Car Park Ventilation System

Based on

Monitoring of
Carbon Monoxide (CO)

(Temperature)

(Carbon Dioxide CO_2)

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CARPARK VENTILATION SYSTEM
WITH CARBON MONOXIDE (CO) MONITORING AND CONTROL

QUESTION (Q) & ANSWER (A)

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<tr><td rowspan="2">Q1</td><td>Why CO monitor and control system?</td></tr>
<tr><td>Mainly for energy conservation/ energy saving.

Potential energy saving depends on the car park usage, control strategy, control setting and types of vehicles/ engines (majority) entering/ leaving the car park.</td></tr>
<tr><td rowspan="2">Q2</td><td>What is the coverage of the sensor?</td></tr>
<tr><td>The CO system design is based on the guideline by CP13-1999 (Singapore) and with reference to Australian Standard 1668.2-1991.

Considerations:
1. Maximum distance of any corner in the car park to the nearest sensor shall be less than 25m.
2. First 12m from fresh air opening are considered as natural ventilation (NV) zone.
3. Sensors are grouped according to the zones by the exhaust fans.</td></tr>
<tr><td rowspan="2">Q3</td><td>How to determine number of sensing points required?</td></tr>
<tr><td>The number of sensing points is calculated using the guidelines of AS1668.2 with the considerations given above.

N = A /1000 x SQRT (L/W)

Where N = no. of sensing points
A : Area of car park in sq meters
L : Length of car park in meters
W : Width of car park in meters
SQRT = square root</td></tr>
<tr><td rowspan="2">Q4</td><td>Where to place the sensor?</td></tr>
<tr><td>Sensor shall be installed at 0.9m ~ 1.8m above floor level (AS1668.2). However, for practical reason (in order to avoid vandalism), the sensors can be installed just above 1.8m.</td></tr>
<tr><td rowspan="2">Q5</td><td>What type of mounting : duct mounted or wall mounted?</td></tr>
<tr><td>Please read attached Space vs Duct Installations.</td></tr>
<tr><td rowspan="2">Q6</td><td>How to carry out testing & commissioning?</td></tr>
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Q7	**Product country of origin?**
	CO/CO2 combinational sensors – Sweden CO sensor/controller - Singapore
Q8	**What are the minimum requirements of a typical CO sensor?**
	Sensor shall have: 1. Minimum measuring range : 0 ~ 50 ppm or 0 ~ 100 ppm 2. Accuracy : +/- 10% or less
9	**What are the different types of control strategy?**
	1. ON/OFF control The pairs of exhaust & supply fans can be controlled with the following control set-points: 1^{st} stage : Fans switched ON when CO is above 9ppm (CP13-1999, residential) Fans switched OFF again when CO drops below 6ppm 2^{nd} stage: Fans switched ON when CO is above 25ppm (CP13-1999, residential) Fans switched OFF again when CO drops below 20ppm If only single stage fans available, the fans shall be controlled at 25ppm. Whereas more than one sensor are to control a fan, the worst case of the sensors' reading shall be used for control purpose. **2. Variable Frequency Drive (VFD)/ Variable Speed Drive (VSD) Control** a. Control ventilation at minimum ventilation rate, say 20Hz, when CO measurement is below 20ppm. b. Ventilation rate shall increase proportionally when CO level increase beyond 20ppm and reach the maximum when CO level is above 50ppm. c. Periodic higher ventilation shall be built-in to the VFD system from the BMS. Provisions : a. Timer override - The car park ventilation may include timer over ride for periodic peak car park usage, for instance, morning and evening rush hours. b. Manual override - The car park should also include manual override. c. Temperature override – in case of high temperature, the ventilation may be activated so as to create "wind" effect and improve the comfort. **Note : Control of 1^{st} or 2^{nd} stage fans are only applicable in Normal Mode (NM) operation.**

Q10	**What is the pay back period?**
	Pay back period varies from 9 to 24 months. Typical payback period is around 12 month.
Q11	**How to calculate energy saving?**
	Energy saving and simple payback:

