Standard Operating Procedure
Using the Ozone Generator

Researchers should not use the ozone generator until they have read and fully understood these safe operating procedures. However, reading this procedure does not substitute for hands-on training, so new users of the ozone generator must work under the close supervision of an experienced user.

I. Hazards:

- Oxygen is a fire hazard. It is very dangerous and vigorously accelerates the burning of combustible materials. To avoid fire and/or explosion, never use oil, grease, cotton fibers, or any other combustible material on or near the ozone generator. Smoking, heat, and open flame should be kept at a distance of no less than 5 feet from any part of the system. It is STRONGLY recommended that only individuals experienced in the safe handling of oxygen be allowed to operate this equipment.
- OSHA exposure limit for ozone is 0.1 ppm for a period of 8 hours. (Ref. OSHA Air Contaminants Standard, 29 CFR 1910.1000)
- Ozone is a highly toxic oxidizer. Ozone has a distinctive odor, which is easily recognized at very low concentrations. If this odor presents itself at any level, disconnect the generator and contact the manufacturer.
- High voltage and high capacitance is present in ozone generators. Only qualified electricians should work on this equipment.

II. Controlling the Hazards

BEFORE working with unfamiliar chemical reagents, read the relevant Material Safety Data Sheets (MSDS) and understand the hazards. Set up your work in a laboratory fume hood or glove box and ALWAYS wear the appropriate PPE.

Personal Protective Equipment (PPE)

Eye Protection

- Chemical splash goggles or safety glasses that meet the ANSI Z.87.1 1989 standard must be worn whenever handling chemicals. Ordinary prescription glasses will NOT provide adequate protection unless they also meet this standard. When there is the potential for splashes, goggles must be worn, and when appropriate, a face shield added.
- A face shield is required any time there is a risk of explosion, large splash hazard or a highly exothermic reaction. All manipulations which pose this risk should occur in a fume hood with the sash in the lowest feasible position. Portable shields, which provide protection to all laboratory occupants, are acceptable.

Skin Protection

- Gloves should be worn when handling chemicals. Nitrile gloves are adequate for handling many chemicals, but they are combustible. Use adequate protection to prevent skin exposures. Heavy gloves are required for work with large quantities.
- *A fire resistant lab coat must be worn*.
- A chemical-resistant apron worn over the lab coat is required for working with large quantities.
- Long pants should be worn.
- No open toe shoes are allowed.

III. Protocols

1. Make sure the **On/Off Main Power Breaker Switch** (amber) is on the OFF position

2. Close the incoming oxygen gas source

3. Completely open the **Back Pressure Adjustment Valve**

4. Connect ozone output to reaction flask cooled to -78 °C. Introduce ozone by means of a glass pipette or a gas dispersion tube fitted through a polyethylene stopper (a needle will clog). Make sure the reaction vessel has a vent to a mineral oil bubbler.

5. Set the **Ozone Output Adjustment Knob** to 0%

6. Turn the **On/Off Main Power Breaker Switch** (amber) to the ON position

7. Set the **Gas flow Adjustment Knob** so that the **Gas Flow Meter** indicates 20 scfh. This will have to be reset and balanced with the **Ozone Reactor Pressure Gauge** setting. See the PERFORMANCE CHART and PERFORMANCE CURVE below for the indicated ozone output throughout the operation range.

8. Set the ozone reactor pressure by adjusting the **Back Pressure Adjustment Valve** and viewing the pressure against the **Reactor Pressure Gauge**. This indicates the level of backpressure being put on the ozone generator cells. The **Back Pressure Adjustment Valve** should be set between 3 and 6 PSIG (MAXIMUM is 9 PSIG).

9. To control the amount of ozone production, rotate the **Ozone Output Adjustment Knob** clockwise. The voltage is shown in the **Reference Meter** and the activation of the ozone generator cells are indicated by the **Ozone Output Indicator Light**. Ozone production does not begin until the **Reference Meter** indicates approximately 2.5 Volts DC or higher. See the PERFORMANCE CHART and PERFORMANCE CURVE for the indicated ozone output throughout the operation range.

10. Disengage the ozone generating by reversing steps 9-1. Be sure to quench the reaction in the fume hood at -78 °C with the reducing agent specified in your procedure (dimethyl sulfide or triphenylphosphine). Do NOT move the reaction until the specified quench time has been completed or until the disappearance of ozonide is observed by thin layer chromatography.

