Tennessee Valley Authority
Research and Technology Applications

TEXAQS-II 2005 Supporting Information for Deliverables

Topic: Calibrations

The original records are maintained at the address below:

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In addition, electronic copies of the calibrations have been transmitted to Ken Rozacky at TCEQ via TVA's password protected ozone FTP site:

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Description of gas instrument calibration and data format
Multipoint pre and post flight calibrations for the NO_y speciation instruments and the SO_2 instruments in addition to span checks for the ozone and CO systems are performed on all flight days through the automated TEII 146 on-board calibration system.

The calibration sequence is automated using the Campbell datalogger to control the mixtures by sending 0-5000 mV signals to the gas and air mass flow controllers in the TEII 146 calibrator.

Before using the calibrator to prepare mixtures, the MFC's in the calibrator are calibrated in the field. We know that MFC's often exhibit offsets and slope variation from nominal, especially under field conditions, so we endeavor to take nothing for granted. Under aircraft hangar conditions in Texas, a multipoint calibration of this system was performed by forcing the datalogger to feed MFC control voltages ranging from 0 to 5000 mv. A Drycal primary standard was placed on the calibrator output port to develop the relationships for the air and gas. When the gas flowmeter was being calibrated, the zero air supply to the calibrator was shut off and capped, and vice versa to ensure that only one MFC can contribute any flow during the test. (This step is very important especially for the gas MFC since only a very slight offset (in percentage terms) of the Air MFC can cause an erroneous gas MFC calibration.) The least squares fit to the resulting curve is then programmed into the datalogger so that the datalogger can calculate the MFC control voltages needed for the desired target air and gas flow mixtures.

Below are the calibrator mass flow controller test results for summer 2005. For the 200 ppb range instruments the nominal test points are 0, 20, 100, and 180 ppb.

146 Calibrator Cal	flow	AirSLPM	Millivolts	GasSCCM	Millivolts
07/25/2005		0.168	0	0	0
		2.32	500	4.67	500
		4.54	1000	10.51	1000
		8.834	2000	21.53	2000
		13.09	3000	32.74	3000
		17.41	4000	43.99	4000
		21.78	5000	54.7	5000

Pre-flight cals are used to reduce flight data unless post flight cals indicate a significant change in performance had occurred. Multipoint gas substitution calibrations for the fast ozone instrument are performed once a week (or whenever daily span/zero checks indicate a problem) using TVA's TEII 49PS ozone calibrator. Calibration of the Aero-Laser CO instrument is performed on a similar schedule using the zero scrubber built into the analyzer and an external reference tank from Scott Specialty gases. Conversion efficiency of the molybdenum converters for NOy and NOy* is calculated using the ratio of GPT NO_2 to NO response. Conversion efficiency of the NO_2 photocell is also calculated using the ratio of GPT NO_2 to NO response. All GPT tests are done with slight (a few percent of NO_2) excess NO in the mixture, i.e. essentially all the ozone is titrated out. This method is used because it has been shown that using slight excess ozone can lead to slight underestimates of conversion efficiency.

The TX05cals.xls workbook contains the results of the automated calibrations that were used for flight and audit data reduction for the NO_x (NOy, NOy*, NO2, and NO) and SO_2 systems, along with the span checks for the CO and Ozone instruments. A separate worksheet is prepared for each calibration sequence. Calibration gases at each level (Calmode) are fed to the inlets for 10 minutes to allow time for the calibration system to reach a stable mixture at the aircraft inlets. The final three 5 second readings for each Calmode are split off from the data file and placed in the seven columns following the first Calmode column on each worksheet. These values are then averaged and placed in the columns following the second Calmode column. The target concentrations are placed below the averaged stable values for each level. Finally, data reduction span factors, zeros, and conversion efficiencies are calculated from the averaged stable values and the target concentrations (see the last few columns on the right of the worksheet for this information).

For the NO_x and SO_2 systems the span factors are calculated from the 180 ppb targets (90 percent of full scale), unless instrument drift at these levels happened to result in off scale readings. In that event the 100 ppb levels are used for the span factors. The zero readings are used primarily as a starting point for flight data reduction because the zero

adjustments are based on a moving baseline fitted to the series of in-flight zeros performed during the flight.

Ozone and CO span/zero checks are used only to ensure that instrument performance has not changed appreciably from the most recent full calibration. The multipoint ozone and CO calibrations are presented in the TX05OzoneCOcals.xls workbook. This workbook shows all the individual calibrations for ozone (OzoneDetail worksheet), a figure showing all the ozone calibrations for the study combined (OzoneCombined worksheet), and a worksheet showing all the CO calibration response and background values (AeroLaser CO) workbook.