Resonance Ltd.
ADVANCED COSPEC

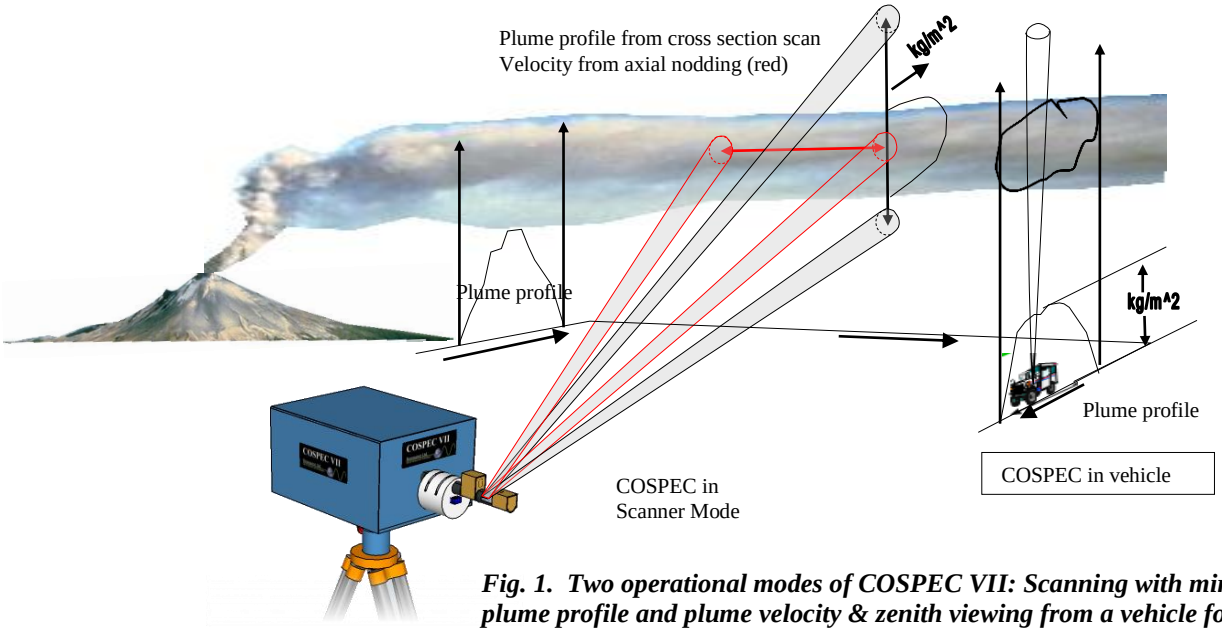

Fig. 1. Two operational modes of COSPEC VII: Scanning with mirror for plume profile and plume velocity & zenith viewing from a vehicle for plume

DESCRIPTION

SO_2, NO_2 and other gases selectively and characteristically absorb light from scattered solar radiation (skylight) as it passes through the atmosphere. By correlating the resulting absorption spectrum with corresponding reference spectra stored in software, the COSPEC measures, in real time, the integrated concentration of SO, NO_2 etc. along the line of sight, independently of the presence of other potentially interfering gases.

The ADVANCED COSPEC, incorporating a high quantum efficiency CCD sensor coupled to a Czerny-Turner fiber-optic spectrometer, has a high signal to noise ratio and is sufficiently sensitive to track plumes over great distances under adverse weather conditions. Internal signal processing compensates for changing ambient light levels and diurnal spectral shifts.

Over 180 COSPECs are currently in use worldwide.

FEATURES

- Fibre optically coupled Pointing and Auto-Calibration Assembly (PACA) allows remote operation through fiber cable for airborne and vehicular surveys or point and shoot operation with PACA attached to main housing

