

Ozone Generation using the Total Zone TZ-2® for IAQ Remediation	INTERNATIONAL LABORATORY Services Division	NUMBER IH97300
	INDUSTRIAL HYGIENE GROUP Ozone Generation Procedure	REVISION Final Rev4
		DATE 02/06/12
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1.0 Purpose/Scope

This procedure provides a standardized method for the operation of the *International Ozone Total Zone® TZ-2* ozone generator. It should be used in conjunction with the SBMS Subject Area Indoor air quality and IH SOP IH97200 *Indoor Air Quality Investigations*.

International Ozone Total Zone ozone generator TZ-2 model uses corona discharge technology known as "SP-ARC \ddot{o} " (Silicate Polarized Arc) to produce 3000 mg per hour of ozone with an output of 100 cfm. The system has a 12 hour timer and is thus capable of delivering 72,000 cubic feet exchange of room air in one timer setting. This capacity far exceeds the needs of the average room, so care must be used in setting the timer appropriately to the size of the room. Because ozone is hazardous by inhalation, this equipment is only to be used in un-occupied areas under the direction of a professional Industrial Hygienist.

2.0 Responsibilities

- 2.1 Use of the TZ-2 Ozone generator is limited to persons who act under the direction of a competent hazard assessment person and have demonstrated the competency to satisfactorily use the equipment, as evidenced by experience and training, to the satisfaction of the Industrial Hygiene Manager or IAQ Program Administrator and met the qualification criteria set in Section 7.



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2.2 Personnel that perform remediation with this instrument are responsible to follow all steps in this procedure.

3.0 Definitions

Ozone: a molecule composed of three atoms of oxygen. Two atoms of oxygen form the basic oxygen molecule. The third oxygen atom can detach from the ozone molecule, and attach to molecules of other substances, thereby altering their chemical composition. It is this ability to react with other substances that forms the basis of purification by ozone treatment.

4.0 Prerequisites

4.1 Training prior to using this ozone generator:

- 4.1.1 Demonstration of proper operation of the instrument as defined in Section 7.
- 4.1.2 Other appropriate training for the area to be entered (check with ESH coordinator or FS Representative for the facility).

4.2 Area Access:

- 4.2.1 Contact the appropriate Facility Support Representative or Technician to obtain approval to enter radiological areas.
- 4.2.2 Verify with the appropriate Facility Support Representative or Technician if a Work Permit or Radiological Work Permit is needed or is in effect. If so, review and sign the permit.
- 4.2.3 Use appropriate PPE for area.

4.3 Case-by-case approval:

- 4.3.1 The TZ-2 is capable of generating ozone at many times (1000x) the PEL and TLV® in a typical office size room.
- 4.3.2 Ozone generation for the specific area must be approved by the SHSD Industrial Hygiene Manager or IAQ Program Administrator.

5.0 Precautions

5.1 Hazard Determination: Because concentrations of ozone that do not exceed occupational exposure limits have little remediation effect on indoor air odor sources, the meter is intentionally operated in a manner to produce ozone levels exceeding OELs. Thus, observe the following warning from EPA:



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INDUSTRIAL LABORATORY

Services Division

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Ozone Generating Procedure

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Ozone Generation using the Total Zone TZ-2® for IAQ Remediation

Observe the following EPA Warning:

High concentrations of ozone in air, **when people are not present**, are sometimes used to help decontaminate an unoccupied space from certain chemical or biological contaminants or odors (e.g., fire restoration). However, little is known about the chemical by-products left behind by these processes. While high concentrations of ozone in air may sometimes be appropriate in these circumstances, **conditions should be sufficiently controlled to insure that no person or pet becomes exposed.**

Ozone can adversely affect indoor plants, and damage materials such as rubber, electrical wire coatings, and fabrics and art work containing susceptible dyes and pigments (U.S. EPA, 1996a).

This ozone generation operation is reviewed for hazards, risks and controls in [SHSD JRA-16](#).