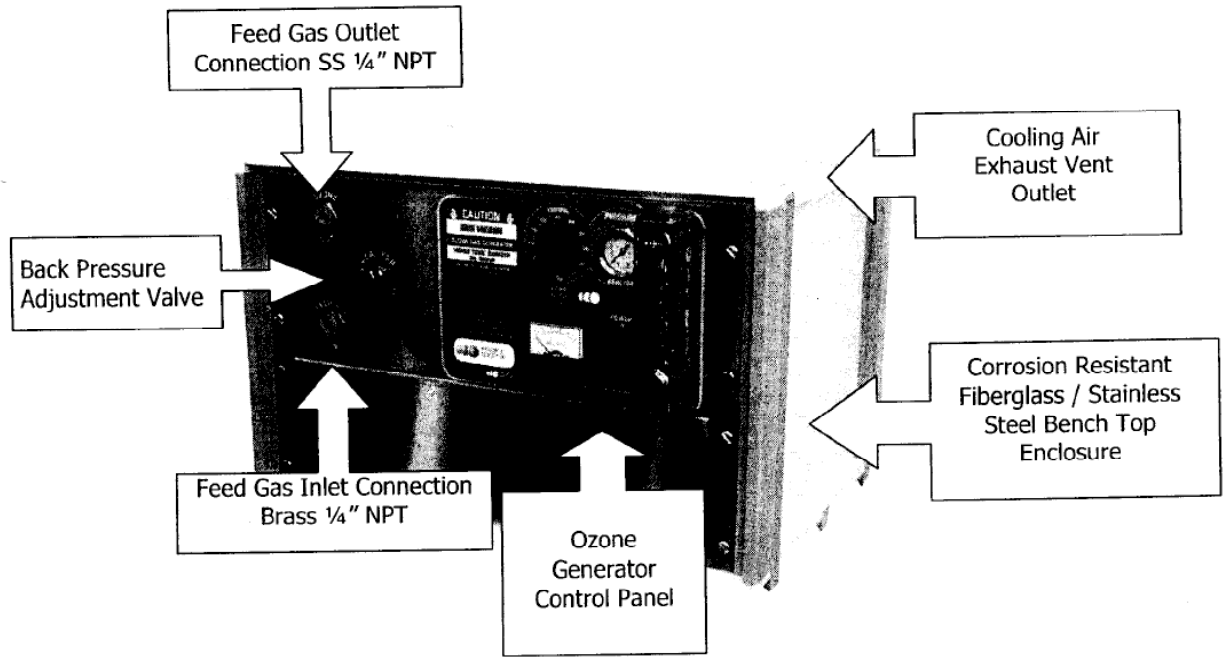
IV. Example Problems

1. Ozonides resulting from the reaction of ozone with alkenes are explosive as there is a peroxide (R-O-O-R) and fuel (CH bonds) in the same molecule. Therefore, always quench the reaction with a reducing agent (PPh_3 or Me_2S) before raising the temperature.

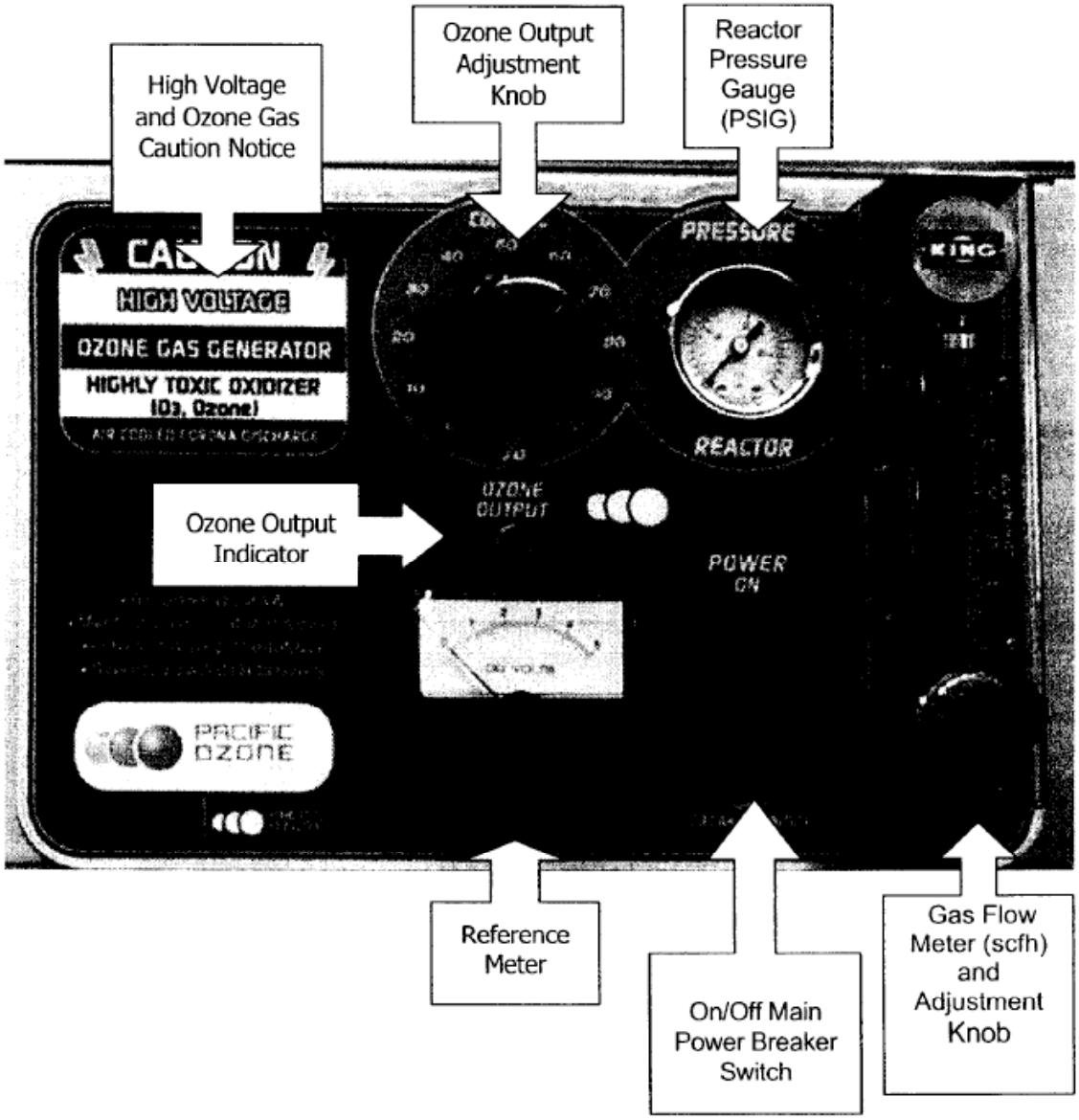
2. Never use liquid nitrogen to cool the reaction flask as liquid oxygen will condense from the ozone/oxygen stream. A mixture of liquid oxygen and hydrocarbons is highly explosive.