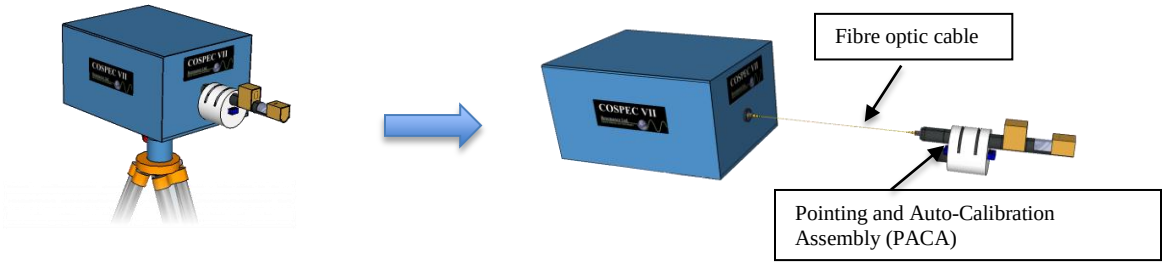

Fig. 2. Simple reconfiguration for fast airborne and vehicular surveys

- Temperature-controlled, thermoelectrically-cooled, back-thinned CCD detector.
- High efficiency UV-Vis spectrometer
- Altitude scanner for profiling plume and nodding scanner for plume velocity measurement
- Auto cell changer Calibration cells traceable to COSPEC standards
- GPS, elevation sensor and electronic compass
- Includes Tablet PC with touchscreen and optional keyboard
- Windows 7 and Complete LabView-based software package

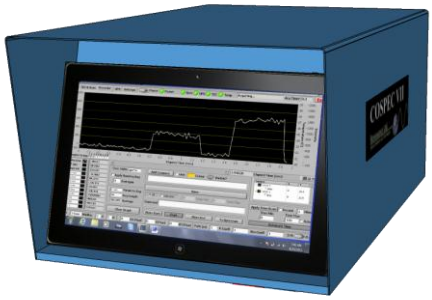

Fig. 3. Tablet PC with COSPEC software pre-loaded

- Fiber optic mixing to randomize far field image structure (in field of view) before light enters spectrometer
- Time stamped gas data in format compatible with Excel and other software
- Data transferred over wireless network or with memory stick
- Free software updates from Resonance website
- All units supplied with water tight carrying case and tripod

SPECIFICATIONS

Target Gases:	**SO_2, NO_2 and other gases such as BrO and OClO**
Spectral Range	**300 to 410 nm**
Limit of Detection:	**< 2 ppm-m**
Dynamic Range:	**0-6000 ppm-m**
Field of View:	**Set by telescope (typically 15 to 25 millirads)**
Operating Temperature:	**0-50°C**
Output Signal:	**Stored on hard drive or USB flash for easy importing into MS Excel**
Calibration cells:	**3 SO_2 gas cells cross calibrated against COSPEC standards**
Calibration/beam nodding	**Two automated 3 position cell changers for mounting gas cells or prisms**
Scanner	**120 degree beam scanner**
Display/Control	**LCD with touch screen and wireless keyboard**
Electrical Requirements:	**DC: 6 to 30V, AC: 90V to 240V, 50/60 Hz; 30W max (with PC)**
Size and Weight:	**Telescope 8 (dia) x 28 cm, 1 kg; Instrument36 cm x 23 cm x 17 cm, 8 kg**

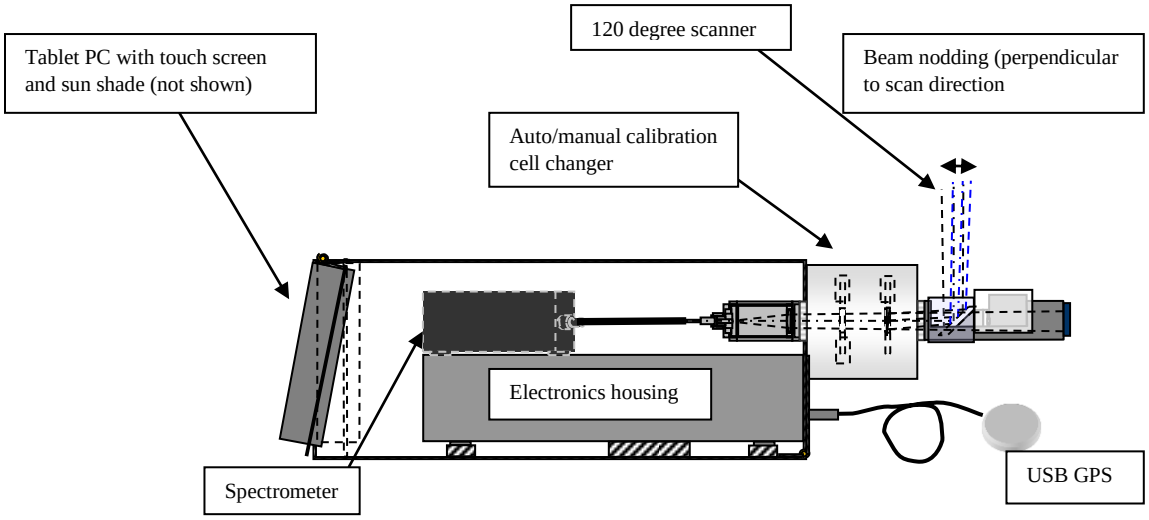

Fig. 5. COSPEC schematic diagram

ACCESSORIES

- Wide angle scanner with ultra accurate positioning
- Temperature control for optical bench and detector to increase DOAS sensitivity
- Case with quartz tube for use in rainy environment
- Rechargeable Lithium Ion battery pack
- Solar panels
- RF links