Item	Unit	Quantity
Total Fan Wattage	KW	A
Operating hours (daily)	Hour	B
Nominal energy usage per day	KWH	A x B
Monthly energy usage	KWH	30 AB
Energy rate	Cents	0.1675 (low tension rate)
Monthly energy usage in $ & cents	$	0.1675 x 30 x A x B
Potential energy saving	%	
Monthly saving from CO system	$	
Capital Investment for CO system	$	
Simple payback	Year	

Q12	**What is the warranty period?**
	One year limited warranty against faulty parts & manufacturing defects.
Q13	**How many models of CO sensor does Telasia Symtonic have?**
	3 models : a. CO-M1 (old model, not recommended for new design) b. DCO-S1 c. DCO-S2 (available in mid 2005) d. aSENSE-mIII (integrated sensor, CO, CO2, Temp & RH)
Q14	**Other Considerations**
	In addition to CO controlled system, temperature and timer control should also be considered in controlling the car park environment.

Special Notes:

1. In case of fire, the Fire Mode (FM) ventilation shall override CO system.
2. In premises where diesel engines out number petrol engines, CO_2 sensors should be considered in place of CO sensors.

Testing & Commissioning Procedures
for
Carbon Monoxide (CO) Monitoring & Ventilation Control System

Introduction

The testing & commissioning (T&C) of carbon monoxide monitoring and ventilation control system can be separated into two parts, namely;

1. Sensor/detector verification

The sensor/detector verification is to ensure that the CO measurement or monitoring is within reasonable tolerance range and accuracy. This would allow the control system to perform ventilation based on the CO level in the enclosed car park.

2. System functional tests

The system functional test checks the system functional procedures based on the reading from the CO sensor/detector(s), that is, if the ventilation comes ON at pre-determined CO level.

Sensor/Detector verification

The sensor verification can be done by injecting known gas concentration into the (CO) sensor and to verify the reading accordingly [note 1]. Typically two gas concentrations would be required (purified air [note 2] and 100ppm CO gas). The purified air is used to zero the sensors while the 100ppm CO gas can be used to re-calibrate the sensor if necessary [note 3].

Note 1: ***sensor operation per manufacturer's recommendation, DCO-S1 requires minimum 24 hours operation prior to T&C.***
Note 2: ***fresh-air can be used in place of purified air, this can be re-confirmed with portable CO instruments. DCO-S1 checks the lowest CO reading over 24 hours period and use the lowest CO reading for long term drift adjustment (AZC- automatic zero calibration)***
Note 3: ***Re-calibration procedure per manufacturer's recommendation.***

System Functional Test

The system functional test will ensure that the CO ventilation control system responses according to the CO concentration in the car park. A simple approach is to inject CO gas into the sensor. This may be done together with sensor verification [note 4].

Note 4: ***The control of CO concentration at the sensor head can be difficult with CO gas. In order to ease the system tests, the baseline output from DCO-S1 allows easy system functional tests and debugging (consult Telasia Symtonic). After the system tests with sensor simulation, the sensor can be checked with CO gas to ensure proper response of the sensor and system.***

Sensor Setup and Maintenance of DCO-S1

The DCO-S1 is a microprocessor based digital carbon monoxide sensor/controller. It has some built-in features that allow easy installation and T & C.

1. Zeroing function and AZC (automatic zero calibration) function

   After proper installation and power up of DCO-S1, the unit displays the current CO and temperature readings. The "back-fill" effect of the sensor element tends to have higher CO reading after power up. This effect should wear off in 24 hours. Therefore, re-calibration should only be done at least 24 hours after power up.

   Alternatively, users can activate the zero function by pressing the "zero" button on the sensor board and force the reading to zero. By doing so, the sensor will continuously searching for the background and re-calibrate itself. A complete zeroing process takes around 7 days.

2. Automatic Baseline Correction

   During the continuous operation, the DCO-S1 records the lowest CO reading over a 24-hour period and does a self-adjustment every 24-hour. This is to counter act on the long-term zero drift of the sensor (if any).

