Appendix C: Method Used by ARB to Determine Ozone Room Concentrations from IACD

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The test room was a small office approximately 8 ft. wide, 11 ft. long, and 8 ft. high (88 ft^2, volume of about 20 m^3), the size of a small bedroom or home office. The room is located in a warehouse building in Sacramento, California, about 1,000 meters from any major freeway or surface street. The room was furnished with an office desk made of hard wood and laminated composite wood, and one upholstered desk chair with a high back. The room had linoleum flooring, and painted wallboard construction for the walls and ceiling. A 6-foot fluorescent light fixture was mounted in the ceiling. The room had no air supply or return registers, and no large openings other than the door. All power cords and air sampling lines were run through an 8-inch hole in the door's center, which was sealed with duct tape. The adjoining warehouse space was conditioned, and its doors were kept closed during the tests in this study. Two adjoining bathrooms had automatic exhaust fans, which were turned off during the testing.

We selected a target range of 0.3-0.5 indoor-outdoor air changes per hour for the air exchange rate (AER) for the room tests. This range reflects common conditions for older single-family homes in California without open windows or mechanical ventilation in operation. Compared to newer homes in California, older single-family homes tend to have less airtight exterior shells, and they often have additional air exchange when the central heating or cooling system is operating because the system has substantial air leakage in its ductwork. This range does not reflect comparable "closed" conditions for new homes, which can have indoor-outdoor air exchange rates of 0.1 air changes per hour or less when closed up. Thus, the target AER range is realistic for California homes, and does not provide conditions that would result in an overestimation of ozone concentrations from the ozone generators tested.

In order to provide the target AER of about 0.3-0.5 air changes per hour, any suspected air leakage paths were sealed. The door frame was sealed with one-half inch wide, closed cell foam weather-stripping. In addition, two-inch wide duct tape was used to seal the edges of the door, the gap around the ceiling light fixture, and both horizontal edges and vertical gaps of the baseboard vinyl coving.

The AER of the test room was measured on three consecutive days prior to the start of the room tests. Once the ozone generator room tests began, the room AER was measured once a week. The room AER was measured using the single zone tracer gas decay method of ASTM Standard E741, with carbon dioxide (CO_2) gas as the tracer gas (Persily, 2000). CO_2 gas from a cylinder was injected into the room center with the door closed. CO_2 concentrations were measured inside the test room, and in the warehouse during the pre-tests, using a TSI QTrak Plus. Once the CO_2 concentration reached more than 3,000 ppm (usually much higher) in the test room, the CO_2 source was turned off. The decay of measured CO_2 concentration over time was used to calculate the dilution (by room ventilation) with "replacement" air using the empirical equation shown below. A decay period of 30 minutes was chosen to obtain an accurate measurement.

The initial and end concentrations of CO_2 were used to calculate the AER of the test room as follows, assuming no change in CO_2 concentrations in the adjoining space:

AER = Air exchange rate (number of air exchanges per hour, h^{-1})
= [ln C (t1) - ln C (t2)] / (t2 - t1) (Persily, 2000)

where:
ln = Natural log
C = Concentration (dimensionless)
t1 = Time at start of measurement period (hours in decimal fraction form)
t2 = Time at end of measurement period (hours in decimal fraction form)