COSPEC is configured per the customer's requirements.

Fig. 4. A custom COSPEC at MASAYA Volcano in 2003 with PACA on separate tripod

Application to Plumes

- Tracking of plumes over long distances under virtually all weather conditions
- Determination of emission kilograms per day, dispersion, depletion and rise rates;
- To evaluate plume dispersion and deposition models
- To provide information about the volcanic activity particularly as it relates to the prediction of eruptions.

Application to Atmospheric Science

- To locate and identify fumigation sources. Individual site emissions can be distinguished from neighbouring or even non-local ones
- To quickly check industrial emissions especially when in-stack monitors are not effective or practical to optimize the effectiveness of a point monitor network
- For troposphere constituent measurements (SO_2, NO_2, Halogen oxides etc.) using multi-axis DOAS method
- For stratospheric Ozone and constituent measurements

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In 2001 Resonance inherited the time-tested COSPEC from Barringer Research Limited. In 2002 Resonance embarked on a 3-year project with McGill University to update the COSPEC design. This resulted in the development and field testing of the Resonance mini-DOAS line of remote sensors. The first three instruments Resonance Mini DOAS systems one, two and three (RMDI, RMDII, and RMDIII) provide convenient low cost solutions to plume monitoring. The final system, The ADVANCED COSPEC, combines the exceptional optical sensitivity of the original COSPEC with the power of a CCD DOAS spectrometer.

The ADVANCED COSPEC provides a complete solution for plume characterization because it can measure the plume cross section, the plume velocity, GPS coordinates, scanner pointing direction altitude and azimuth. The unique high sensitivity of COSPEC VII makes it the ideal instrument for DOAS studies of SO_2, NO_2, BrO and OClO in volcanic and stack plumes.

The standard model comes equipped with software to measure SO_2 in stack or volcanic plumes from a stationary or mobile platform. It can record the SO_2 in the optical path while simultaneously recording the position and pointing direction of the sensor with GPS, elevation sensors and an electronic compass. In addition to continuous (manual or automatic) scanning through 120 degrees, its internal prism can toggle the field of view between two angles perpendicular to the scan direction. This enables a measurement of SO_2 at two points in the plume on a continuous basis to determine the plume velocity.

Each COSPEC is a set of three calibration cells, a sky calibration, carrying case, software disks and operator's manual. The old COSPEC vertical look attachment has been replaced by more versatile the mini-scanner plus elevation sensors. The old COSPEC calibration cell changer has been replaced by the auto calibration assembly (which can be operated manually as well). With 3 gas cells the auto calibration assembly can achieve 5 gas calibration points.

http//www.resonance.on.ca **res@resonance.on.ca** **705 733 3633 (Canada)**

OPERATIONAL SPECIFICATIONS

COSPEC VII, SO_2 OR NO_2 MODES

Operational Day -solar elevation > -1° for clear skies -solar elevation > 3° for overcast skies

Noise Level (a) with controlled source (Quartz Iodine Lamp set-up)`3.5 ppm-m (peak-to-peak, noise envelope) with 1 second electronic time constant

(b) Passive Operation

`5 ppm-m (p-t-p, NE) with ls T.C. for solar elevation ˆ 35°, increases to = 30 ppm-m (p-t-p, NE) ,1s T.C. for solar elevations of 0°.

Diurnal Baseline -Adjustable to suit user needs.

Stability Typical values of baseline variation are:`lOOppm-m for the full operational day, `30ppm-m for a time period (centered around noon) of 3 hours less than the full operational day.

Cloud Effects on -Nil (cancelled with the secondary Baseline automatic gain control circuit)

Figs. 6-15 (below). COSPEC in the field throughout the years

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http://www.geo.mtu.edu/FIELD_TRIPS/guatemala_fied_trip.html

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