5.1.1 This ozone generator is capable of generating very dangerous levels of ozone regarding worker health. Relatively low amounts of ozone can cause chest pain, coughing, shortness of breath, and, throat irritation. Ozone may also worsen chronic respiratory diseases such as asthma and compromise the ability of the body to fight respiratory infections. People vary widely in their susceptibility to ozone. Recovery from the harmful effects can occur following short-term exposure to low levels of ozone, but health effects may become more damaging and recovery less certain at higher levels or from longer exposures (US EPA).

The Occupational Safety and Health Administration (OSHA) Permissible Exposure limit and ACGIH TLV are listed below:

Organization	Activity Level	OEL	Exposure duration
OSHA	Any work	0.1 ppm	8-hr TWA
ACGIH	Any work	0.2 ppm	<2 hours
ACGIH	Light Work	0.1 ppm	8-hr TWA
ACGIH	Moderate work	0.08 ppm	8-hr TWA
ACGIH	Heavy work	0.05 ppm	8-hr TWA

The proximity of a person to the ozone generating device will affect exposure. The concentration is highest at the point where the ozone exits from the generator, and decreases away from the unit. The TZ-2 is capable of generating airborne levels of ozone many times the PEL and TLV.

Ozone Generation is allowed only when ALL of the following conditions are met:

- User of the ozone generator is fully trained and qualified on this procedure and is



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- knowledgeable of the hazards of ozone.
- The area is appropriately marked and guarded to prevent unauthorized entry during operation of the equipment. Because of the high concentration ozone generating capacity of the TZ-2, it can only be operated in an un-occupied area.
 - Ozone generation for the specific area must be approved by the SHSD Industrial Hygiene Manager or IAQ Program Administrator.
 - Ozone measuring equipment (such as Dräger CMS Chip or Dasibi Ozone Meter) is used to verify safe re-entry into the area. The TZ-2 user must verify safe atmospheric levels in the area before allowing re-occupancy any area that has had ozone generation.

- 5.1.2 Ozone can damage electrical insulation and computer components. Advise occupants to remove sensitive equipment.
- 5.1.3 By its very nature, the TZ-2 ozone generator may be used in areas where low level IAQ hazards exist or are suspected to be present. Exposures to ambient level IAQ irritants may cause temporary or permanent health impairments in sensitive individuals during the set-up of the ozone generator. Do not enter a suspect area if you are sensitive to the potential contaminants to be treated.
- 5.1.4 The operation of this ozone generator does not expose the operator to physical or radiological hazards.
- 5.1.5 The ozone generator design does not cause significant ergonomic concerns in routine use.
- 5.1.6 The ozone generator does not generate Hazardous Waste and its temporary use has been evaluated by EPD to not require air permitting. See Attachment 9.3.

5.2 Personal Protective Equipment:

- 5.2.1 In areas where ozone generation is occurring, ozone levels will temporarily exceed the *occupational exposure limits (OEL)* by many times the allowable levels. Entry into areas during TZ-2 operation and for 2 hours afterwards is not authorized. Typically, about two hours after the generator is turned off, the ozone levels will drop below the *Occupational Exposure Limit (OEL)* because the ozone will naturally revert back to diatomic oxygen due to the half-life of ozone and reaction of ozone with porous and organic surfaces. But verification by instrumentation or direct reading detection of the actual ozone level is required prior to entry. In an emergency situation, if entry into a recently ozonated area is required earlier than 2 hours after treatment, appropriate respiratory protection must be worn, i.e., an airline respirator, SCBA, or other appropriate air-supplying respiratory device.

6.0 Procedure



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6.1 Equipment:

- Ozone generator TZ-2.
- Ozone Detection equipment (Dräger CMS Chip meter, Dasibi® meter, indicator tubes or passive detection badges.
- Area marking sign(s).

6.2 Theory of Operation: The generator produces ozone based on electric corona arc, in the same manner as lightning. The actual concentration of ozone produced by an ozone generator depends on many factors. Concentrations of ozone will be higher if:

- The device is placed in a small space rather than a large space,
- The room has fewer rather than more materials and furnishings that adsorb or react with ozone and,
- There is less rather than more outdoor air ventilation.