3. Only pass oxygen gas through the ozone generator. Ozone is produced by a high voltage electric discharge and gases such as hydrogen will result in a serious explosion.

V. Ozone Generator Layout



VI. Control Panel Layout



VII.

Performance Charts

Ozone output: Ozone is charted in grams per cubic meter (g/m3), which indicates the ozone concentration by weight in a volume of gas and in grams per hour (g/hr), which indicates the total amount ozone by weight that is produced over an hour of time.

Flow: The increase or decrease of the feed gas flow will influence the concentration and output of ozone. Feed gas flow is controlled with the feed gas flow meter located on the ozone generator control panel.

Power: The power setting will influence ozone output and is indicated on the 0 - 5 VDC reference meter located on the ozone generator control panel.

Pressure: Backpressure will influence ozone production and is indicated on reactor pressure located on the ozone generator control panel.

See the attached PERFORMANCE CHART for your model. An example is shown below:

Oxygen Flow	Reactor Pressure	Reference Meter Indicator 0 - 5 VDC - Output in grams/m3					
(SCFH)	(PSI)	2.5	3.0	3.5	4.0	4.5	5.0
5	6	0.00	0.00	0.00	0.00	0.00	0.00
10	6	0.00	2.10	11.40	27.60	76.40	115.00
15	6	0.00	1.50	8.30	27.30	65.10	102.00
20	6	0.00	1.50	6.10	22.70	53.50	84.60
25	6	0.00	0.90	4.80	15.00	45.00	78.10
30	6	0.00	0.70	4.10	12.70	42.00	66.70
35	6	0.00	0.40	3.30	11.10	38.00	57.70
40	6	0.00	0.30	3.10	10.10	32.20	49.00
Oxygen Flow	Reactor Pressure	Reference Meter Indicator 0 - 5 VDC - Output in grams/hour					
(SCFH)	(PSI)	2.5	3.0	3.5	4.0	4.5	5.0
5	6	0.00	0.00	0.00	0.00	0.00	0.00
10	6	0.00	0.67	3.65	8.84	24.48	36.85
15	6	0.00	0.72	3.99	13.12	31.29	49.02
20	6	0.00	0.96	3.91	14.55	34.28	54.21
25	6	0.00	0.72	3.84	12.01	36.04	62.56
30	6	0.00	0.67	3.94	12.21	40.37	64.11
35	6	0.00	0.45	3.70	12.45	42.61	64.70
40	6	0.00	0.38	3.97	12.94	41.27	62.80

VIII.

Performance Curves

Adjustable Output: Ozone output may be adjusted by changing the flow, power and pressure settings. Performance may be influenced by ambient temperature, temperature and make up of the feed gas and line voltage. Please note the ozone generator for specific output data regarding your ozone generator.

Standard temperature: 70°F in a well-ventilated environment

Standard line voltage: 120/240V50/60Hz

See the attached PERFORMANCE CURVES for your model. An example is shown below: