FINAL REPORT

# TETROON EVALUATION PROGRAM

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# ABSTRACT

The actual volume of a "constant volume" superpressured tetrahedron shaped balloon changes as the amount of superpressure is changed. The experimental methods used to measure these changes in volume are described and results are presented. The basic equations used to determine the amount of inflation gas required for a tetroon to float at a predetermined flight level are presented and inflation techniques discussed.

# CONTENTS

# MATHEMATICAL SYMBOLS

$\sigma$ - maximum tensile stress in tetroon material

$\rho$ - density

h - length of basic tubular cylinder from which a tetroon is manufactured

k - constant

n - number of moles of gas

P - absolute pressure

$\Delta P$ - helium pressure inside tetroon less the air pressure outside tetroon

R - gas constant

t - material thickness

T - absolute temperature

V - volume of tetroon

W - weight

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Subscripts:

$\ell$ - at launch
o - initial value ($V_o$ = volume at $\Delta P$ = 5 mb)
a - air
b - ballast
f - at float
g - inflation gas
p - payload
t - tetroon

## 1. SUMMARY

Three different sizes ($1m^3$, $5m^3$, and $6m^3$) of tetrahedron shaped balloons manufactured from a dyed red polyester film were studied by inflation techniques to determine volume accuracies and volume changes with changing stress levels or superpressure levels.

Review of the data show that at nominal skin stress levels of 6,000 psi and lower there is no measurable volume "creep" due to creep elongation of the polyester film. At a nominal skin stress of 8,000 psi, creep may be detectable, while at 10,000 psi the creep is definitely measurable and would significantly affect the floating altitude stability because of a changing volume.

This report explains the volume measurements and experimental techniques used. The normalized volumes are graphed for ease of interpretation and ease of comparison between the different sizes.

A complete explanation of basic inflation techniques is presented. Details of inflation equipment and mathematical tools to help in solving the technician's problem of "how to inflate a tetroon" are left to the discrimination of the user; however, some helpful suggestions are provided.

Some additional work is required to form a basis from which a comprehensive handbook on tetroon inflation and performance predictions can be made. Recommendations for this future work are presented.


## 2. BALLOON DESCRIPTIONS

Five balloons each of the three different sizes were tested. These balloons had the shape of tetrahedrons and are commonly referred to as tetroons. Instead of being manufactured from four equilateral triangular pieces of material, the tetroon is generally fabricated from a tube or cylinder of material of length h and circumference 2.31h. The ends of this tubular piece of material are sealed off like a pillow would be on each end, except that the opposite ends are sealed in perpendicular skew directions.

When these balloons are inflated and pressurized they do not form a flat sided tetrahedron, but instead have rounding or bulging surfaces. The maximum material stressing occurs at the center of each bulging face and has a nominal maximum stress corresponding to the following empirical equation (reference 1):

$$\sigma = \frac{\Delta Ph}{4t} \qquad (1)$$

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The volume of the tetroon is nominally considered to be equal to $.26h^3$.

The smallest tetroon, Model No. T-PR51-1.000, is a $1m^3$ tetroon manufactured from polyester dyed red film with a skin thickness of 51µm. The $5m^3$ tetroon is manufactured from 102µm thick red polyester film and has a part number of T-PR102-5.000. The $6m^3$ is manufactured from the same material as the $5m^3$ and it carries a part number of T-PR102-6.000.

The following table shows the various superpressure values required to produce the nominal stresses of interest. This table can easily be derived from the preceding stress equation, (1), for tetroons.

| Stress (psi) | ΔP(mb) Required for: $1m^3$ | $5m^3$ | $6m^3$ |
|---|---|---|---|
| 2,000 | 17.9 | 20.9 | 19.8 |
| 4,000 | 35.8 | 41.9 | 39.5 |
| 6,000 | 53.7 | 62.8 | 59.2 |
| 8,000 | 71.6 | 83.6 | 79.0 |
| 10,000 | 89.5 | 104.6 | 98.7 |

## 3. CHOOSING AND INFLATING A TETROON

In flying a tetroon the problem generally focuses upon two basic parameters, payload and altitude. The term altitude really implies a density level where $T_{af}$ and $P_{af}$ are known. A third parameter, $\Delta P_f$, which must be defined is the desired pressurization of the tetroon above the ambient pressure.

For the purpose of this discussion it is assumed that for any particular tetroon the volume, V, is a unique function of ΔP as long as the tetroon is never stressed beyond its elastic capabilities (hysteresis volume effects assumed insignificant); i.e.,

volume = function dependent only on ΔP

or

$$V = f(\Delta P) \qquad (2)$$

The floating density level of a tetroon is determined from the buoyancy equilibrium equation; i.e.,

System Weight = System Buoyancy

or

$$W_t + W_p + W_b = V_f \rho_{af} - V_f \rho_{gf} \qquad (3)$$

The density of a gas is proportional to absolute pressure and inversely proportional to absolute temperature. Thus, the densities can be expressed as follows:

$$\rho_a = k_a \frac{P_a}{T_a} \quad ; \quad \rho_g = k_g \frac{P_g}{T_g}$$

$$\text{or} \qquad (4)$$

$$\rho_{af} = k_a \frac{P_{af}}{T_{af}} \quad ; \quad \rho_g = k_g \frac{P_{gf}}{T_{gf}}$$

$P_{gf}$ is the chosen value of absolute pressure which corresponds to the superpressure:

$$\Delta P_f = P_{gf} - P_{af} \qquad (5)$$

$T_{gf}$ is the absolute temperature of the inflation gas at the float level, and the supertemperature effects should not be ignored, i.e., $T_{gf} \neq T_{af}$.

Thus, the amount of ballast required can be calculated from the floating requirements using equations (3) and (4):

$$W_b = V_f \left[ k_a \frac{P_{af}}{T_{af}} - k_g \frac{P_{gf}}{T_{gf}} \right] - W_p - W_t \qquad (6)$$

If $W_b < 0$ the tetroon is too small and a larger one must be used. However, if too large of a tetroon is used then $W_b$ becomes excessively large.

Once a tetroon is chosen the second problem is to determine how much gas (helium) to put in it. For any given tetroon the number of moles of gas it should contain can be calculated from the floating conditions by using the equation of state for a gas, PV - nRT:

$$n_g = \frac{P_{gf} V_f}{T_{gf} R} \qquad (7)$$

At launch the tetroon must contain the same amount of gas such that:

$$n_g = \frac{P_{g\ell} V_\ell}{T_{g\ell} R} \qquad (8)$$

Two situations may exist at launch:

a) the tetroon may be flacid and not fully inflated,

or

b) the tetroon may be pressurized.

Under either situation, the following equation may be used to calculate $V_\ell$ if the Net Lift at launch is measured; i.e.,

System Weight = System Buoyancy

or

$$W_t + W_p + W_b = \text{Net Lift} + V_\ell \, \rho_{a\ell} - V_\ell \, \rho_{g\ell} \qquad (9)$$

Rearranging:

$$V_\ell = \frac{\text{Net Lift} + W_t + W_p + W_b}{\rho_{a\ell} \quad \rho_{g\ell}} \qquad (10)$$

Using the earlier expression for $\rho$, (4), substituted into (10) and using this expression for $V_\ell$ in (8):

$$n_g = \frac{P_{g\ell}}{T_{g\ell} R} \left[ \frac{\text{Net Lift} + W_t + W_p + W_b}{k_a \dfrac{P_{a\ell}}{T_{a\ell}} - k_g \dfrac{P_{g\ell}}{T_{g\ell}}} \right] \qquad (11)$$

For an indoor inflation when the gas has been allowed to reach temperature equilibrium with the air, then $T_{a\ell} = T_{g\ell}$, and:

$$n_g = \frac{P_{g\ell}}{R} \left[ \frac{\text{Net Lift} + W_t + W_p + W_b}{k_a \, P_{a\ell} - k_g \, P_{g\ell}} \right] \qquad (12)$$

Depending on which of the two launch situations exist, this equation may be simplified even further. If the underinflated situation exists, then $P_{g\ell} = P_{a\ell}$, and:

$$n_g = \frac{\text{Net Lift} + W_t + W_p + W_b}{R(k_a - k_g)} \qquad (13)$$

For this situation, one would slowly inflate the balloon until the net lift reaches the value determined by:

$$\text{Net Lift} - R(k_a - k_g) n_g - (W_t + W_p + W_b) \qquad (14)$$

which is (13) rearranged.

However, for the pressurized situation one would slowly inflate (by trial and error if necessary) until the right side of equation (12) satisfied the predetermined value for $n_g$.

It is easy to predict which of the two launch situations will exist as follows:

1) Assume that the tetroon would be just inflated to full, but with no overpressure.

2) Calculate $n_g$ based upon $P_{g\ell} = P_{a\ell}$ and $T_{g\ell} = T_{a\ell}$, i.e.,

$$n_g = \frac{P_{a\ell} V}{T_{a\ell} R}$$

where

V = nominal, just full volume of the tetroon.

3) If this calculated value of $n_g$ is less than the predetermined float requirement, then more gas would have to be added and the pressurized situation would exist.

4) If this calculated value of $n_g$ is more than the predetermined float requirement, then less gas would be required and the underinflated situation would exist.

The above explanation describing how to choose and inflate a tetroon made two assumptions. The first assumption was that the V versus ΔP characteristics of the tetroon are unique; i.e., a single V vs. ΔP graph exists and the tetroon exhibits no volume hysteresis effects. This characteristic needs to be more fully evaluated, as explained later. Also, each tetroon should have its own actual volume measured to minimize errors in the float level due to manufactured volume variations.

The second assumption was that the temperature of the inflation gas at float is known. This is not true and supertemperature estimates must be made. The ambient conditions and material radiometric properties will affect the supertemperature. Reference 2 explains errors caused by such effects in more detail. This reference further discusses many other aspects of tetroon flying and is recommended reading prior to establishing a detailed manual.