6.3 Securing and Posting the Area: Prior to starting the generator:

- 6.3.1 Notify the room occupants, Facility Project Manager, Research Space Manager, ESH Coordinator, and IH Manager or IAQ Program Administrator.
- 6.3.2 Have sensitive equipment removed.
- 6.3.3 Post warning signs at all entrances. See Attachment 9.2 for sign wording.
- 6.3.4 Secure doors with locks.
- 6.3.5 Schedule the ozonation at the end of the work shift when the area will be unoccupied. The acceptable scenario is starting the generator at 5 pm with re-occupancy the next morning. The ideal situation is ozonation on Friday at 5 pm with re-occupancy on Monday morning.

6.4 Calculating the appropriate operating time:

The TZ-2 fan output is 100 cfm

Calculate the volume of air to be treated (i.e., the room size)

L x W x H, example: 12ø x 12ø x 8ø = 1152 cu ft (a typical office size)

$$1152 \text{ cu ft} / 100 \text{ cfm} = 11.5 \text{ minutes}$$

Thus after 11.5 minutes, all the air in the room (assuming even mixing, which is not true) will have passed through the unit. The estimated concentration of ozone in the room would maximize at about 8-10 ppm.

For a room of 1000 cubic feet, experience **indicates about 1 hour of generator operation** is needed for odor control such as cigarette smoke and mold & mildew odors.

Multiple applications of the ozone generator may be needed for permanent control some odors.



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6.5 Calculating the resulting ozone concentration:

$$\text{ppm of ozone in room} = \frac{(\text{mg of ozone} \div \text{m}^3 \text{ of room air}) \times 24.45}{\text{molecular weight}}$$

Example of a typical office room calculation:

- Room size: 12 ft x 12 ft x 8 ft = 1152 cu ft. Metric = 32621 Liters = 32.6 m³
- TZ-2 generates ozone at the rate of 3000 mg/hr.
- Molecular weight of ozone is 48.

$$\text{ppm of ozone} = \frac{[(\text{mg ozone}) \div \text{m}^3 \text{ room air}] \times 24.45}{\text{MW}}$$

$$\text{ppm of ozone} = \frac{[(3000 \div 32.6)] \times 24.45}{48} = 47 \text{ ppm}$$

During the hour of generator operation, some of the ozone will decay and react, thus the 47 ppm calculation would be higher than the actual concentration.

6.6 Properly locating the generator and setting up the room:

- 6.6.1 **Do not use in flammable or explosive atmosphere.**
- 6.6.2 **Remove plants and food items.**
- 6.6.3 Set the unit by a wall unit air condition return if possible. If there is no wall unit AC, then set the unit in the middle of the room. If there is a wall A/C unit, allow it to run in the recirculating mode. This will help mix and cool the air. Cooler temperature and lower humidity allow the ozone to work better.
- 6.6.4 Mop up any wet areas before starting.
- 6.6.5 Close doors and windows.
- 6.6.6 Do not allow ozone to enter a whole building HVAC system. Seal returns into a whole building HVAC unit.
- 6.6.7 Do not pressurize the room. Shut off and seal the supply coming from a whole building HVAC unit. If not possible, open a window an adequate amount to allow all the supply volume to escape the room and be vented outdoors. Do not allow the ozone to leak into occupied areas.
- 6.6.8 Set the unit at least 6 inches from walls and any structure that could block the air intake (back of unit). Do not set the unit to blow directly on any objects.

6.7 Final pre-start check: Prior to operation:

- 6.7.1 Ensure that ozone will not enter occupied portions of the building by infiltration through HVAC unit(s) or opening in walls.
- 6.7.2 Evacuate everyone from the room.
- 6.7.3 Ensure that all pathways for persons to enter the area are locked and posted.
- 6.7.4 Ensure that the pathway for person activating the TZ-2 is clear

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6.7.5 Prior to starting the generator, ensure that no other actions are needed in the area.

6.8 **Warm-up:** A warm-up is not required. High levels of ozone are produced immediately

6.9 **Turning Power On:** The meter is very simple to operate. There is only one control, the timer switch. Turn the timer knob to the desired time (in hours). The generator immediately starts producing ozone. Ozone is directed out the front of the unit.

Leave the area immediately.



