Practice (ISP) for the technology used to modulate airflow in CO DCV systems for new enclosed parking structures.

Codes and Regulations

ASWB researched relevant codes, standards and regulations, both at the state and federal levels, to determine if there are any mandated requirements for CO gas mitigation in enclosed parking structures.

Title 24, which establishes the energy efficiency standards for residential and nonresidential buildings in California, has mandatory requirements for enclosed parking structures in Section 120.6(c) (see appendix). Section 120.6(c) mandates that enclosed parking structures with a design exhaust rate greater than or equal to 10,000 cfm shall have controls which detect CO concentrations and that automatically stage fans or modulate fan airflow rates to maintain CO concentrations at acceptable levels. It should be noted that although Title 24 establishes ventilation requirements, it does not specify the technology required to modulate airflow.

Subject Matter Expert Interviews

ASWB conducted interviews with equipment manufacturers, CO DCV system installation contractors and industry experts to determine the ISP for airflow modulation in CO DCV systems for enclosed parking garages as it applies to new construction.

ASWB contacted a national manufacturer who primarily supplies CO sensors for CO DCV systems in the southern California territory. The manufacturer stated that it observed that for new construction, CO DCV systems implementers were specifying VFDs to modulate airflow. This manufacturer would not release the any sales data due to the proprietary nature of the information.

ASWB contacted a contractor who installs CO DCV systems in the Los Angeles area. The contractor stated that they were only installing VFDs to modulate airflow on all new projects. They also stated that incentives, although available, were not a consideration when selecting VFD technology since they did not request incentive funding for their projects. This contractor claimed that they typically install about 75 CO DCV systems annually.

ASWB contacted a two parking structure designers located in the Los Angeles area. Both designers stated that enclosed parking structures were being designed with CO DCV systems that utilize VFD technology.

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Summation of Factors For and Against Industry Standard Practice

The collected information, expert opinions and other relevant information have been compiled and presented in tabulated form. Table 1 lists the factors that indicate that VFDs are ISP for airflow modulation in CO DCV systems for new construction of enclosed parking structures.

Table 1: Factors Determining that it is ISP to Modulate Airflow in CO DCV Systems for with VFDs

Factors Indicating Industry Standard Practice	Significance (1 – 3) 1=low, 3=high	Significance Explanation
Equipment suppliers and installation contractors state all CO DCV systems for new construction utilize VFDs.	3	Suppliers and contractors recommend VFD technology due to long term energy savings and extended equipment life.
CO DCV systems utilizing VFDs for airflow modulation provide energy savings because they allow greater speed variability.	3	Fans are more energy efficient when operated at less than design capacity due to fan affinity laws.
VFDs provide greater energy efficiency over 2-speed drives.	3	VFDs prove to be more energy efficient when motors operate at partial load.
CO DCV systems utilizing VFDs decrease operating and maintenance costs.	2	Reduced operation times and speeds increase equipment service life and maintenance intervals.

Table 2 lists the factors that indicate that VFDs are not ISP for airflow modulation in CO DCV systems for new construction of enclosed parking structures.

Table 2: Factors Determining that it is NOT ISP to Modulate Airflow in CO DCV Systems with VFDs

Factors Indicating Industry Standard Practice	Significance (1 – 3) 1=low,3=high	Significance Explanation
Fan cycling and 2-speed drives are still viable options for CO DCV systems.	1	Consultants highly recommend VFDs for their adjustable speed capabilities to better match variable airflow requirements.
Title 24 (2013) does not specify any particular technology to modulate airflow.	1	Fan cycling and 2-speed motors are options to modulate airflow, however, implementers are utilizing VFDs on new construction.
Utilizing VFDs with CO DCV systems incurs higher capital cost	1	VFDs offset initial capital costs with long term energy savings and reduced operation and maintenance costs.
Equipment suppliers and installation contractors indicate that incentives are not a factor in specifying VFDs.	1	Suppliers and Contractors base their recommendation of VFDS primarily on energy savings.

