Appendix A: Error Analysis

A.1   Absorption Measurements

The sources for noise in the absorption measurements are discussed in sections 3.1.2 and 3.2.2. The temperature measurement has a maximum error of 2% [1].

A.2   OH* Chemiluminescence

The sources for error in the OH* chemiluminescence measurement include the efficiencies of the optical components (PMT, fiber optics, monochrometer), signal conditioning, and spurious light sources. Based on repeated measurements, the maximum error of the OH* signal was found to be 0.25 dBV. A discussion of calibrating the OH* signal can be found in the master's thesis of Ludwig Haber[2, 3].

A.3   Dynamic Velocity Sensor

The sources for error in the dynamic velocity sensor include 1) difference in sensitivities of the two microphones, 2) approximation of the derivative with a finite difference, and 3) near field effects.

Two microphones were selected with very similar sensitivities in magnitude and phase to combat errors in the velocity measurement. As seen in Figure A1.1, the two microphones used exhibited a maximum difference of 0.5 dB in magnitude and 0.5 degrees in phase.
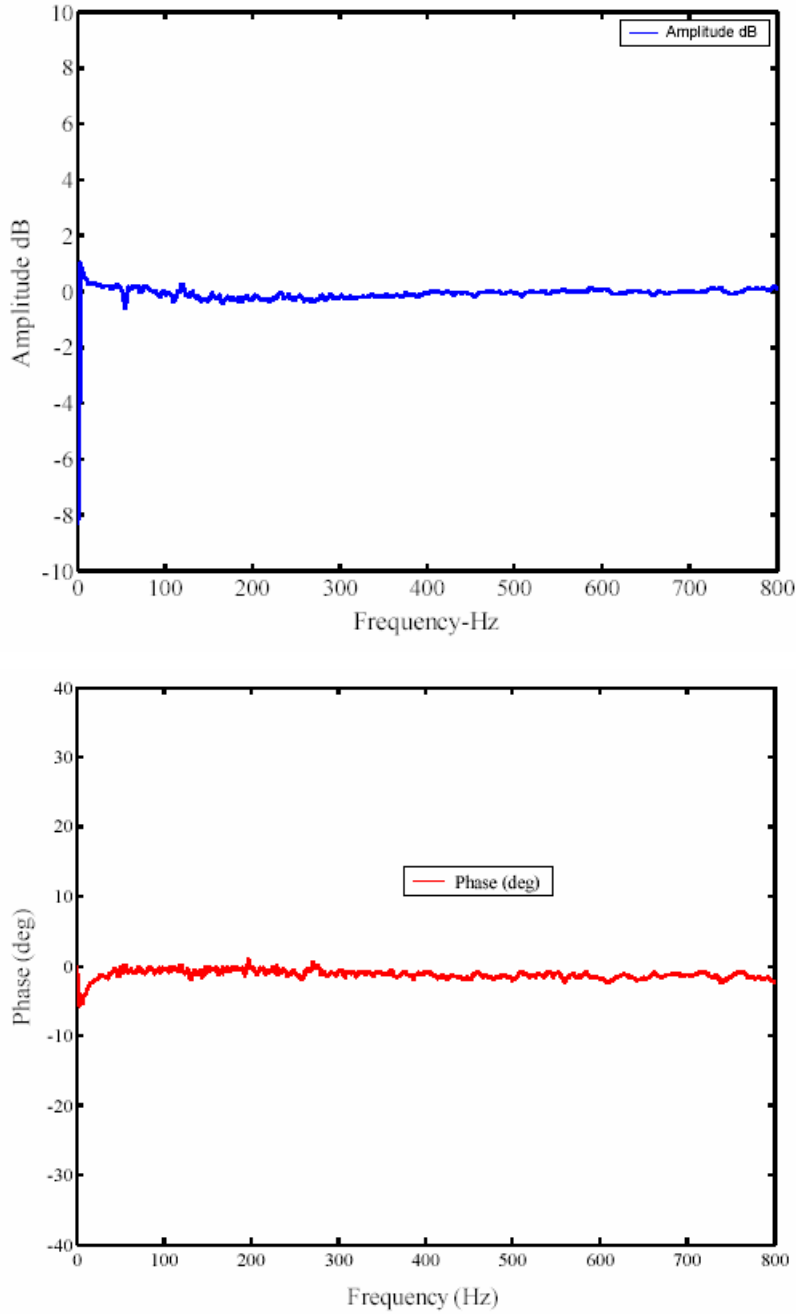
Figure A1.1. Frequency Response between Microphones. Microphones with similar sensitivities were used in the sensor [4].

The sensor is designed to simulate the 1-D Euler equation,

$$u'(t) = -\frac{1}{\rho}\int \frac{\partial p'}{\partial x}\partial t \tag{A1.1}$$

where the derivative is approximated as

$$\frac{\partial p'}{\partial x} \cong \frac{P_2 - P_1}{\Delta x} \tag{A1.2}$$

where P_1 and P_2 are the microphone signals and Δx is the distance between the microphones. Crocker gives the ratio of the measured intensity to the true intensity, resulting from the finite difference approximation as

$$\frac{I_M}{I_T} = \frac{\sin(k\Delta x)}{k\Delta x} \tag{A1.3}$$

where k is the wavenumber of the excitation [5]. For the laminar burner, with a maximum frequency of 1.0 kHz and a distance of 50 mm, the maximum error is 13%. The turbulent burner arrangement had a distance of 19.05 mm, resulting in a maximum error of 4.3% at a maximum frequency of 1.5 kHz.

The measurement was taken at a sufficient distance from the loudspeaker to insure near field effects were negligible. The large range over which there was good coherence in the velocity frequency responses shown in Chapter three provide evidence that planar waves were being measured.

The contribution of the sensitivity, finite difference, and near field effect errors on the maximum error is given by

$$e_t^2 = e_{sens}^2 + e_{findif}^2 + e_{nearfield}^2 \tag{A1.4}$$

resulting in a maximum error of 0.5 dB in magnitude and 0.5 degrees in phase.

A.4 Flow Meters

The flow meters used in the laminar study were factory-calibrated by Hastings, rated to be accurate to 1% full scale. A maximum flow rate of 25 slpm for the air flow meter translates to a maximum error of 4.17 cc/sec. A maximum flow rate of 1.5 slpm for the fuel flow meters translates to a maximum error of 0.25 cc/sec for methane, 0.129 cc/sec for propane, and 0.203 cc/sec for ethane.

The fuel flow meters in the turbulent study were also factory-calibrated by Hastings. A maximum flow rate of 9 slpm translates to a maximum error of 0.09 scfm. The air flow meter had a maximum flow rate of 150 scfm. A linear fit to the calibration

data resulted in a maximum error of 0.16%. The calibration curve is shown in Figure A1.2. The maximum error for the air flow meter is then 0.24 scfm.
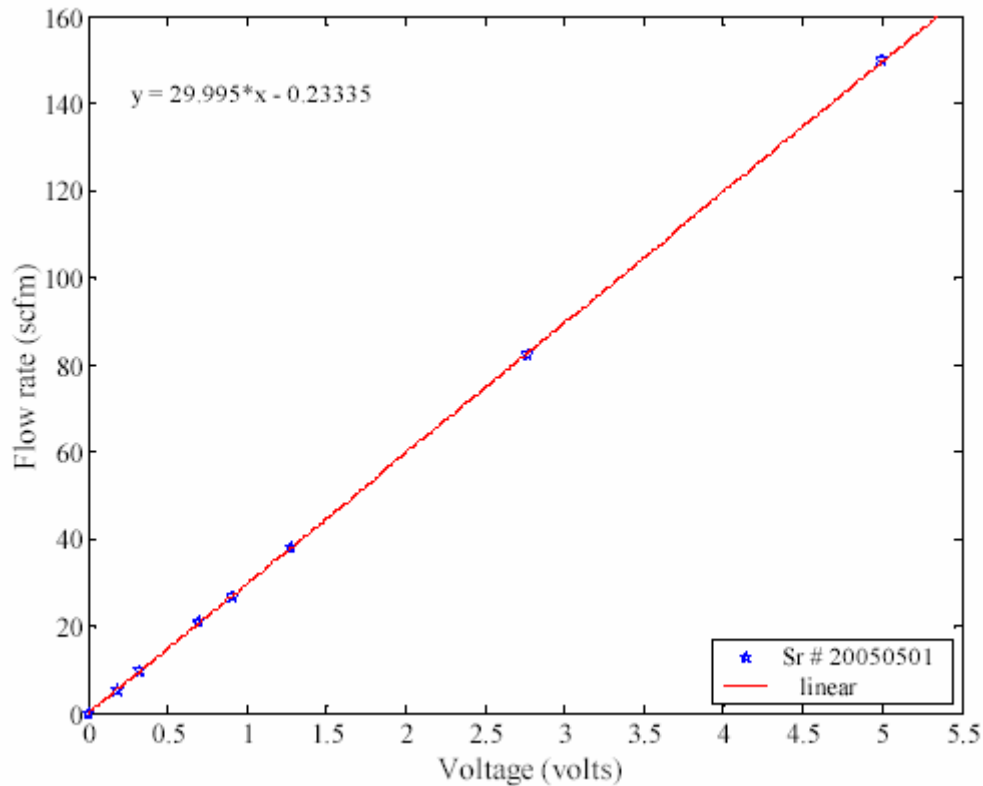

Figure A1.2. Flow Meter Calibration. A linear curve was fit to the calibration data supplied for the Eldridge air flow meter (SR 20050501).

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