0.089" metering orifice test
January 26th, 2005

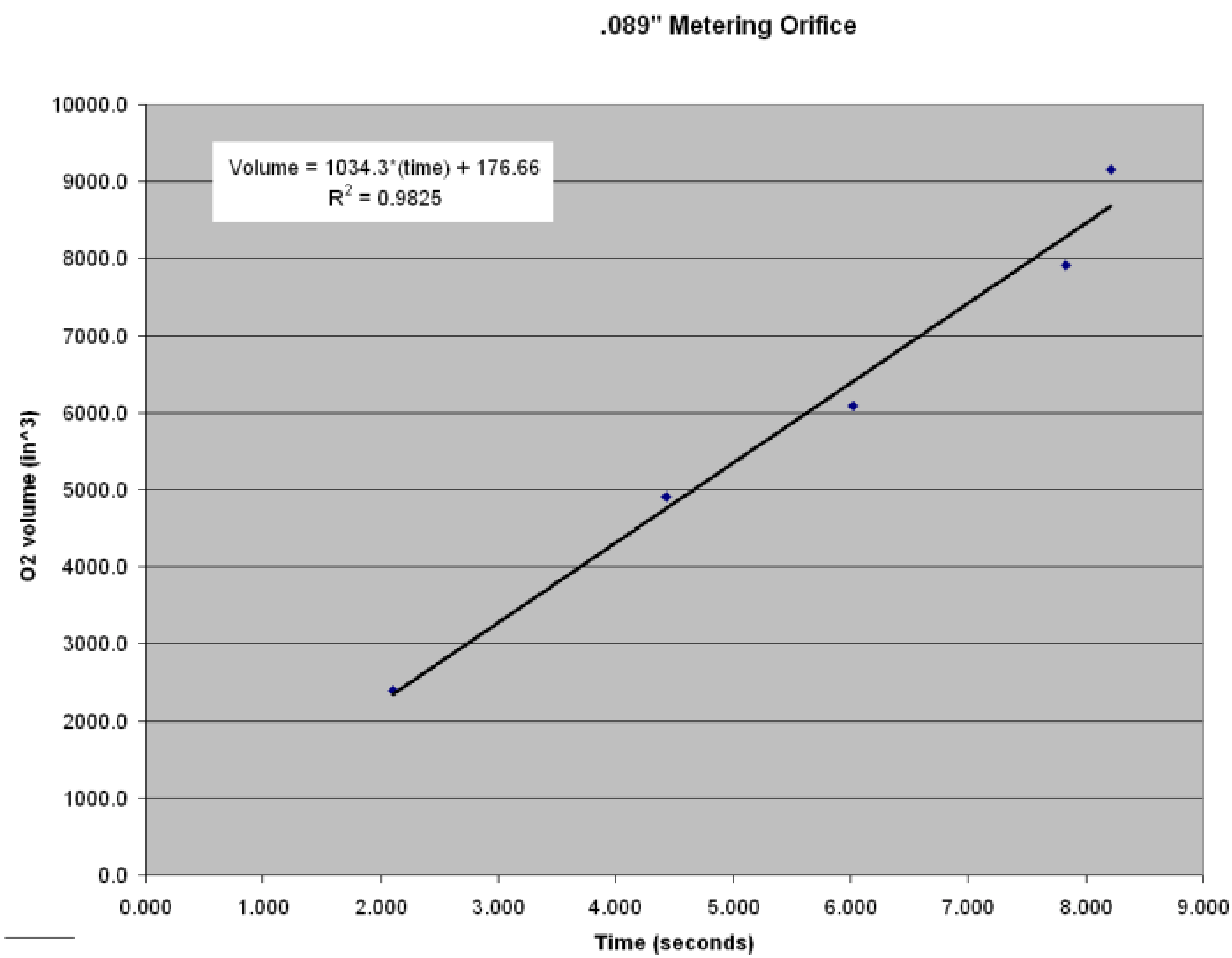
GIVEN

Inlet	302	PSI
Outet	130	PSI
Room Temp	60	F
Barrel Circumference	69.38	inches (outside)
Barrel Wall Thickness	0.125	inches
Barrel Wall height	33.09	inches (average)

DATA

Trial #	Duration (seconds)	Side 1 height (from top in inches)	Side 2 height (from top in inches)	Average height (inches)	O2 column height (inches)	O2 Volume (in^3)	Flow Rate (in^3/s)
1	8.216	8.50	8.75	8.63	24.47	9160.4	1114.9
2	6.024	16.75	16.88	16.81	16.28	6094.8	1011.7
3	4.434	19.88	20.13	20.00	13.09	4901.3	1105.4
4	2.100	26.63	26.75	26.69	6.40	2397.3	1141.6
5	7.836	11.88	12.00	11.94	21.15	7920.1	1010.7

Barrel I.D (inches) 21.8343


.089" Metering Orifice
Volume = 1034.3*(time) + 176.66
R2 = 0.9825
O2 volume (in^3)
10000.0
9000.0
8000.0
7000.0
6000.0
5000.0
4000.0
3000.0
2000.0
1000.0
0.0
0.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
9.000
Time (seconds)

Calculate transfered O2 volumetric flow rate

Find the oxygen flow rate through a specific diameter metering orifice at a given upstream pressure.

Given :

$C_d := 1.096$ Flat plate metering orifice

$P_{atm} := 14.7psi$

$P_{atm} = 1.014 \times 10^5 \, Pa$ Atmospheric pressure

$P_{inlet} := 1000psi$

$P_{inlet} = 6.895 \times 10^6 \, Pa$ Upstream pressure

$$A_1 := \frac{\pi \cdot (.089in)^2}{4}$$

$A_1 = 4.014 \times 10^{-6} \, m^2$ Metering orifice area t

$R := 260 \frac{J}{kg \cdot K}$ Gas constant for oxygen

$\gamma := 1.4$ ratio of specific heats for oxygen

$T_1 := 288.71K$ Gas temperature (60F)

$$q := C_d \cdot A_1 \cdot P_{inlet} \cdot \sqrt{\frac{\gamma}{R \cdot T_1}} \cdot \left(\frac{2}{1+\gamma}\right)^{\frac{\gamma+1}{2\gamma-2}}$$

$$q = 0.0758 \frac{kg}{s}$$

$$V_{dot} := \frac{q \cdot R \cdot T_1}{P_{atm}} \qquad V_{dot} = 0.056 \frac{m^3}{s} \qquad V_{dot} = 118.953 \frac{ft^3}{min}$$

Metering orifice (.089" dia)

Given :

$$m_{dotO2} := .0758 \frac{kg}{s}$$

$$m_{paraffin} := .1804kg$$

from spreadsheet (mass paraffin consumed at 7 seconds given mdot)

$$T_{burn} := 7s$$

$$Isp := 210s$$

Then

$$m_{O2} := m_{dotO2} \cdot T_{burn}$$

$$m_{O2} = 0.531\,kg$$

$$m_{propellant} := m_{O2} + m_{paraffin}$$

$$m_{propellant} = 0.711\,kg$$

Calculate average thrust from burned propellants

$$Thrust := \frac{m_{propellant} \cdot g \cdot Isp}{T_{burn}}$$

$$Thrust = 209.176\,N$$

$$Thrust = 47.025\,lbf$$

Oxidizer to fuel ration

$$OF := \frac{m_{O2}}{m_{paraffin}}$$

$$OF = 2.941$$