With the built-in drift correction function, the sensor shall be maintenance free for 2 years. However, it is advised that a sensor check [note 5] shall be performed on the yearly basis. During the sensor checking, if the sensor reading has drifted away from the verification gas, the sensor shall be re-calibrated.

Note 5: The sensor can be check by injecting known CO gas into the sensor head. The sensor shall response with higher CO reading/output.

DCO-S1 Sensor Calibration

Calibration setup

The following equipment and gas mixtures are required for a full calibration of the DCO-S1 carbon monoxide sensor.

1. Gas bottles with single stage regulators
    a. Purified air gas (free of carbon monoxide)
    b. 90 ppm CO, balance in air, tolerance ±5%, certified value ± 2%
2. Gas flow meters (0 ~ 50cc per minute)
3. Tygon or PVC tubes for connections
4. Calibration cap for adaptation to the sensor head CAP07.
5. PC with user interface program (UIP-Wizard)
6. A232 cable

The calibration setup is shown in Figure 1.0

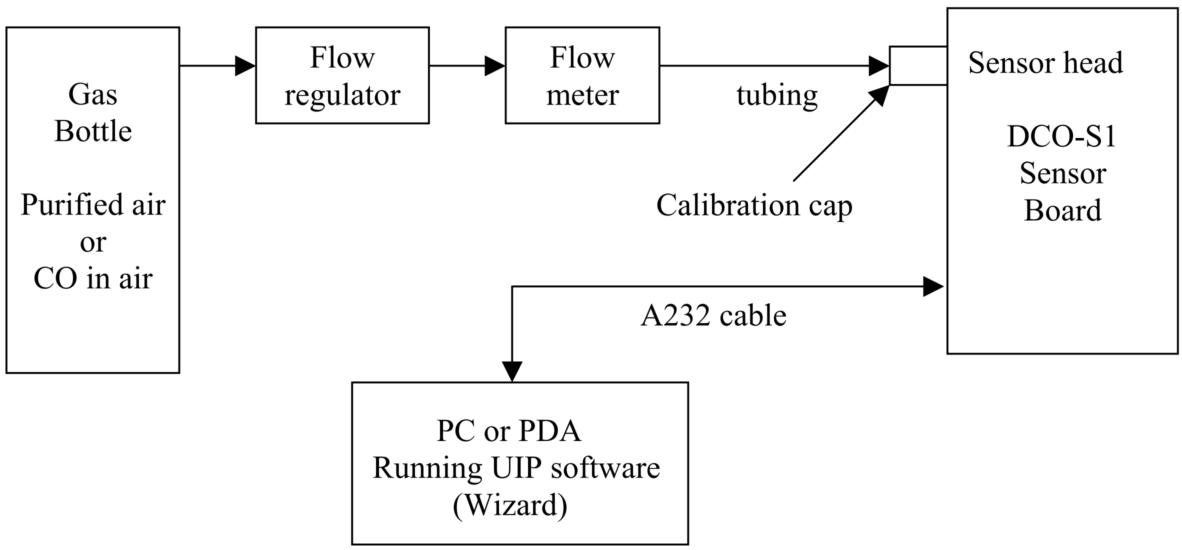

Figure 1: Calibration setup

Procedures

<u>Zero Point calibration</u>

1. Connect the calibration setup as shown in figure 1. Turn on the regulator of purified air bottle and allow purified air to flow into the calibration cap. Control the outlet gauge to approximately 10psi.
2. Adjust the air flow to 40 c.c. per minute using flow meter.
3. Allow the sensor to settle for at approximately 20 minutes.
4. Press zero button on PCB to zero OR initiate zeroing from the UIP via A232 connection to sensor
5. Turn off the regulator and remove the calibration cap from sensor head.

Span calibration

6. Connect the calibration setup as shown in figure 1. Turn on the regulator of CO gas mixture (90ppm CO, balance in air) and allow the gas mixture to flow into the calibration cap. Control the outlet gauge to approximately 10psi.
7. Adjust the air flow to 40 c.c. per minute using flow meter.
8. Allow the sensor to settle for approximately 20 minutes.
9. Key in span gas concentration in UIP and initiate Span calibration by clicking "SPAN"
10. Turn off the regulator and remove the calibration cap from sensor head. (see software manual).