## 4. EXPERIMENTAL VOLUME MEASUREMENTS

Each tetroon was inflated for the first time on the day it was to be tested. The inflation gas used was helium. The tetroon was initially inflated to a superpressure of 5 mb, and the volume was calculated as explained below. The complete testing cycle for a single tetroon lasted less than 8 hours. After the initial volume measurement data were taken, the balloon was then inflated to a constant superpressure for a time period of 4 hours. This superpressure was selected to correspond to nominal skin stresses of 2,000, 4,000, 6,000, 8,000, or 10,000 psi. One tetroon of each size was tested at this constant pressure for each of the corresponding skin stresses. This yields five tetroons of each size, or a total of 15. After this initial stressing of 4 hours, the pressure was increased so that the balloon would be stressed at 10,000 psi for 1 hour (for the cases of preliminary stressing at 10,000 psi, the tetroon was held at 10,000 psi for an additional hour). Then the pressure was lowered so that the tetroon would be stressed at 8,000 psi for 1/2 hour, the pressure was then lowered again for a skin stress of 6,000 psi for another 1/2 hour, and lowered again to attain 4,000 psi for 1/2 hour, and finally reduced to attain 2,000 psi for a final 1/2 hour. Thus, the actual stressing time was 7 hours.

4.1 Volume Calculations

As explained in section 3, the volume of any balloon inflated with a lifting gas can be calculated from the following equation:

$$V = \frac{\text{Net Lift} + W_t + W_p + W_b}{\rho_a - \rho_g} \qquad (15)$$

For the experimental setup $W_p = W_b = 0$. Also, helium was used as the inflation gas so that, using equation (4):

$$V = \frac{\text{Net Lift} + W_t}{\frac{P_a}{T_a}\left(.348521 \frac{\text{kg}\ {}^0\text{K}}{\text{m}^3\ \text{mb}}\right) - \frac{P_g}{T_g}\left(.048109 \frac{\text{kg}\ {}^0\text{K}}{\text{m}^3\ \text{mb}}\right)} \qquad (16)$$

Thus, to calculate the volume, one needs only to measure the net lift of the tetroon, the absolute pressure of the air, the absolute pressure of the helium (or pressure differential between the air and the helium since $P_g = P_a + \Delta P$), and the temperature of the air (assuming $T_a = T_g$). Accounting for these factors and the tare weight of the experimental setup, the equation used to calculate volume was:

$$V = \frac{W_t + \text{Scale Reading} + \text{Tare Weight}}{\frac{P_a}{T_a}\left(.348521 \frac{\text{kg}\ {}^0\text{K}}{\text{m}^3\ \text{mb}}\right) - \frac{P_a+\Delta P}{T_a}\left(.048109 \frac{\text{kg}\ {}^0\text{K}}{\text{m}^3\ \text{mb}}\right)} \qquad (17)$$

## 4.2 Test Method

Each tetroon was initially tied to a kilogram balance scale prior to inflation. (See Figure 1.) When the tetroon became buoyant, it would rise up and pull up on the pan of the scale. Adjustments were made such that when calibrated weights equal to the net lift of the tetroon were placed on the pan of the scale, the scale pointer would point to its neutral or zero position. This technique of lift measurement provided a sensitivity such that the equilibrium under a particular steady state condition could be measured within ±.5g for the $1m^3$ and ±1.0g for the $5m^3$ and $6m^3$ tetroons.

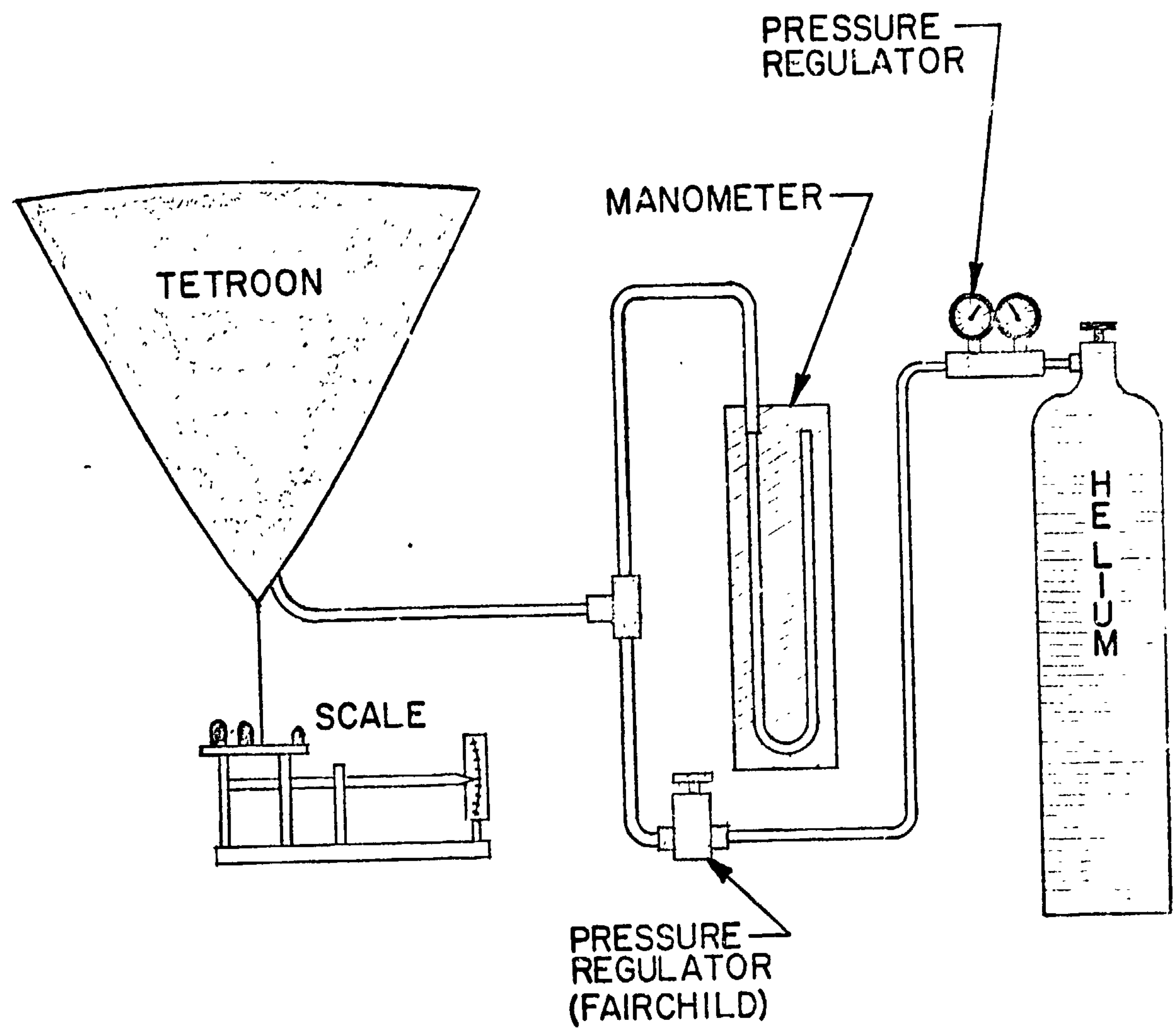
For all the $1m^3$ tetroons and the first $5m^3$ tetroon tested, the recorded temperature was that measured with a standard laboratory thermometer calibrated in $1^0$C increments. During the testing of the first $5m^3$ tetroon, Test #6, it became evident that temperature fluctuations in the test area between the top and the bottom of this much larger tetroon resulted in a requirement to more accurately estimate the true average temperature of the helium. Consequently, for all the remaining $5m^3$ and $6m^3$ tetroons, an improved temperature average was attained by measuring the temperature near the bottom of the tetroon with the thermometer and at the top of the tetroon with a thermistor connected to a digital voltmeter readout. The temperature of the helium was assumed to be the average of the two readings.

The barometric pressure was measured with a mercury cistern barometer calibrated in millibars. The superpressure of the tetroon was measured with a water manometer or mercury manometer, whichever was appropriate in the superpressure range of interest.

The inflation of each tetroon was regulated with two pressure regulators in series. The first pressure regulator, that connected directly to the helium bottle, was maintained at an output pressure of 20 psi. The second regulator was a Fairchild Model 10C, 0-2 psig range precision regulator.

## 4.3 Results

The data for each of the tetroon tests is included in the appendix. The initial volumes, those calculated from measurements taken at a superpressure of 5 mb, are listed below. In examining the table it is evident that the basic volume inaccuracies from manufacturing tolerances are significant and cannot be ignored.




EXPERIMENTAL SET-UP

FIG. 1

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| Balloon Type | Test # | $V_O$ ($m^3$) | $V_O$-Nominal Volume / Nominal Volume (%) |
|---|---|---|---|
| T-PR51-1.000 | 1 | 1.0595 | 6.0 |
| | 2 | 1.0554 | 5.5 |
| | 3 | 1.0586 | 5.9 |
| | 4 | 1.0439 | 4.6 |
| | 5 | 1.0479 | 4.8 |
| T-PR102-5.000 | 6 | 5.058 | 1.2 |
| | 7 | 5.127 | 2.5 |
| | 8 | 5.096 | 1.9 |
| | 9 | 5.047 | 0.9 |
| | 10 | 5.047 | 0.9 |
| T-PR102-6.000 | 11 | 5.976 | -0.4 |
| | 12 | 6.238 | 4.0 |
| | 13 | 6.206 | 3.4 |
| | 14 | 6.230 | 3.8 |
| | 15 | 6.198 | 3.3 |

In order to compare results between different tetroon sizes, it was necessary to produce graphs of the actual volume divided by the initial volume, $V/V_O$, versus time. These graphs are found in Figures 2 through 6. In reviewing these figures, it is quite apparent that for the prestressing at 2,000, 4,000, and 6,000 psi there is no volume creep during the first 4 hours. Also, for the same test, it does not appear that the prestressing value affects the second part of the test where the stress limits are raised to 10,000 psi and then slowly lowered.

The prestressing at 8,000 psi may indicate a slow trend towards increased volume during the first 4 hours, but once again the last part of the test does not seem to be affected by the initial stressing since the results are very similar to those in Figures 2, 3 and 4.

Figure 6 very definitely shows that at a nominal stress level of 10,000 psi there is significant volume growth which, as expected, affects the results of the second part of the test.

It should be remembered that the $1m^3$ balloons were made from 51μm material, while the $5m^3$ and $6m^3$ balloons were made from 102μm material. Consequently, both materials would have been manufactured from separate cast extrusion runs of a nearly identical polymer. The variations in running conditions during the making of the films would produce films with slightly varying characteristics.