The factors in Table 1, which indicate that Variable Frequency Drives for airflow modulation are ISP, outweigh the factors in Table 2, which indicate that Variable Frequency Drives for airflow modulation are not ISP; 11 over 4 respectively. Equipment suppliers and installation contractors observe that the primary consideration driving the use of VFD technology in CO DCV systems is the significant energy savings that VFDs provides.

CONCLUSIONS

Based on the collected information, expert opinions and other relevant information compiled for this study, ASWB recommends that SCE consider Variable Frequency Drives (VFD) to be Industry Standard Practice for airflow modulation in CO Demand Control Ventilation systems used in enclosed parking structures for new construction projects. Although other technologies are available to modulate airflow, equipment suppliers and installation contractors indicate that VFDs are always used to modulate airflow in CO Demand Control Ventilation systems for new construction projects.

Table 3: ISP for New Construction

Installation Type	Recommended to be considered ISP	Explanation
New	Yes	Equipment suppliers, installation contractors and parking structure designers are in complete agreement that VFD technology is the standard practice for CO Demand Control Ventilation Systems

ADDENDUM: ABOUT ISP STUDIES

Among the measures submitted for customized rebates, occasionally there is a proposed energy saving measure (ESM) that is currently commercially available, however the equipment does not have a level of efficiency prescribed by the California's Building Energy Efficiency Standards (Title 24). So there may be a question about the baseline from which to calculate energy savings. Most often, the appropriate baseline is existing old equipment, but the baseline could be some other level of efficiency, including the possibility that the installation of the proposed ESM has become the "industry standard practice" for that market or that application.

The baseline question needs to be answered expeditiously in order to minimize the risk to ratepayers that the program might offer incentive payments for the wrong level of energy savings. And while a full-fledged market penetration study might greatly reduce our uncertainty, these one-off customized measures usually do not warrant a longer, expensive study for this limited purpose.

Instead, SCE conducts low-rigor ISP studies which are brief targeted market penetration studies. The findings are based on the collection of data on key factors (e.g., the existence of applicable alternative equipment) in targeted markets and geographic areas. The findings are also based on short interviews with market actors who are familiar with the technology and who can be expected to know something about the ESM installation rates (e.g., equipment manufacturers, distributors, installers, repairers, and major users).

In summary, the purpose of this ISP study is not to assess the potential energy savings that an ESM can achieve when compared to the existing old equipment. Rather, the purpose is to recommend the appropriate baseline for calculating the potential energy savings. The methodology (sample sizes, number of markets covered, etc.) is not intended to provide statistically significant measurements of market penetration rates. The intent is to collect enough data to make informed decisions regarding SCE's incentive and rebate programs and to substantiate its energy savings claims for the Energy Division's impact evaluation studies.

APPENDIX - TITLE 24 CODE

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

(c) **Mandatory Requirements for 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 percent 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 percent of design airflow.
3. CO shall be monitored with at least one sensor per 5,000 ft^2, 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 at 25 ppm or less at all times.
5. The ventilation rate shall be at least 0.15 cfm/ft^2 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.
7. CO sensors shall be:
   A. Certified by the manufacturer to be accurate within plus or minus 5 percent of measurement.
   B. Factory calibrated.
   C. Certified by the manufacturer to drift no more than 5 percent per year.
   D. Certified by the manufacturer to require calibration no more frequently than once a year.
   E. 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.
      i. If any sensor has not been calibrated according to the manufacturer's recommendations within the specified calibration period, the sensor has failed.
      ii. During unoccupied periods the system compares the readings of all sensors, e.g. if any sensor is more than 15 ppm above or below the average of all sensors for longer than 4 hours, the sensor has failed.
      iii. During occupied periods the system compares the readings of sensors in the same proximity zone, e.g. if the 30 minute rolling average for any sensor in a proximity zone is more than 15 ppm above or below the 30 minute rolling average for other sensor(s) in that proximity zone, the sensor has failed.