6.10 **Operator Position:** **No one, under any circumstances, is allowed to remain in the area after starting the TZ-2. The meter should only be left unattended after provisions have been made to restrict access to the area.**

6.11 **Re-occupying the room.** No one is enter the room until two hours have elapsed after the unit has shut down unless direct reading measurements indicate 0.1 ppm is not exceeded. This delay period is based on the following:

- É In a non-reactive container, ozone will decay with a half-life of about 3 days.
- In the presence of reactive surfaces, the decay is typically about 20 minutes.
- 2 hours is selected as a safety measure to ensure the ozone is fully reacted before re-entry.

6.11.1 Prior to entering verify by sight and sound that the generator is off and the timer has ended.

6.11.2 Use a direct reading instrument measurements or indicator tube/badge to indicate the OEL is not exceeded.

6.11.3 Enter the room and verify that status of the room, and disassemble the generator for removal.

6.11.4 Inform the personnel in Step 6.3 when the area is ready for re-occupancy.

6.12 **Recording readings:**

6.12.1 Use the BNL [Direct Reading Sampling Instrument Form](#) to record post-ozonation readings.

6.12.2 Return ozone generator and original sampling form to the SHSD IH Laboratory at the end of the project.

6.12.3 Send a copy of any hazard evaluation report written to the IH Laboratory.

7.0 **Implementation and Training**



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Prior to using this ozone generator, the operator:

- 7.1 Demonstrates proper operation of this device on a 3 year basis by completing the Attachment *Job Performance Measure Completion Certificate*.
- 7.2 Completes training and a medical surveillance required for any PPE used on the job or for other hazards encountered in the work area.

8.0 References

- 8.1 TZ-2 Ozone Generator *Owners Guide*
- 8.2 EPA Indoor Air Publications: “*Ozone Generators that are Sold as Air Cleaners: An Assessment of the Effectiveness and Health Consequences.*” 07/26/04, www.ep.a.gov/iaq/pubs/ozonegen.html.
- 8.3 BNL SBMS Subject Area *Indoor Air Quality*

9.0 Attachments

- 9.1 Sign for posting ozone remediation areas
- 9.2 Ozone Generator Operation Qualification *Job Performance Measure* form.
- 9.3 Environmental Evaluation of Ozone Generation in IAQ Remediations.

10.0 Documentation

Document Development and Revision Control Tracking		
PREPARED BY: <i>(Signature and date on file)</i> R. Selvey Author Date 09/02/04	REVIEWED BY: <i>(Signature and date on file)</i> J. Peters SHSD IH Group Date 09/02/04	APPROVED BY: <i>(Signature and date on file)</i> R. Selvey SHSD IH Group Leader Date 09/03/04
ESH Coordinator/ Date: <i>none</i>	Work Coordinator/ Date: <i>none</i>	SHSD Manager / Date <i>none</i>
QA Representative / Date: <i>none</i>	Training Coordinator / Date: <i>none</i>	Filing Code: IH52
Facility Support Rep. / Date: <i>none</i>	Environ. Compliance Rep. / Date: <i>none</i>	Effective Date: 09/03/04
ISM Review - Hazard Categorization <input checked="" type="checkbox"/> High <input type="checkbox"/> Moderate <input type="checkbox"/> Low/Skill of the craft	Validation: <input type="checkbox"/> Formal Walkthrough <input checked="" type="checkbox"/> Desk Top Review <input type="checkbox"/> SME Review	Implementation: Training Completed: Tracked in BTMS Procedure posted on We