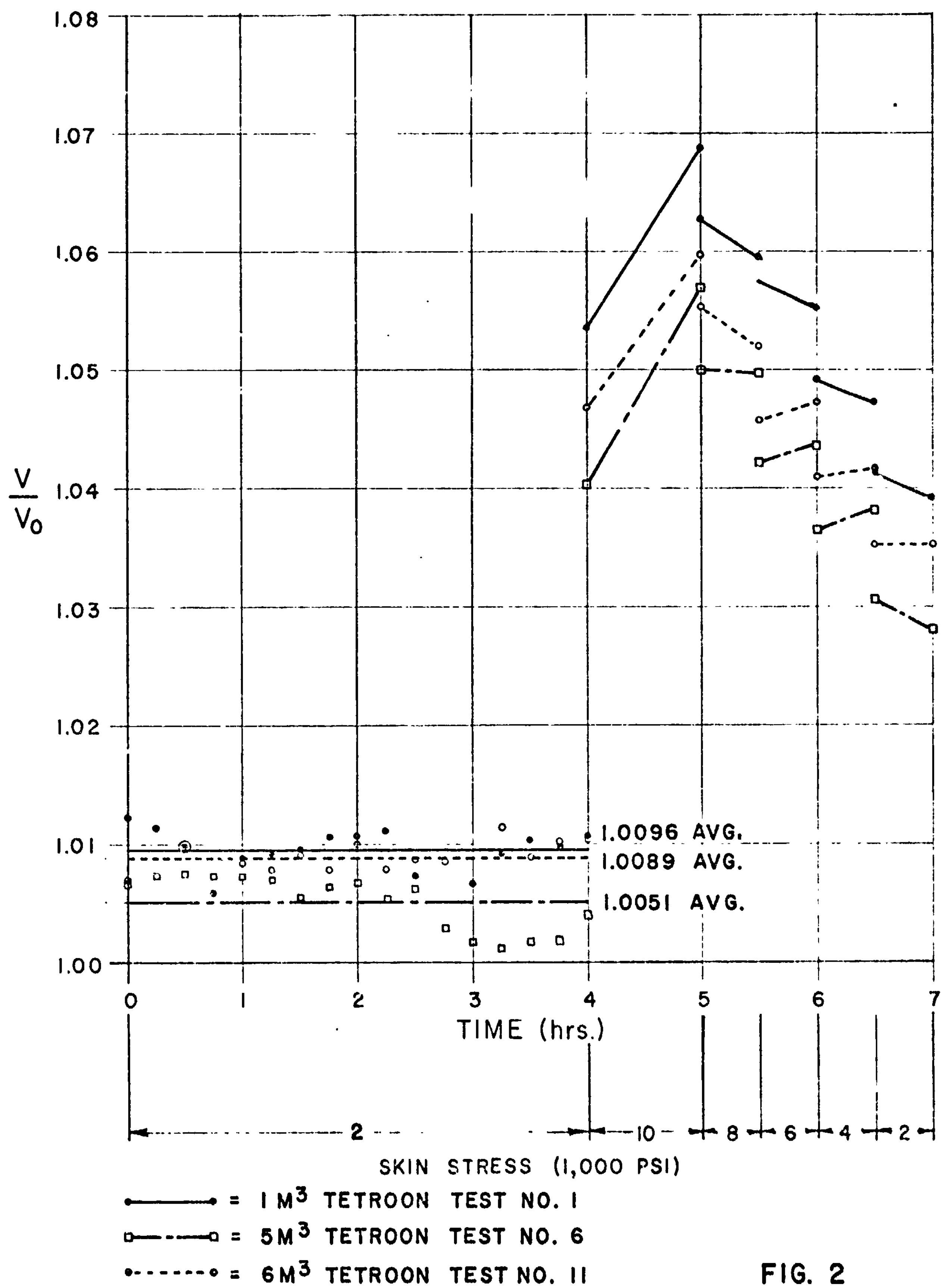
1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1.00
V/V0
0
1
2
3
4
5
6
7
TIME (hrs.)
1.0096 AVG.
1.0089 AVG.
1.0051 AVG.
2
10
8
6
4
2
SKIN STRESS (1,000 PSI)
= 1 M3 TETROON TEST NO. 1
= 5 M3 TETROON TEST NO. 6
= 6 M3 TETROON TEST NO. 11

FIG. 2

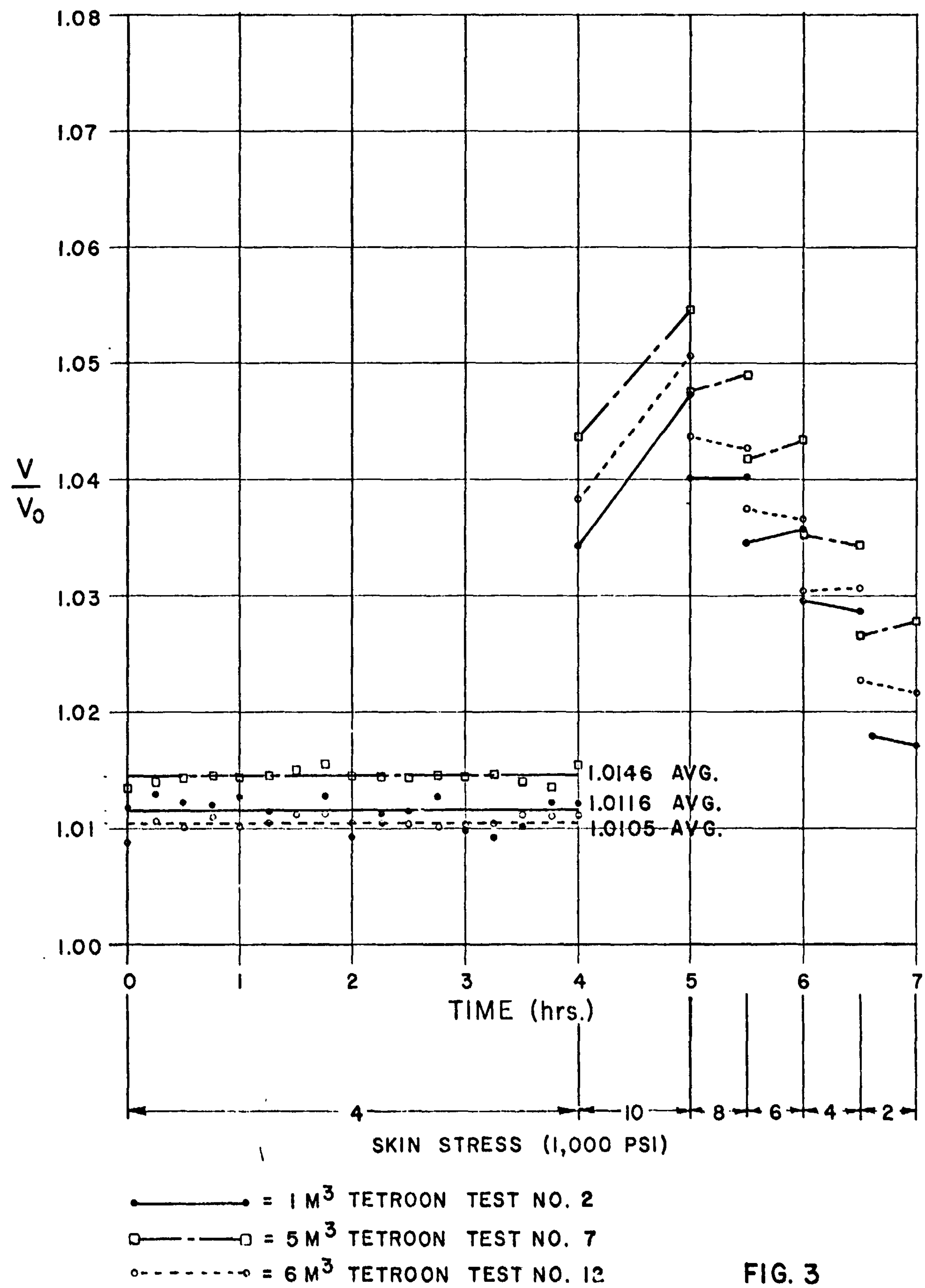
1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1.00
V/V0
0 1 2 3 4 5 6 7
TIME (hrs.)
1.0146 AVG.
1.0116 AVG.
1.0105 AVG.
4
10
8
6
4
2
SKIN STRESS (1,000 PSI)
= 1 M3 TETROON TEST NO. 2
= 5 M3 TETROON TEST NO. 7
= 6 M3 TETROON TEST NO. 12