Space vs Duct Installation

	Advantage	Disadvantage
In Duct Measurement	➢ More economical, less sensors required ➢ Straight forward control as one sensor controls one or two fans serving the same area	➢ May not provide adequate control if exhaust/supply fans serve a large area ➢ Measurement is an average reading that does not take care of the worst case situation ➢ Requires minimum air flow in the duct for the measurement
Space Measurement	➢ More representative of space condition ➔ more accurate control can be achieved ➢ Provision for complete switch-off of the fans (if allowed) when CO concentration is very low	➢ Higher cost up-front since sensors required ➢ More complicated in controls as the number of sensing points increases

The location and distribution of exhaust-air intakes and source of make-up air as well as airflow rates at each exhaust air intake shall be such that air passing across the queuing area is uniformly distributed for its full length.

4.7 AIR PRESSURE Air pressure in an enclosure ventilated by exhaust-air system shall comply with Clause 3.4.3.

4.8 REPLENISHMENT OF EXHAUST AIR Clause 3.5 shall apply generally for the replenishment of exhaust air. Where a supply ventilation system for replenishment of exhaust air is provided, it shall have a flow rate of not less than 75% and not more than 90% of the exhaust-airflow rate.

4.9 EXHAUST-AIR DISCHARGE Exhaust-air discharge shall be in accordance with Clause 3.7.

4.10 STAFF—VENTILATION RATE Where staff are employed in generally fixed areas within an enclosure, e.g. pay booth, outdoor air shall be provided to that area at a flow-rate that is at least the greater of—

(a) the flow rate specified in Section 2; and

(b) 5 L/s per square metre of the area.

4.11 LOCATION OF EXHAUSTS IN BELOW GROUND ENCLOSURES All enclosures having a floor level below that of the external natural ground level shall be served by a mechanical exhaust system and shall have between 30% and 50% of the required exhaust air drawn into exhaust-air intakes which have their bottom edges located within 100 mm of floor level. Low level intakes shall be arranged so that any blockage is clearly visible.

4.12 ENERGY SAVING Subject to the approval of the Regulatory Authority, the following energy-saving measures may be adopted:

(a) Where vehicles remain parked with all engines remaining unoperable for periods in excess of 2 h, the prescribed appropriate airflow rate may be halved during such periods.

(b) Automatic operation of systems at lower flow rates controlled by approved detection devices which continuously monitor the concentration of atmospheric contaminants in the enclosure in accordance with Clause 4.13.

4.13 MONITORING OF ATMOSPHERIC CONTAMINANTS

4.13.1 General Where the operation of mechanical ventilation is automatically controlled by approved atmospheric contaminant (AC) monitoring system(s), the air quantity required may be varied, subject to the requirements of this Clause. The atmospheric contaminant(s) to be monitored shall be approved.

NOTES:

1 This Clause specifies requirements where the critical AC is monitored.

2 The critical AC in an enclosure used solely by—

(a) petrol fuelled vehicles is CO; and

(b) diesel fuelled vehicles is NO_2.

3 An enclosure used by petrol-fuelled and diesel-fuelled vehicles should be monitored for CO and NO_2 unless the ratio of the different fuelled vehicles is less than 1:10. Where the ratio is greater than 1:10 response of the mechanical ventilation should be dictated by the higher signal of each monitoring system.

4 Requirements applicable to monitoring an AC as a comparator for another AC are not specified in this Clause.

5 Where an AC other than the critical AC is monitored, reliable air quality should demonstrably be achieved in any such controlled mechanical ventilation system.