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Revision Log
Purpose: Periodic review; Changed resulting from: improvement process Section/page and Description of change: Minor text changes throughout the document (marked) to make the document read better and more clearly from a Human Performance standpoint. Checked text to eliminate %should, may, shall.+ Revised Section 4 with addition of red text for emphasis of critical steps. Removed requirement for Work Permit because the controls in this procedure provide adequate protection. Added link to SHSD JRA-16 in Step 5.1.4. Added <i>EcoSensor</i> to list of equipment. SME Reviewer/Date: R. Selvey 02/25/08 (signature on file)
Purpose: Clarify/enhance procedural controls; Changed resulting from: Improvement process Section/page and Description of change: Revised 5.17. Added Attachment 9.3 SME Reviewer/Date: (signature on file) R. Selvey 02/09/09
Purpose: Clarify/enhance procedural controls; Changed resulting from: Improvement process Section/page and Description of change: Rev 3: Changed %Building Manager+to %Facility Project Manager+in all areas of the document. Reviewed and revised minor changes for clarity throughout the document. Updated meters for post-measurements. SME Reviewer/Date: (signature on file) R. Selvey 12/06/11
Purpose: Clarify/enhance procedural controls; Changed resulting from: Improvement process Section/page and Description of change: Rev 4: Review to correct calculation error and add more detail on how long to operate the meter and when to schedule operation. SME Reviewer/Date: (signature on file) N. Bernholc and R. Selvey 02/06/12



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Attachment 9.1

Sign for Posting Ozone Remediation Areas

(see next page)

CAUTION

DO NOT ENTER

**ROOM IS UNDERGOING
TREATMENT FOR MOLD**

**VERY HIGH LEVELS OF OZONE MAY
BE PRESENT THAT COULD CAUSE
SERIOUS INJURY IF INHALED**

For information on entry, CONTACT _____

Operation of the 1Z-2 Ozone Generator for IAQ Remediation Job Performance Measure (JPM) Completion Certificate

Candidate's Name	Life Number:
------------------	--------------

Practical Skill Evaluation: Demonstration of Evaluation Methodology by Oral Exam

Criteria	Qualifying Performance Standard	Unsat.	Recov.	Satisf.
1. Hazard Analysis	Understands the need to perform a hazard analysis of the area and potential exposure to the self as sampler and workers in the area.			
2. Personal Protective Equipment	Understands the need to be aware of the ozone airborne levels, airborne levels of other contaminants, radiological hazards, noise hazards, etc. Knows how to determine the need for PPE.			
3. Sampling Equipment	Knows where equipment needed for the procedure is located and how to properly sign it out.			
4. Operating ozone generators	Knows the ozone generators safety envelope.			
5. Documentation	Demonstrates correctly filling out IH monitoring forms.			

Ozone generator Operation: Practical Skill Evaluation: Demonstration of Methodology

Criteria	Qualifying Performance Standard	Unsat.	Recov.	Satisf.
1. Area Safety & Posting	Demonstrates the method to correctly prepare the area for remediation			
2. Turning the Ozone generator On and Off	Demonstrates correctly activating the ozone generator and turning it on			
3. Recording data	Demonstrates correctly record data from the ozone detection equipment			

I accept the responsibility for performing this task as demonstrated within this JPM and the corresponding SOP.

Candidate Signature:	Date:
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I certify the candidate has satisfactorily performed each of the above listed steps and is capable of performing the task unsupervised.

Evaluator Signature:	Date:
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Environmental Evaluation for Ozone generation during Indoor Air Quality Remediations

Operation Description: On an occasional basis (typically 1-4 times per year), an IH professional may respond to an Indoor Air Quality complaint of mold odors. In these instances, an International Ozone TZ-2 or TZ-BB1 Electronic Odor Control System can be used to generate ozone in rooms to neutralize unpleasant odors.

The TZ-2 is capable of generating ozone levels at the rate of 3000 mg/hour. For a typical size office (12' x 15' x 8' = 40m³) the resulting concentration will be temporary levels of up to 75 mg/m³ or 40 ppm range.



The TZ-BB1 is much smaller and only generates sub-ppm levels of ozone.



Environmental impact:

Indoor atmospheric concentrations of ozone are temporarily generated in the 0.01 to 50 ppm range.

The ozone is generated indoors and reverts back to oxygen naturally. The half-life of ozone in areas with organics and reactive surfaces is 20 -30 minutes, after which it reverts back to oxygen.

There are no releases to the atmosphere unless the room has a ventilation exhaust. These are typically turned off, because the intent of the ozone treatment is to generate a concentration of ozone in the room.

Based on an email from EPD (EWMSD) dated 8/26/04, this operation does not need to be permitted pursuant to 6NYCRR 201-3.2(c)(45).

Waste Disposal: None