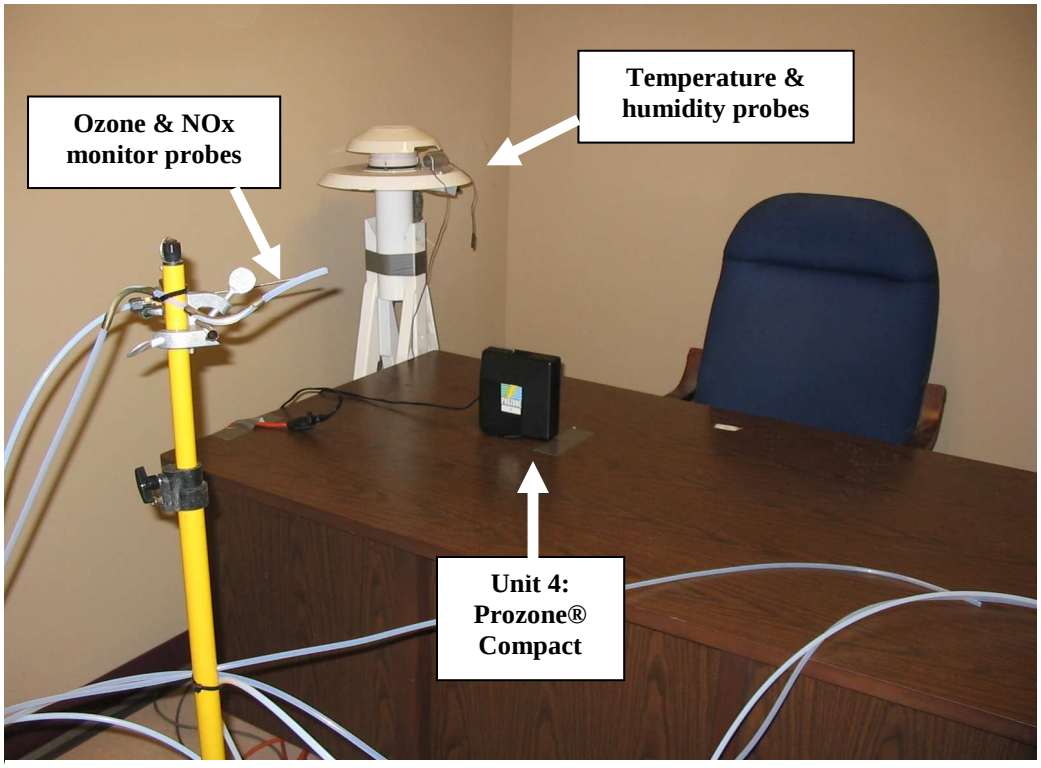
The results of the AER testing are shown in Table C-1. Both the initial AERs on the three days prior to the room tests of the ozone generators and the AERs measured during the test periods were stable – they ranged from 0.25 to 0.28 AER. The measured AERs during the test periods averaged 0.27 air changes per hour. This AER was slightly below our target level of 0.3-0.5 per hour. This method assumes no significant change in CO_2 concentrations in the adjoining space during the testing, and that the concurrent CO_2 concentrations were much less in the adjoining space than those utilized for the AER measurement. The adjoining space did not contain any combustion sources or other notable sources of CO_2, so levels were assumed to be near the average of 358 ppm measured in the warehouse during the pre-tests, a reasonably low amount relative to the room CO_2 concentrations, which ranged from about 2,900 ppm to 4,900 ppm.

Table C-1. Summary of Room Air Exchange Rate Tests

Date	**Room Test #**	**AER (air exchange rate; air changes per hour)**
6/23/05	Pre-test	0.27
6/24/05	Pre-test	0.25
6/27/05	Pre-test	0.28
Pretest Average		**0.27**
7/12/05	1L, 3L, 3LA, 3H, 4, 4D	0.28
7/25/05	1H, 2L, 2H	0.25
Test Average		**0.27**

Room tests were conducted during daytime hours on weekdays between July 5 and September 12, 2005. Prior to appliance testing, ozone concentrations were monitored in the test room and the adjacent warehouse open area for 30 minutes to characterize initial background conditions. At the completion of background ozone monitoring, appliance testing began. The appliance was placed in a central location in the room on top of a desk, 3 feet from the wall, at a height of approximately 2.5 feet off the floor. User instructions from the manufacturers were considered in selecting the location and settings for each appliance. The room-sampling probe for ozone was situated four feet above the floor to approximate the average “breathing zone height” for adults, and located ~3 feet from the device.

The appliance was remotely started at one of the pre-selected settings. For each test, the appliance was operated until ozone levels in the room reached steady-state (defined as a maintained constant ozone level of ± 5% for 30 minutes), or for 3 hours if steady-state was not achieved. After steady-state or 3 hours was reached, the appliance was turned off by remote switch, and the monitoring was continued until the room ozone level returned to ambient levels. In addition, the test room was monitored before and during the room tests for NO, NO_2, NO_x, room temperature (T), and relative humidity (RH). After each test period, room air was fully vented out of the building.



Test room set-up with Prozone® Compact