4.13.2 System requirements An AC monitoring system installed to regulate mechanical ventilation serving a garage, parking station or other enclosure used for servicing or operation of motor vehicles shall—

(a) be provided with an approved analog or digital display;

(b) operate continuously and effectively whenever motor vehicles are present in the enclosure in accordance with Clause 4.13.3;

(c) under any fault condition automatically activate an alarm and operate the mechanical ventilation in the enclosure in accordance with Clause 4.13.6;

(d) be clearly marked to indicate servicing and calibration requirements in accordance with Clause 4.13.7; and

(e) analyse the air—

(i) at all sampling points continuously and simultaneously and automatically operate the mechanical ventilation system in accordance with Clauses 4.13.4.2; or

(ii) from all sampling points intermittently, at least twice every 4 min and automatically operate the mechanical ventilation in accordance with Clauses 4.13.4.1 and 4.13.4.2.

NOTE: This Standard permits AC monitoring systems which incorporate sampling and detection devices that analyse the air at sampling points and transmit signals to a central reporting station as well as AC monitoring systems which draw samples of air from sampling points to a central analyser which transmits signals to a central reporting station.

4.13.3 Operation and accuracy of AC monitors The monitoring system shall be selected to—

(a) operate 24 h per day or be automatically activated at such time as will ensure that it accurately analyzes and properly reacts to the first sample analysed after the premises are opened to receive vehicles, provided that the system operates continuously whenever motor vehicles are present in the enclosure; and

(b) measure the concentration of AC to within ±10% of—

(i) the exposure standard (ES) in the range between 10% and 120% of the ES; and

(ii) the full range deflection of the monitoring system (120% of the ES).

4.13.4 Analysis of AC and operation of mechanical ventilation

4.13.4.1 *Transportation of air to analyser* Where air samples are passed through tubing from the sampling point to the central analyser—

(a) one or more pumps shall draw air through sampling lines at a rate sufficient to ensure that transport lag time for air samples within any tube is less than 30s;

(b) the flow rate through each sampling point in the system and through the analyser shall not vary by more than ±10% of the design rate.

(c) flow meters shall be provided in the system to monitor flow rates.

(d) the operation shall ensure that any previous sample is flushed from the analyzing cell before analysis of the next sample commences.

4.13.4.2 *Response time of monitoring systems* When a system detects—

(a) an increase in AC above a set point, reaction of the system to the increase above the value calculated in accordance with Clause 4.13.4.3 shall be immediate after the increase has been sustained for 4 min or detected on consecutive analyses of the same sampling point for a period not longer than 4 min; or

(b) a decrease in AC below a set point, reaction of the system to the decrease below the value calculated in accordance with Clause 4.13.4.3 shall be delayed until the decrease has been sustained for at least 4 min or detected on consecutive analyses of the same sampling point for a period not shorter than 4 min.

4.13.4.3 *Set points* A mechanical ventilation system which is controlled by one or more AC monitoring system(s) shall, when the concentration of the approved AC in the enclosure is—

(a) 80% or more of the ES, operate at the full ventilation rate in accordance with Clause 4.13.4.4;

(b) 50% or less of the ES, operate at not less than the minimum ventilation rate in accordance with Clause 4.13.4.5; and

(c) between 50% and 80% of the ES, operate at a rate not less than determined by the following equation—

$$VR = MR + \left[\frac{(C - 0.5)}{0.3}\right] \times (FR - MR)$$

where

VR = ventilation rate, in litres per second

MR = minimum VR (see Clause 4.13.4.5)

FR = full VR (see Clause 4.13.4.4)

C = concentration of AC, in parts per million.

4.13.4.4 *Full ventilation rate (FR)* The full ventilation rate of a mechanical ventilation system shall be not less than that required by Clause 4.2 according to the enclosure being ventilated.

4.13.4.5 *Minimum ventilation rate (MR)* The minimum ventilation rate of a mechanical ventilation system shall be not less than 25 % of the full ventilation rate *(FR)* but, in any case, not less than 3000 L/s for each zone or level.

Operation of mechanical ventilation in an enclosure may be intermittent, subject to—

(a) Concentration(s) of approved AC dropping below 15% of the ES;

(b) response time specified in Clause 4.13.4.2(b); and

(c) availability of approved natural ventilation, adequate to control low concentrations of pollutants.

4.13.4.6 *Make-up air* Where required, make-up air for each zone or level shall be maintained in accordance with Clause 4.8 to suit minimum, maximum and all intermediate ventilation rates of the mechanical ventilation systems.