FIG. 3

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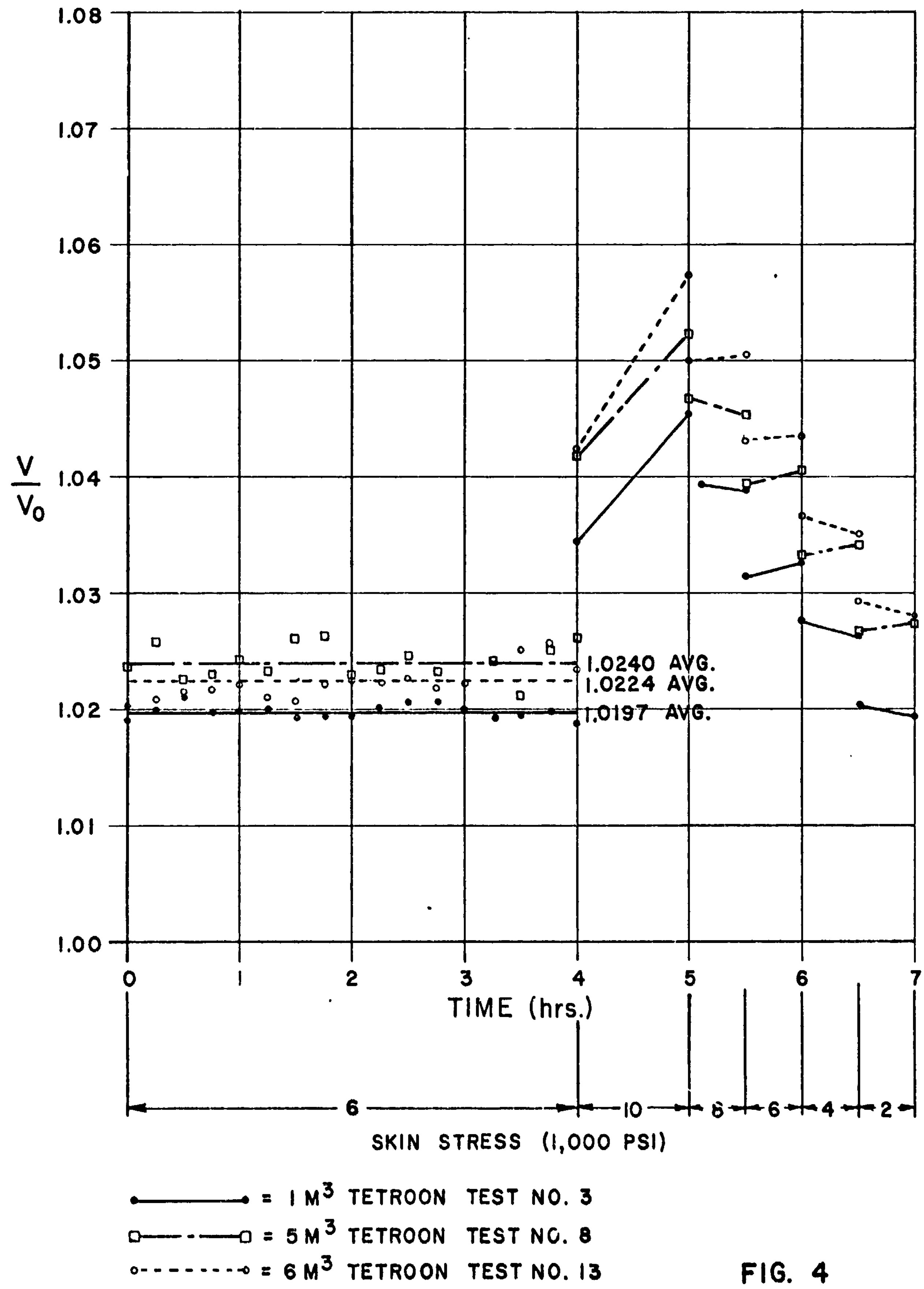
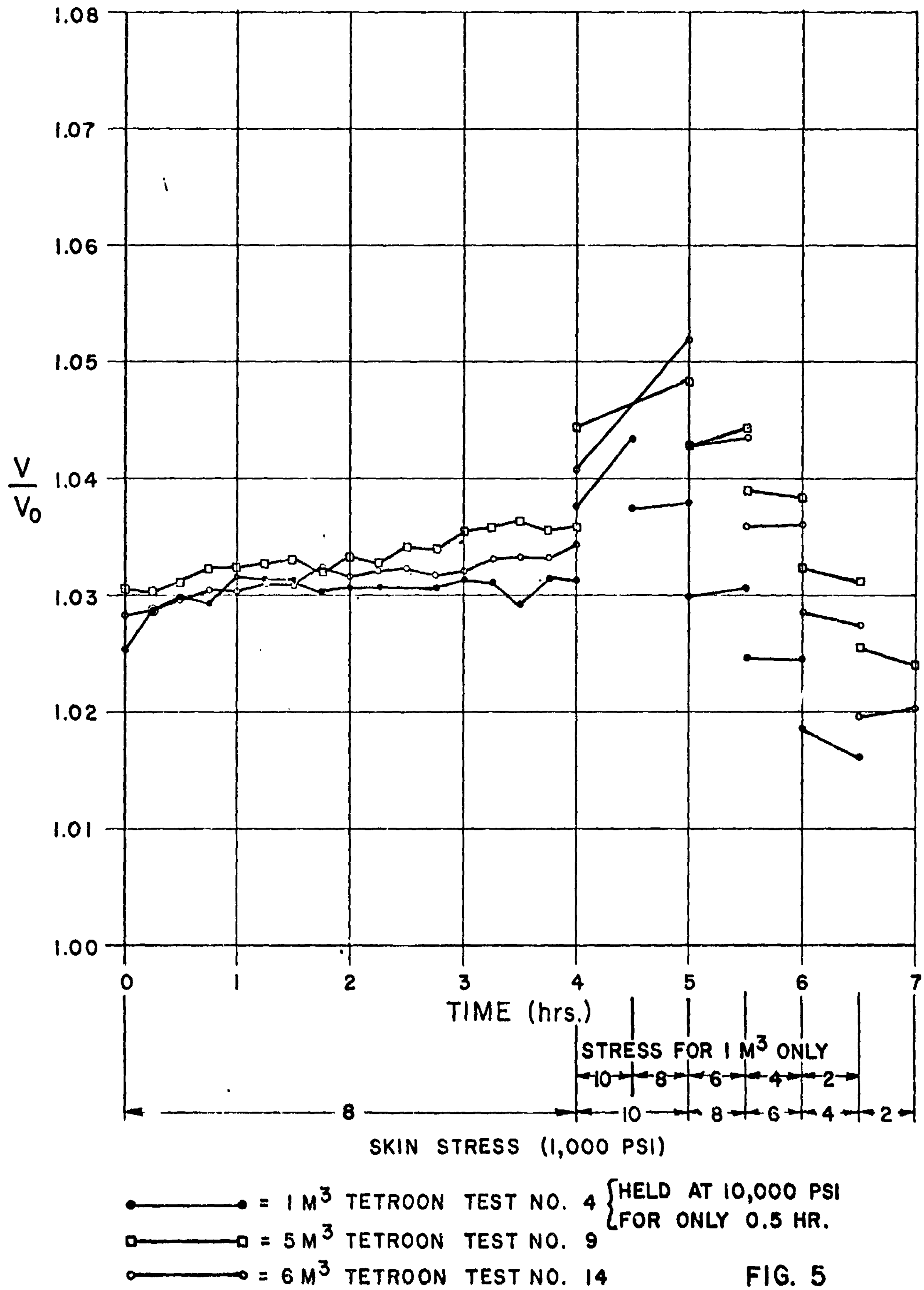



FIG. 4



1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1.00
V/V0
0
1
2
3
4
5
6
7
TIME (hrs.)
STRESS FOR 1 M3 ONLY
10
8
6
4
2
8
10
8
6
4
2
SKIN STRESS (1,000 PSI)
= 1 M3 TETROON TEST NO. 4 {HELD AT 10,000 PSI FOR ONLY 0.5 HR.
= 5 M3 TETROON TEST NO. 9
= 6 M3 TETROON TEST NO. 14


FIG. 5

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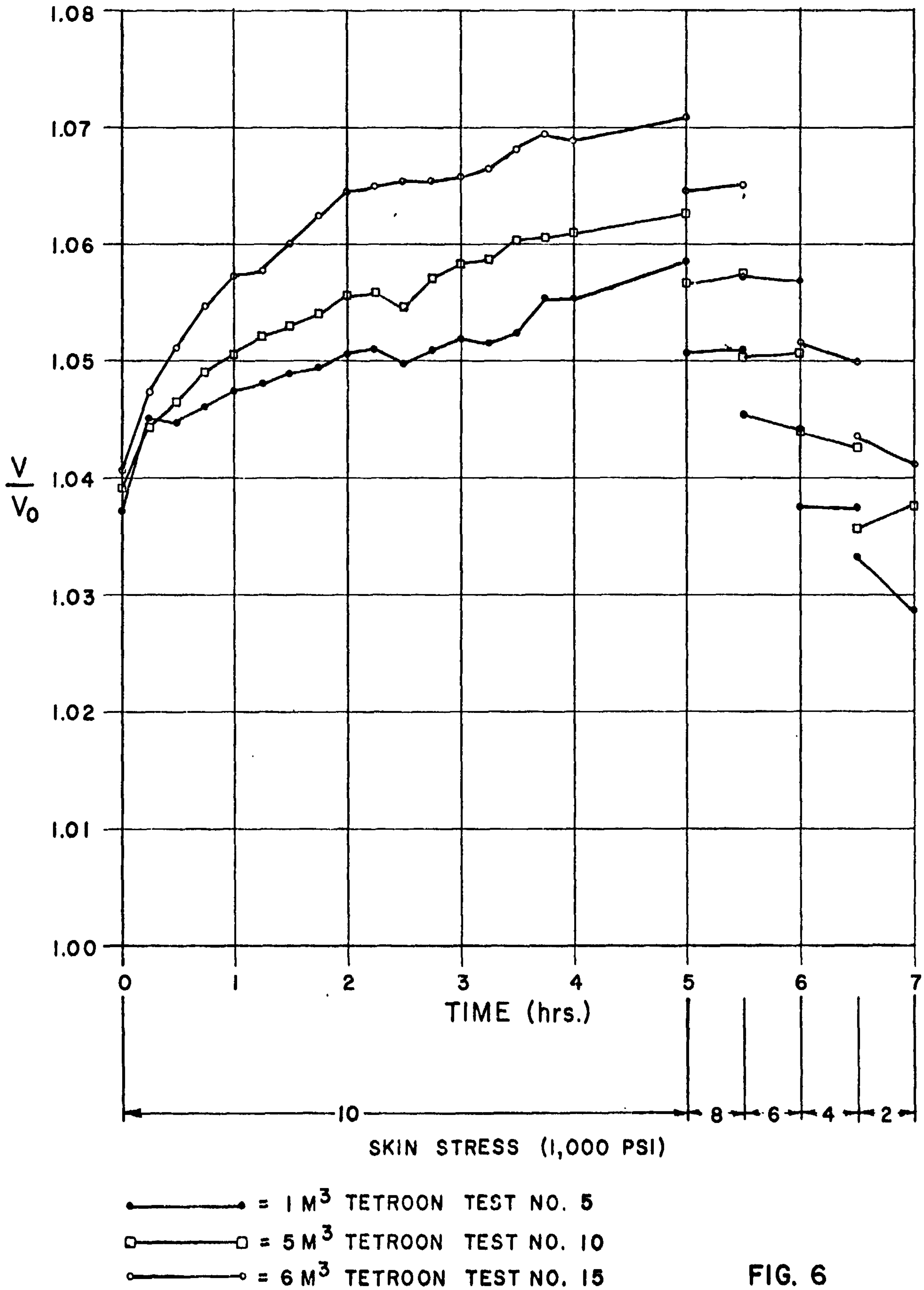


FIG. 6

## 5. CONCLUSIONS AND RECOMMENDATIONS

In order to predict tetroon flight characteristics or to analyze flight trajectories, it would be extremely helpful if the tetroons were to be operating in an elastic region such that the individual volumes would be a unique function of the superpressure. The tests performed under this study suggest that this may be the case for tetroons experiencing stress levels of 6,000 psi and lower, and even possibly as high as 8,000 psi. It is unfortunate that the sequence of testing did not allow for a confirmation of the hypothesis of elastic volume recovery. Future tests of the nature of those performed here would help to prove or disprove this hypothesis.

