

# HAIS Fast-O<sub>3</sub> Instrument

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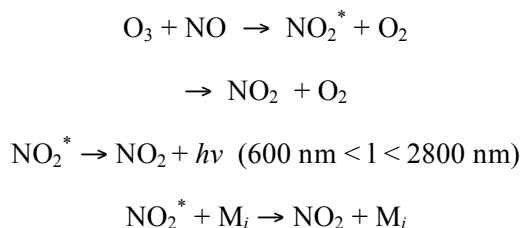
**URL:** <http://www.acd.ucar.edu/cari/>

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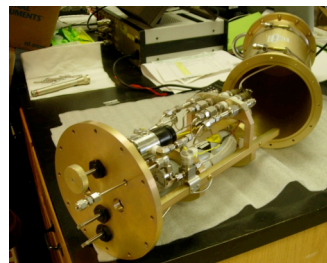
## Principle of Operation:

The operating principle of the O<sub>3</sub> instrument is the measurement of chemiluminescence from the reaction of nitric oxide (NO) with ambient O<sub>3</sub> using a dry-ice cooled, red-sensitive photomultiplier employing photon counting electronics.

Reaction Vessel Chemistry:



The reagent NO (grade >99%) is supplied from a commercially purchased lecture bottle filled to a maximum pressure of 500 psig. Since NO is a toxic gas, the small high pressure cylinder, its regulator, and several safety features are contained inside a specially designed pressure safe vessel that is vented overboard the aircraft.



Ambient air is sampled through a standard HIMIL inlet protruding outside the aircraft boundary layer. Ambient air sample flow is controlled to 500 sccm, while the NO reagent is introduced to the reaction vessel in near-excess flow of  $\sim 4$  sccm. Gas flows as well as the reaction vessel temperature ( $35 \pm 0.1^\circ\text{C}$ ) and pressure ( $10 \pm 0.05$  torr) are all controlled at constant conditions resulting in maximum stability of the detected signal and instrument sensitivity.

The instrument sensitivity ( $\sim 2000$  cps/ppbv) is determined from calibrations performed on the ground before and after each flight or set of back-to-back flights using a UV absorption based calibrator (TECO model 49PS) operated with high-quality ultra-pure air. A near-linear calibration curve is generated in 100 ppb intervals from 0 to 1 ppm. This calibration range is sufficient to measure O<sub>3</sub> mixing ratios over the altitude range of the aircraft.

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## Hardware Description:

The fast-O<sub>3</sub> instrument has been specifically developed for use onboard HIAPER, the NSF/NCAR G-V aircraft. The instrument requires several accessories in addition to the instrument module to operate effectively. Therefore, the total Fast-O<sub>3</sub> equipment rack consists of several major components. The fast-O<sub>3</sub> instrument module ( $\sim 25$  lbs) houses the reaction vessel and PMT. A small scroll pump ( $\sim 30$  lbs) allows operation of the instrument's reaction vessel at the desired pressure and flow rate. A nitric oxide containment vessel (26 lbs) supplies the reagent NO to the reaction vessel in the instrument. The DAQ ( $\sim 45$  lbs) which acts as a power supply unit as well as data recording system for the chemiluminescence signal as well as several instrument housekeeping signals. A KVM or laptop installed in the equipment rack allows interface with LabView based software in the DAQ.



A 0-10 VDC signal corresponding to a preliminary O<sub>3</sub> mixing ratio (0-1 ppm range) can be output to the aircraft data system upon request.

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## Instrument Performance:

**Sensitivity:**  $\sim 2000$  cps/ppbv

**Background:**  $\sim 100$  cps

**Detection Limit:** 0.02 ppbv

**Time Response:** 1 Hz (Instrument can have 5 Hz capability, depending on inlet configuration.)

**Linear Range:** 1 ppbv → 1000 ppbv (O<sub>3</sub>)

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### **Publications Describing the Instrument:**

Ridley, B. A., and F. E. Grahek, A small, low flow, high sensitivity reaction vessel for NO chemiluminescence detectors, *J. Atmos. Oceanic Technol.*, 7, 307-311, 1990.

Ridley, B. A., F. E. Grahek, and J. G. Walega, A small, high-sensitivity, medium-response ozone detector for measurements from light aircraft, *J. Atmos. Oceanic Technol.*, 9, 142-148, 1992.

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