4.13.5 Sampling points

4.13.5.1 *Number required* The number of sampling points required for an enclosure shall be the greater of that determined by Clause 4.13.5.2 and the following equation—

$$N = \frac{A}{1000} \times \sqrt{\frac{L}{W}}$$

where

N = number of sampling points, rounded up to the nearest whole number

A = area of the enclosure, in square metres

L = the length or major dimension, in metres

W = the width or minor dimension, in metres.

4.13.5.2 *Distribution* Sampling points shall be distributed as evenly as possible in the enclosure so that no part of the enclosure is more than 25 m away from a sampling point for CO monitoring systems and 12.5 m for NO_2 monitoring systems.

NOTE: Regulatory Authority may also require a sampling in an area where people congregate, such as a waiting area for drivers or passengers of motor vehicles, which is not within a separate pressurized ventilated area.

4.13.5.3 *Location* Sampling points shall be located—

(a) between 900 mm and 1800 mm above the floor surface in positions which will allow samples to be fully representative of the local atmosphere;

(b) at least 100 mm clear of walls, columns and other vertical or near vertical surfaces, and not in positions significantly influenced by either make-up air or motor-vehicle exhaust emissions; and

(c) closer to exhaust inlets than make-up air outlets, and as far as is practicable, situated so that the distance from exhaust openings is 3/10 of the distance between make-up air and exhaust air openings.

4.13.5.4 *Enclosure area* Where the enclosure does not consist of one regular area, each more or less regular area shall be treated as one enclosure.

4.13.6 Monitor failure

4.13.6.1 *Failure detection* Every monitoring system shall include devices to detect and signal fault conditions, including erroneous response or non-response to atmospheric contaminants concentration, and loss of power to the system.

4.13.6.2 *Mode of operation in the event of a failure* On detection of a failure and until the failure is rectified—

(a) an alarm located in an approved position shall be automatically activated; and

(b) mechanical ventilation to all enclosures monitored by that system or the faulty component(s) of the system shall automatically operate at the full ventilation rate (FR).

4.13.7 Marking, commissioning, reliability and records In order to ensure the extended reliability of monitoring systems and the evidence of that reliability, Appendix M is supplied for guidance.

Project References (Local & Overseas)

Year	Country	Local Projects	Overseas
2001	Singapore	Carpark at Tan Tock Seng Hospital	
2002	Singapore	China Square Central	
	Singapore	3082 Invensys Building	
	Singapore	Sin Ming Autocare	
	Singapore	Tomlinson Condominium	
	Singapore	CIAS 3075 Cargo Agent B	
	Singapore	Eastlink Light Industrial Bldg	
	Singapore	AMT Building at Changi Business Hub	
	Singapore	Al-Iman Mosque at Bukit Panjang	
2003	Singapore	Hendon Camp	
	Singapore	Defence Medical Research Institute	
	Singapore	Temasek Tower	
	Singapore	Sin Ming Autocare	
	Singapore	NTUC Centre	
	Singapore	Mandai Camp CO system	
	Singapore	Sembawang Camp	
	Singapore	Kranji Camp	
	China		Beijing Children's Hospital
	China		Baiyun Airport
	China		Scientific Resource Building
	Australia		Carpark project
2004	Singapore	Carpark at KK Hospital	
	Singapore	ITE, Simei	
	Singapore	Carpark at Suntec	
	Singapore	Caltex House & Hitachi Tower	
	Singapore	Eureka Building	
	Singapore	Common Service Tunnnel,LTA	
	Singapore	Keat Hong Camp	
	Singapore	Mobile office	
	Singapore	Queenstown Multi-storey Carpark	
	Singapore	Infineon HQ	
	China		Fu Li City
	Hong Kong		HKIE'D
	Singapore	Montreal Park Condo	
	HongKong		Cathay Pacific City
2005	Singapore	Monterey Park Condominium	
	Singapore	National Library	
	Singapore	Bukit Panjang Community Club	
	Singapore	Vision Crest Condominium	
	Singapore	Draycotte Park Condominium	