It is possible that the tetroon volume may also become a function of skin temperature as well as superpressure; i.e., the physical characteristics of the film may change with actual film temperature. This is known to be true for large temperature changes, but it may be possible to demonstrate that the volume changing characteristics are relatively insignificant over the temperature regions of interest. In order to accurately assess this characteristic of tetroons it would be desirable to perform volume measurement tests on tetroons inside temperature controlled chambers.

It must also be remembered that superpressure is a function of supertemperature. It consequently becomes a problem to predict what the actual superpressure on a tetroon is with a changing radiation environment or with variations in the radiometric properties of the membrane material. It would be desirable to measure the actual supertemperature between the helium and the air of flying tetroons under a variety of ambient conditions and with different levels of coloring in the film. With accurate supertemperature information, one can much more accurately predict the value of the helium temperature at float which is necessary for accurate volume prediction.

In summary, it would be desirable that the following tests be performed under future work.

a) Volume hysteresis effect when stress levels of 6,000 and 8,000 psi are not exceeded.

b) Volume increase characteristics at a variety of tetroon skin temperatures.

c) Supertemperature measurements during flight on tetroons under a variety of ambient conditions and with a variety of materials.

## References

1. Grass, L. A., Superpressure Balloon for Constant Level Flight, AFCRL-62-824, Air Force Cambridge Research Laboratories. August 1962.

2. Delver, Norbert F., and Booth, Howard G., The Deployment of Superpressured Balloons, COM-75-10451, Weather Bureau Research Station, Las Vegas, Nevada. March 1965.

Appendix

Test # 1 Date: 21 December 1976

Tetroon Type: T-PR51-1.000

Tetroon Weight: 0.4687 kg

Tare Weight: 0.000 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0K$) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | .5795 | 5 | 967.7 | 293.6 | 1.0595 | 1.0000 |
| 0 | .5830 | 17.7 | 967.6 | 293.6 | 1.0726 | 1.0124 |
| .25 | .5817 | 17.7 | 967.2 | 293.6 | 1.0717 | 1.0115 |
| .50 | .5815 | 17.7 | 967.1 | 293.1 | 1.0698 | 1.0097 |
| .75 | .5805 | 17.9 | 969.9 | 293.5 | 1.0657 | 1.0059 |
| 1.00 | .5800 | 17.7 | 966.5 | 293.4 | 1.0689 | 1.0089 |
| 1.25 | .5800 | 17.7 | 966.1 | 293.4 | 1.0693 | 1.0092 |
| 1.50 | .5798 | 17.5 | 965.8 | 293.4 | 1.0694 | 1.0093 |
| 1.75 | .5790 | 17.5 | 965.2 | 293.5 | 1.0707 | 1.0106 |
| 2.00 | .5787 | 17.7 | 964.9 | 293.5 | 1.0708 | 1.0107 |
| 2.25 | .5790 | 17.4 | 964.75 | 293.5 | 1.0712 | 1.0110 |
| 2.50 | .5743 | 17.8 | 964.2 | 294.9 | 1.0671 | 1.0072 |
| 3.00 | .5670 | 17.9 | 963.4 | 295.2 | 1.0667 | 1.0068 |
| 3.25 | .5670 | 17.7 | 962.95 | 295.8 | 1.0693 | 1.0092 |
| 3.50 | .5673 | 17.7 | 962.2 | 295.8 | 1.0704 | 1.0103 |
| 3.75 | .5668 | 17.8 | 961.8 | 295.7 | 1.0700 | 1.0099 |
| 4.00 | .5665 | 17.9 | 960.6 | 295.6 | 1.0707 | 1.0106 |
| 4.00 | .5790 | 89.4 | 959.6 | 296.0 | 1.1163 | 1.0536 |
| 5.00 | .5937 | 89.4 | 958.7 | 295.9 | 1.1324 | 1.0688 |
| 5.00 | .5910 | 71.5 | 958.7 | 295.9 | 1.1261 | 1.0629 |
| 5.50 | .5870 | 71.5 | 958.5 | 296.0 | 1.1226 | 1.0596 |
| 6.00 | .5860 | 53.7 | 958.0 | 295.8 | 1.1180 | 1.0552 |
| 6.00 | .5830 | 35.8 | 958.0 | 295.8 | 1.1115 | 1.0491 |
| 6.50 | .5830 | 35.3 | 957.7 | 295.2 | 1.1095 | 1.0472 |
| 6.50 | .5800 | 17.9 | 957.7 | 295.2 | 1.1031 | 1.0412 |
| 7.00 | .578 | 18.1 | 957.2 | 295.0 | 1.1008 | 1.0390 |

Test #2
Tetroon Type: T-PR51-1.000
Tetroon Weight: 0.4692 kg
Tare Weight: 0.013 kg

Date: 28 December 1976

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0$K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | .5444 | 5.0 | 956.0 | 295.0 | 1.0554 | 1.0000 |
| 0 | .5522 | 35.8 | 955.95 | 294.8 | 1.0683 | 1.0122 |
| .25 | .5537 | 35.8 | 955.6 | 294.5 | 1.0691 | 1.0130 |
| .50 | .5524 | 35.8 | 955.8 | 294.7 | 1.0683 | 1.0122 |
| .75 | .5524 | 35.8 | 955.65 | 294.6 | 1.0681 | 1.0120 |
| 1.00 | .5524 | 35.8 | 955.2 | 294.7 | 1.0689 | 1.0128 |
| 1.25 | .5507 | 36.3 | 955.0 | 294.7 | 1.0675 | 1.0115 |
| 1.50 | NR | NR | NR | NR | NR | NR |
| 1.75 | .5507 | 35.8 | 954.6 | 295.0 | 1.0690 | 1.0129 |
| 2.00 | .5407 | 35.8 | 954.2 | 296.7 | 1.0652 | 1.0093 |
| 2.25 | .5457 | 35.8 | 954.1 | 295.8 | 1.0672 | 1.0112 |
| 2.50 | .5457 | 36.0 | 954.1 | 295.9 | 1.0676 | 1.0116 |
| 2.75 | .5472 | 35.8 | 953.9 | 295.8 | 1.0690 | 1.0129 |
| 3.00 | .5427 | 35.8 | 953.75 | 296.2 | 1.0659 | 1.0099 |
| 3.25 | .5407 | 35.8 | 953.0 | 296.3 | 1.0651 | 1.0092 |
| 3.50 | .5427 | 35.8 | 953.0 | 296.0 | 1.0661 | 1.0101 |
| 3.75 | .5437 | 36.3 | 952.1 | 296.0 | 1.0682 | 1.0121 |
| 4.00 | .5437 | 35.8 | 951.7 | 295.9 | 1.0682 | 1.0121 |
| 4.00 | .5577 | 89.45 | 951.5 | 295.5 | 1.0915 | 1.0342 |
| 5.00 | .5687 | 89.45 | 950.9 | 295.9 | 1.1052 | 1.0472 |
| 5.00 | .5647 | 71.56 | 950.9 | 295.9 | 1.0976 | 1.0400 |
| 5.50 | .5637 | 71.56 | 950.7 | 296.2 | 1.0979 | 1.0403 |
| 5.50 | .5617 | 53.67 | 950.6 | 296.0 | 1.0919 | 1.0346 |
| 6.00 | .5637 | 53.67 | 950.7 | 295.8 | 1.0931 | 1.0357 |
| 6.00 | .5607 | 35.8 | 950.7 | 295.8 | 1.0867 | 1.0297 |
| 6.50 | .5602 | 35.8 | 951.1 | 295.8 | 1.0857 | 1.0287 |
| 6.62 | .5512 | 17.9 | 951.3 | 296.2 | 1.0743 | 1.0179 |
| 7.00 | .5517 | 17.9 | 951.8 | 296.0 | 1.0735 | 1.0171 |

Test #3 Date: 30 December 1976

Tetroon Type: T-PR51-1.000

Tetroon Weight: 0.4704 kg

Tare Weight: 0.0165 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0$K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | .5365 | 5 | 950.1 | 295.0 | 1.0586 | 1.000 |
| 0 | .5473 | 53.7 | 950.1 | 295.0 | 1.0787 | 1.0190 |
| .25 | .5483 | 53.7 | 950.1 | 295.0 | 1.0797 | 1.0199 |
| .50 | .5493 | 53.7 | 950.1 | 295.0 | 1.0808 | 1.0210 |
| .75 | .5483 | 53.7 | 950.1 | 294.9 | 1.0794 | 1.0197 |
| 1.00 | .5483 | 53.7 | 950.1 | 295.0 | 1.0797 | 1.0199 |
| 1.25 | .5483 | 53.7 | 950.0 | 295.0 | 1.0798 | 1.0200 |
| 1.50 | .5473 | 53.7 | 950.0 | 295.0 | 1.0788 | 1.0191 |
| 1.75 | .5475 | 53.7 | 950.1 | 295.0 | 1.0789 | 1.0192 |
| 2.00 | .5475 | 53.7 | 950.0 | 295.0 | 1.0790 | 1.0193 |
| 2.25 | .5475 | 53.7 | 949.25 | 295.0 | 1.0799 | 1.0201 |
| 2.50 | .5478 | 53.7 | 949.1 | 295.0 | 1.0803 | 1.0205 |
| 2.75 | .5473 | 53.7 | 948.6 | 295.0 | 1.0804 | 1.0206 |
| 3.00 | .5463 | 53.7 | 948.3 | 295.0 | 1.0797 | 1.0199 |
| 3.25 | .5465 | 53.7 | 948.1 | 294.9 | 1.0788 | 1.0191 |
| 3.50 | .5455 | 53.7 | 947.75 | 294.9 | 1.0791 | 1.0194 |
| 3.75 | .5455 | 53.7 | 947.3 | 295.0 | 1.0796 | 1.0198 |
| 4.00 | .5438 | 53.7 | 947.1 | 295.0 | 1.0785 | 1.0188 |
| 4.00 | .5528 | 89.5 | 946.9 | 295.1 | 1.0952 | 1.0346 |
| 5.00 | .5633 | 89.5 | 946.3 | 295.0 | 1.1066 | 1.0453 |
| 5.10 | .5603 | 71.6 | 946.2 | 295.0 | 1.1001 | 1.0392 |
| 5.50 | .5598 | 71.6 | 946.0 | 295.0 | 1.0998 | 1.0389 |
| 5.50 | .5553 | 53.7 | 946.0 | 295.0 | 1.0918 | 1.0314 |
| 6.00 | .5553 | 53.7 | 945.5 | 295.2 | 1.0931 | 1.0326 |
| 6.00 | .5533 | 35.8 | 945.4 | 295.2 | 1.0878 | 1.0276 |
| 6.50 | .5523 | 35.8 | 945.1 | 295.0 | 1.0863 | 1.0262 |
| 6.50 | .5493 | 17.8 | 945.1 | 295.0 | 1.0799 | 1.0201 |
| 7.00 | .5488 | 17.8 | 944.8 | 294.8 | 1.0790 | 1.0193 |

Test #4 Date: 18 January 1977

Tetroon Type: T-PR51-1.000

Tetroon Weight: 0.4664 kg

Tare Weight 0.0158 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0$K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| 0 | .5561 | 5 | 975.3 | 294.9 | 1.0459 | 1.0000 |
| 0 | .5700 | 71.6 | 975.4 | 295.2 | 1.0726 | 1.0255 |
| .25 | .5735 | 71.6 | 975.7 | 295.2 | 1.0759 | 1.0287 |
| .50 | .5755 | 71.6 | 975.7 | 295.0 | 1.0772 | 1.0299 |
| .75 | .5750 | 71.6 | 975.65 | 294.9 | 1.0764 | 1.0292 |
| 1.00 | .5770 | 71.6 | 975.8 | 295.1 | 1.0790 | 1.0316 |
| 1.25 | .5770 | 71.6 | 975.9 | 295.0 | 1.0785 | 1.0312 |
| 1.50 | .5780 | 71.6 | 975.8 | 294.7 | 1.0785 | 1.0312 |
| 1.75 | .5760 | 71.6 | 976.0 | 295.1 | 1.0777 | 1.0304 |
| 2.00 | .5760 | 71.6 | 976.0 | 295.2 | 1.0781 | 1.0308 |
| 2.25 | .5760 | 71.6 | 976.0 | 295.2 | 1.0781 | 1.0308 |
| 2.75 | .5720 | 71.6 | 975.55 | 296.2 | 1.0781 | 1.0308 |
| 3.00 | .5740 | 71.6 | 975.5 | 295.8 | 1.0788 | 1.0315 |
| 3.25 | .5730 | 71.6 | 975.6 | 296.0 | 1.0784 | 1.0311 |
| 3.50 | .5705 | 71.6 | 975.7 | 296.2 | 1.0764 | 1.0292 |
| 3.75 | .5730 | 71.6 | 975.4 | 296.1 | 1.0790 | 1.0316 |
| 4.00 | .5720 | 71.6 | 975.1 | 296.2 | 1.0786 | 1.0313 |
| 4.00 | .5750 | 89.4 | 974.7 | 296.2 | 1.0854 | 1.0378 |
| 4.50 | .5800 | 89.4 | 974.1 | 296.3 | 1.0916 | 1.0437 |
| 4.50 | .5770 | 71.6 | 974.1 | 296.3 | 1.0853 | 1.0377 |
| 5.00 | .5770 | 71.6 | 973.8 | 296.3 | 1.0856 | 1.0380 |
| 5.00 | .5720 | 53.7 | 973.8 | 296.3 | 1.0773 | 1.0300 |
| 5.50 | .5710 | 53.7 | 973.8 | 296.7 | 1.0777 | 1.0304 |
| 5.50 | .5685 | 35.8 | 973.8 | 296.7 | 1.0719 | 1.0249 |
| 6.00 | .5685 | 35.8 | 972.8 | 296.3 | 1.0716 | 1.0246 |
| 6.00 | .5656 | 17.9 | 972.8 | 296.3 | 1.0655 | 1.0187 |
| 6.50 | .5616 | 17.9 | 972.6 | 296.6 | 1.0627 | 1.0161 |

Test #5

Tetroon Type: T-PR51-1.000

Tetroon Weight: 0.4677 kg

Tare Weight: 0.0168 kg

Date: 20 January 1977

| Time (hr) | Scale (kg) | $\Delta P$ (mb) | $P_a$ (mb) | T ($^0K$) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | .5313 | 5 | 954.95 | 295.7 | 1.0479 | 1.0000 |
| 0 | .5536 | 89.4 | 955.1 | 295.9 | 1.0869 | 1.0372 |
| .25 | .5621 | 89.4 | 955.45 | 295.9 | 1.0952 | 1.0451 |
| .50 | .5621 | 89.4 | 955.55 | 295.8 | 1.0949 | 1.0449 |
| .75 | .5626 | 89.4 | 955.85 | 296.1 | 1.0962 | 1.0461 |
| 1.00 | .5646 | 89.4 | 956.30 | 296.1 | 1.0977 | 1.0475 |
| 1.25 | .5651 | 89.4 | 956.65 | 296.2 | 1.0982 | 1.0480 |
| 1.50 | .5666 | 89.4 | 956.85 | 296.1 | 1.0992 | 1.0490 |
| 1.75 | .5676 | 89.4 | 957.25 | 296.1 | 1.0998 | 1.0495 |
| 2.00 | .5686 | 89.4 | 957.45 | 296.2 | 1.1009 | 1.0506 |
| 2.25 | .5686 | 89.4 | 957.45 | 296.3 | 1.1013 | 1.0510 |
| 2.50 | .5676 | 89.4 | 957.50 | 296.3 | 1.1002 | 1.0499 |
| 2.75 | .5686 | 89.4 | 957.50 | 296.3 | 1.1013 | 1.0510 |
| 3.00 | .5696 | 89.4 | 957.40 | 296.3 | 1.1024 | 1.0520 |
| 3.25 | .5686 | 89.4 | 957.30 | 296.4 | 1.1019 | 1.0515 |
| 3.50 | .5681 | 89.4 | 957.30 | 296.5 | 1.1028 | 1.0524 |
| 3.75 | .5726 | 89.4 | 957.50 | 296.4 | 1.1058 | 1.0553 |
| 4.00 | .5726 | 89.4 | 957.5 | 296.4 | 1.1058 | 1.0553 |
| 5.00 | .5736 | 89.4 | 957.5 | 297.0 | 1.1091 | 1.0584 |
| 5.00 | .5691 | 71.6 | 957.5 | 297.0 | 1.1011 | 1.0508 |
| 5.50 | .5691 | 71.6 | 957.7 | 297.1 | 1.1012 | 1.0509 |
| 5.50 | .5666 | 53.7 | 957.7 | 297.1 | 1.0953 | 1.0452 |
| 6.00 | .5656 | 53.7 | 957.8 | 297.0 | 1.0941 | 1.0441 |
| 6.00 | .5621 | 35.8 | 957.8 | 297.0 | 1.0872 | 1.0375 |
| 6.50 | .5616 | 35.8 | 957.8 | 297.2 | 1.0870 | 1.0373 |
| 6.50 | .5606 | 17.85 | 957.8 | 297.2 | 1.0827 | 1.0332 |
| 7.00 | .5596 | 17.85 | 957.9 | 296.2 | 1.0779 | 1.0286 |

Test #6 Date: 25 January 1977

Tetroon Type: T-PR102-5.000

Tetroon Weight: 2.631 kg

Tare Weight: 0.013 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0$K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 2.310 | 5 | 964.8 | 295.7 | 5.058 | 1.000 |
| 0 | 2.334 | 20.9 | 965.3 | 295.7 | 5.092 | 1.0067 |
| .25 | 2.337 | 20.9 | 965.35 | 295.6 | 5.095 | 1.0073 |
| .50 | 2.335 | 20.9 | 965.30 | 295.8 | 5.096 | 1.0075 |
| .75 | 2.333 | 20.9 | 965.20 | 295.8 | 5.095 | 1.0073 |
| 1.00 | 2.334 | 20.9 | 965.10 | 295.7 | 5.095 | 1.0073 |
| 1.25 | 2.337 | 20.9 | 965.15 | 295.5 | 5.094 | 1.0071 |
| 1.50 | 2.325 | 20.9 | 965.30 | 295.7 | 5.085 | 1.0053 |
| 1.75 | 2.331 | 20.9 | 965.30 | 295.7 | 5.091 | 1.0065 |
| 2.00 | 2.328 | 20.9 | 965.40 | 296.0 | 5.092 | 1.0067 |
| 2.25 | 2.322 | 20.9 | 965.30 | 295.9 | 5.085 | 1.0053 |
| 2.50 | 2.321 | 20.9 | 965.20 | 296.2 | 5.090 | 1.0063 |
| 2.75 | 2.312 | 20.9 | 965.20 | 295.7 | 5.072 | 1.0028 |
| 3.00 | 2.308 | 20.9 | 965.30 | 295.7 | 5.067 | 1.0018 |
| 3.25 | 2.305 | 20.9 | 965.30 | 295.7 | 5.064 | 1.0012 |
| 3.50 | 2.308 | 20.9 | 965.30 | 295.8 | 5.067 | 1.0018 |
| 3.75 | 2.308 | 20.9 | 965.10 | 295.8 | 5.068 | 1.0020 |
| 4.00 | 2.314 | 20.9 | 965.05 | 295.9 | 5.078 | 1.0040 |
| 4.00 | 2.420 | 104.6 | 965.05 | 296.0 | 5.262 | 1.0403 |
| 5.00 | 2.498 | 104.6 | 964.80 | 296.1 | 5.346 | 1.0569 |
| 5.00 | 2.483 | 83.6 | 964.80 | 296.1 | 5.311 | 1.0500 |
| 5.50 | 2.486 | 83.6 | 964.85 | 295.8 | 5.309 | 1.0496 |
| 5.50 | 2.467 | 62.8 | 964.85 | 295.8 | 5.271 | 1.0421 |
| 6.00 | 2.471 | 62.8 | 964.9 | 296.0 | 5.273 | 1.0435 |
| 6.00 | 2.455 | 41.9 | 964.9 | 296.0 | 5.243 | 1.0366 |
| 6.50 | 2.457 | 41.9 | 965.1 | 296.1 | 5.246 | 1.0372 |
| 6.50 | 2.443 | 20.9 | 965.1 | 296.1 | 5.213 | 1.0306 |
| 7.00 | 2.433 | 20.9 | 965.35 | 296.0 | 5.200 | 1.0281 |

Test #7 Date: 27 January 1977
Tetroon Type: T-PR51-5.000
Tetroon Weight: 2.618 kg
Tare Weight: 0.012 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0$K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 2.438 | 5 | 970.9 | 294.8 | 5.127 | 1.000 |
| 0 | 2.473 | 41.9 | 971.0 | 295.1 | 5.198 | 1.0138 |
| .25 | 2.476 | 41.9 | 971.1 | 295.0 | 5.199 | 1.0140 |
| .50 | 2.478 | 41.9 | 971.45 | 295.1 | 5.201 | 1.0144 |
| .75 | 2.478 | 41.9 | 971.9 | 295.3 | 5.202 | 1.0146 |
| 1.00 | 2.476 | 41.9 | 972.1 | 295.4 | 5.201 | 1.0144 |
| 1.25 | 2.478 | 41.9 | 972.25 | 295.4 | 5.202 | 1.0146 |
| 1.50 | 2.479 | 41.9 | 972.40 | 295.5 | 5.204 | 1.0150 |
| 1.75 | 2.481 | 41.9 | 972.6 | 295.6 | 5.207 | 1.0156 |
| 2.00 | 2.477 | 41.9 | 972.75 | 295.6 | 5.202 | 1.0146 |
| 2.25 | 2.479 | 41.9 | 972.85 | 295.5 | 5.202 | 1.0146 |
| 2.50 | 2.479 | 41.9 | 973.0 | 295.5 | 5.201 | 1.0144 |
| 2.75 | 2.480 | 41.9 | 973.35 | 295.7 | 5.203 | 1.0148 |
| 3.00 | 2.469 | 41.9 | 973.70 | 296.1 | 5.201 | 1.0144 |
| 3.25 | 2.469 | 41.9 | 973.7 | 296.2 | 5.203 | 1.0148 |
| 3.50 | 2.468 | 41.9 | 973.85 | 296.3 | 5.199 | 1.0140 |
| 3.75 | 2.465 | 41.9 | 973.75 | 296.3 | 5.197 | 1.0137 |
| 4.00 | 2.473 | 41.9 | 973.80 | 296.4 | 5.206 | 1.0154 |
| 4.00 | 2.558 | 104.6 | 973.8 | 296.6 | 5.352 | 1.0439 |
| 5.00 | 2.606 | 104.9 | 973.8 | 297.0 | 5.408 | 1.0548 |
| 5.00 | 2.588 | 83.6 | 973.8 | 297.0 | 5.371 | 1.0476 |
| 5.50 | 2.588 | 83.6 | 973.25 | 297.2 | 5.378 | 1.0490 |
| 5.50 | 2.571 | 62.8 | 973.25 | 297.2 | 5.342 | 1.0419 |
| 6.00 | 2.576 | 62.8 | 973.20 | 297.3 | 5.349 | 1.0433 |
| 6.00 | 2.553 | 41.9 | 973.2 | 297.3 | 5.307 | 1.0351 |
| 6.50 | 2.551 | 41.9 | 973.2 | 297.2 | 5.303 | 1.0343 |
| 6.50 | 2.530 | 20.9 | 973.2 | 297.2 | 5.264 | 1.0267 |
| 7.00 | 2.530 | 20.9 | 973.3 | 297.6 | 5.270 | 1.0279 |

Test #8 Date: 2 February 1977

Tetroon Type: T-PR102-5.000

Tetroon Weight: 2.627 kg

Tare Weight: 0.024 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T (°K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 2.276 | 5 | 954.0 | 296.2 | 5.096 | 1.000 |
| 0 | 2.345 | 62.8 | 954.0 | 296.1 | 5.217 | 1.0237 |
| .25 | 2.346 | 62.8 | 954.0 | 296.2 | 5.220 | 1.0259 |
| .50 | 2.335 | 62.8 | 954.1 | 296.4 | 5.211 | 1.0226 |
| .75 | 2.341 | 62.8 | 954.15 | 296.2 | 5.213 | 1.0230 |
| 1.00 | 2.342 | 62.8 | 954.10 | 296.5 | 5.220 | 1.0243 |
| 1.25 | 2.339 | 62.8 | 954.7 | 296.6 | 5.215 | 1.0234 |
| 1.50 | 2.350 | 62.8 | 954.9 | 296.5 | 5.224 | 1.0251 |
| 1.75 | 2.353 | 62.8 | 955.0 | 296.4 | 5.225 | 1.0253 |
| 2.00 | 2.337 | 62.8 | 955.0 | 296.7 | 5.213 | 1.0230 |
| 2.25 | 2.340 | 62.8 | 955.0 | 296.6 | 5.215 | 1.0234 |
| 2.50 | 2.348 | 62.8 | 955.15 | 296.6 | 5.222 | 1.0247 |
| 2.75 | 2.338 | 62.8 | 955.30 | 296.8 | 5.215 | 1.0234 |
| 3.25 | 2.343 | 62.8 | 955.10 | 296.7 | 5.219 | 1.0241 |
| 3.50 | 2.328 | 62.8 | 955.0 | 296.7 | 5.204 | 1.0212 |
| 3.75 | 2.345 | 62.8 | 954.9 | 296.8 | 5.224 | 1.0251 |
| 4.00 | 2.343 | 62.8 | 954.5 | 297.1 | 5.229 | 1.0261 |
| 4.00 | 2.383 | 104.6 | 954.5 | 297.1 | 5.309 | 1.0418 |
| 5.00 | 2.428 | 104.6 | 953.9 | 297.3 | 5.363 | 1.0524 |
| 5.00 | 2.419 | 83.6 | 953.9 | 297.3 | 5.335 | 1.0469 |
| 5.50 | 2.408 | 83.6 | 953.7 | 297.4 | 5.326 | 1.0451 |
| 5.50 | 2.398 | 62.8 | 953.7 | 297.4 | 5.297 | 1.0394 |
| 6.00 | 2.403 | 62.8 | 953.3 | 297.3 | 5.303 | 1.0406 |
| 6.00 | 2.385 | 41.9 | 953.3 | 297.3 | 5.265 | 1.0332 |
| 6.50 | 2.388 | 41.9 | 953.0 | 297.3 | 5.270 | 1.0341 |
| 6.50 | 2.370 | 20.9 | 953.0 | 297.3 | 5.232 | 1.0267 |
| 7.00 | 2.375 | 20.9 | 953.0 | 297.2 | 5.236 | 1.0275 |

Test #9 Date: 7 February 1977

Tetroon Type: T-PR102-5.000

Tetroon Weight: 2.623 kg

Tare Weight: 0.009 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0$K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 2.283 | 5 | 961.7 | 296.4 | 5.047 | 1.000 |
| 0 | 2.368 | 83.6 | 961.7 | 296.4 | 5.202 | 1.0307 |
| .25 | 2.366 | 83.6 | 961.65 | 296.4 | 5.200 | 1.0303 |
| .50 | 2.368 | 83.6 | 961.6 | 296.5 | 5.204 | 1.0311 |
| .75 | 2.373 | 83.6 | 961.5 | 296.5 | 5.210 | 1.0323 |
| 1.00 | 2.373 | 83.6 | 961.45 | 296.6 | 5.210 | 1.0325 |
| 1.25 | 2.375 | 83.6 | 961.4 | 296.6 | 5.213 | 1.0329 |
| 1.50 | 2.375 | 83.6 | 961.25 | 296.6 | 5.214 | 1.0331 |
| 1.75 | 2.370 | 83.6 | 961.15 | 296.6 | 5.209 | 1.0321 |
| 2.00 | 2.373 | 83.6 | 961.3 | 296.7 | 5.215 | 1.0333 |
| 2.25 | 2.370 | 83.6 | 961.35 | 296.8 | 5.213 | 1.0329 |
| 2.50 | 2.375 | 83.6 | 961.35 | 296.9 | 5.220 | 1.0343 |
| 2.75 | 2.374 | 83.6 | 961.4 | 296.9 | 5.219 | 1.0341 |
| 3.00 | 2.380 | 83.6 | 961.3 | 296.9 | 5.226 | 1.0355 |
| 3.25 | 2.380 | 83.6 | 961.25 | 297.0 | 5.228 | 1.0359 |
| 3.50 | 2.377 | 83.6 | 961.30 | 297.4 | 5.231 | 1.0365 |
| 3.75 | 2.371 | 83.6 | 961.25 | 297.5 | 5.227 | 1.0357 |
| 4.00 | 2.373 | 83.6 | 961.10 | 297.4 | 5.228 | 1.0359 |
| 4.00 | 2.398 | 104.6 | 961.20 | 297.4 | 5.272 | 1.0446 |
| 5.00 | 2.408 | 104.6 | 961.0 | 297.9 | 5.293 | 1.0487 |
| 5.00 | 2.397 | 83.6 | 961.0 | 297.9 | 5.263 | 1.0428 |
| 5.50 | 2.408 | 83.6 | 961.0 | 297.7 | 5.271 | 1.0444 |
| 5.50 | 2.400 | 62.8 | 961.0 | 297.7 | 5.244 | 1.0390 |
| 6.00 | 2.405 | 62.8 | 961.1 | 297.3 | 5.241 | 1.0384 |
| 6.00 | 2.394 | 41.9 | 961.1 | 297.3 | 5.212 | 1.0327 |
| 6.50 | 2.387 | 41.9 | 961.1 | 297.4 | 5.204 | 1.0311 |
| 6.50 | 2.377 | 20.9 | 961.1 | 297.4 | 5.176 | 1.0256 |
| 7.00 | 2.370 | 20.9 | 961.1 | 297.4 | 5.169 | 1.0242 |

Test #10 Date: 8 February 1977

Tetroon Type: T-PR102-5.000

Tetroon Weight: 2.619 kg

Tare Weight: .004 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T (°K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 2.280 | 5 | 958.3 | 296.1 | 5.047 | 1.000 |
| 0 | 2.389 | 104.6 | 958.3 | 296.0 | 5.245 | 1.0392 |
| .25 | 2.412 | 104.6 | 958.25 | 296.1 | 5.271 | 1.0444 |
| .50 | 2.423 | 104.6 | 958.2 | 296.1 | 5.283 | 1.0468 |
| .75 | 2.433 | 104.6 | 958.2 | 296.2 | 5.295 | 1.0491 |
| 1.00 | 2.440 | 104.6 | 958.1 | 296.2 | 5.303 | 1.0507 |
| 1.25 | 2.443 | 104.6 | 957.8 | 296.3 | 5.310 | 1.0521 |
| 1.50 | 2.448 | 104.6 | 957.75 | 296.3 | 5.315 | 1.0531 |
| 1.75 | 2.454 | 104.6 | 957.7 | 296.2 | 5.320 | 1.0541 |
| 2.00 | 2.453 | 104.6 | 957.75 | 296.7 | 5.328 | 1.0557 |
| 2.25 | 2.453 | 104.6 | 957.75 | 296.8 | 5.329 | 1.0559 |
| 2.50 | 2.442 | 104.6 | 957.8 | 297.1 | 5.323 | 1.0547 |
| 2.75 | 2.453 | 104.6 | 957.8 | 297.1 | 5.335 | 1.0571 |
| 3.00 | 2.461 | 104.6 | 957.8 | 297.0 | 5.341 | 1.0583 |
| 3.25 | 2.463 | 104.6 | 957.6 | 297.0 | 5.344 | 1.0588 |
| 3.50 | 2.468 | 104.6 | 957.4 | 297.0 | 5.351 | 1.0602 |
| 3.75 | 2.466 | 104.6 | 957.3 | 297.2 | 5.353 | 1.0606 |
| 4.00 | 2.468 | 104.6 | 957.3 | 297.2 | 5.355 | 1.0610 |
| 5.00 | 2.463 | 104.6 | 956.2 | 297.6 | 5.363 | 1.0626 |
| 5.00 | 2.453 | 83.6 | 956.2 | 297.6 | 5.333 | 1.0567 |
| 5.50 | 2.452 | 83.6 | 955.7 | 297.7 | 5.337 | 1.0575 |
| 5.50 | 2.436 | 62.8 | 955.7 | 297.7 | 5.302 | 1.0505 |
| 6.00 | 2.436 | 62.8 | 955.7 | 297.8 | 5.303 | 1.0507 |
| 6.00 | 2.420 | 41.9 | 955.7 | 297.8 | 5.268 | 1.0438 |
| 6.50 | 2.411 | 41.9 | 955.4 | 297.9 | 5.262 | 1.0426 |
| 6.50 | 2.395 | 20.9 | 955.4 | 297.9 | 5.227 | 1.0357 |
| 7.00 | 2.406 | 20.9 | 955.5 | 297.9 | 5.238 | 1.0378 |

Test #11 Date: 9 February 1977

Tetroon Type: T-PR102-6.000

Tetroon Weight: 2.940 kg

Tare Weight: .0055 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T (°K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 2.861 | 5 | 961.0 | 296.9 | 5.976 | 1.000 |
| 0 | 2.885 | 19.75 | 961.0 | 297.0 | 6.018 | 1.0070 |
| .25 | 2.885 | 19.75 | 961.0 | 297.1 | 6.020 | 1.0074 |
| .50 | 2.902 | 19.75 | 961.0 | 296.9 | 6.034 | 1.0097 |
| 1.00 | 2.886 | 19.75 | 961.0 | 297.3 | 6.025 | 1.0082 |
| 1.25 | 2.884 | 19.75 | 961.0 | 297.3 | 6.023 | 1.0079 |
| 1.50 | 2.887 | 19.75 | 961.0 | 297.5 | 6.030 | 1.0090 |
| 1.75 | 2.880 | 19.75 | 961.0 | 297.5 | 6.023 | 1.0079 |
| 2.00 | 2.887 | 19.75 | 961.0 | 297.8 | 6.036 | 1.0100 |
| 2.25 | 2.872 | 19.75 | 961.0 | 297.9 | 6.023 | 1.0079 |
| 2.50 | 2.877 | 19.75 | 961.0 | 297.9 | 6.028 | 1.0087 |
| 2.[illegible] | 2.872 | 19.75 | 960.9 | 298.1 | 6.027 | 1.0085 |
| 3.25 | 2.889 | 19.75 | 960.9 | 298.1 | 6.045 | 1.0115 |
| 3.50 | 2.873 | 19.75 | 960.8 | 298.1 | 6.029 | 1.0089 |
| 3.75 | 2.873 | 19.75 | 960.65 | 298.5 | 6.038 | 1.0104 |
| 4.00 | 2.874 | 19.75 | 960.5 | 298.4 | 6.038 | 1.0104 |
| 4.00 | 3.002 | 98.74 | 960.5 | 298.5 | 6.256 | 1.0469 |
| 5.00 | 3.060 | 98.74 | 960.0 | 299.1 | 6.333 | 1.0597 |
| 5.00 | 3.054 | 79.0 | 960.0 | 299.1 | 6.305 | 1.0551 |
| 5.50 | 3.070 | 79.0 | 959.9 | 297.4 | 6.287 | 1.0520 |
| 5.50 | 3.055 | 59.24 | 959.9 | 297.4 | 6.250 | 1.0459 |
| 6.00 | 3.065 | 59.24 | 959.9 | 297.3 | 6.259 | 1.0474 |
| 6.00 | 3.049 | 39.5 | 959.9 | 297.3 | 6.221 | 1.0410 |
| 6.50 | 3.053 | 39.5 | 959.9 | 297.2 | 6.225 | 1.0417 |
| 6.50 | 3.035 | 19.75 | 959.9 | 297.2 | 6.186 | 1.0351 |
| 7.00 | 3.035 | 19.75 | 959.9 | 297.1 | 6.186 | 1.0351 |

Test #12 Date: 11 February 1977
Tetroon Type: T-PR102-6.000
Tetroon Weight: 2.954 kg
Tare Weight: .0155 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0K$) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 3.116 | 5 | 963.0 | 296.3 | 6.238 | 1.0000 |
| 0 | 3.127 | 39.5 | 963.0 | 296.4 | 6.287 | 1.0079 |
| .25 | 3.138 | 39.5 | 963.1 | 296.7 | 6.305 | 1.0107 |
| .50 | 3.136 | 39.5 | 963.0 | 296.6 | 6.301 | 1.0101 |
| .75 | 3.136 | 39.5 | 963.1 | 296.9 | 6.307 | 1.0111 |
| 1.00 | 3.134 | 39.5 | 963.2 | 296.8 | 6.302 | 1.0103 |
| 1.25 | 3.148 | 39.5 | 963.1 | 296.2 | 6.304 | 1.0106 |
| 1.50 | 3.153 | 39.5 | 963.1 | 296.1 | 6.307 | 1.0111 |
| 1.75 | 3.160 | 39.5 | 963.1 | 295.8 | 6.308 | 1.0112 |
| 2.00 | 3.148 | 39.5 | 963.0 | 296.1 | 6.303 | 1.0104 |
| 2.25 | 3.133 | 39.5 | 963.0 | 296.9 | 6.304 | 1.0106 |
| 2.50 | 3.128 | 39.5 | 963.1 | 297.1 | 6.303 | 1.0104 |
| 2.75 | 3.128 | 39.5 | 963.1 | 297.0 | 6.301 | 1.0101 |
| 3.00 | 3.138 | 39.5 | 963.2 | 296.6 | 6.302 | 1.0103 |
| 3.25 | 3.150 | 39.5 | 963.3 | 296.1 | 6.303 | 1.0104 |
| 3.50 | 3.156 | 39.5 | 963.2 | 296.0 | 6.308 | 1.0112 |
| 3.75 | 3.156 | 39.5 | 963.2 | 296.0 | 6.308 | 1.0112 |
| 4.00 | 3.155 | 39.5 | 963.2 | 296.0 | 6.307 | 1.0111 |
| 4.00 | 3.258 | 98.74 | 963.0 | 296.0 | 6.478 | 1.0385 |
| 5.00 | 3.326 | 98.74 | 962.5 | 296.1 | 6.555 | 1.0508 |
| 5.00 | 3.306 | 79.0 | 962.5 | 296.1 | 6.512 | 1.0439 |
| 5.50 | 3.303 | 79.0 | 962.4 | 295.9 | 6.505 | 1.0428 |
| 5.50 | 3.293 | 59.24 | 962.4 | 295.9 | 6.473 | 1.0377 |
| 6.00 | 3.287 | 52.24 | 962.4 | 295.9 | 6.467 | 1.0367 |
| 6.00 | 3.270 | 39.5 | 962.4 | 295.9 | 6.428 | 1.0305 |
| 6.50 | 3.270 | 39.5 | 962.4 | 295.9 | 6.428 | 1.0306 |
| 6.50 | 3.245 | 19.75 | 962.4 | 295.9 | 6.381 | 1.0229 |
| 7.00 | 3.237 | 19.75 | 962.4 | 295.9 | 6.373 | 1.0216 |

Test #13
Tetroon Type: T-PR102-6.000
Tetroon Weight: 2.950 kg
Tare Weight: .0065 kg

Date: 14 February 1977

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0$K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 3.096 | 5 | 962.7 | 296.3 | 6.206 | 1.000 |
| 0 | 3.163 | 59.24 | 962.7 | 296.3 | 6.332 | 1.0203 |
| .25 | 3.163 | 59.24 | 962.8 | 296.5 | 6.336 | 1.0209 |
| .50 | 3.165 | 59.24 | 962.8 | 296.5 | 6.338 | 1.0213 |
| .75 | 3.166 | 59.24 | 962.8 | 296.6 | 6.341 | 1.0218 |
| 1.00 | 3.165 | 59.24 | 962.8 | 296.8 | 6.344 | 1.0222 |
| 1.25 | 3.156 | 59.24 | 962.8 | 296.9 | 6.337 | 1.0211 |
| 1.50 | 3.148 | 59.24 | 962.8 | 297.2 | 6.335 | 1.0208 |
| 1.75 | 3.166 | 59.24 | 962.8 | 296.7 | 6.343 | 1.0221 |
| 2.00 | 3.177 | 59.24 | 962.8 | 296.3 | 6.346 | 1.0226 |
| 2.25 | 3.177 | 59.24 | 962.8 | 296.2 | 6.344 | 1.0222 |
| 2.50 | 3.182 | 59.24 | 962.8 | 296.1 | 6.347 | 1.0227 |
| 2.75 | 3.176 | 59.24 | 962.5 | 296.1 | 6.342 | 1.0219 |
| 3.00 | 3.161 | 59.24 | 961.5 | 296.9 | 6.344 | 1.0222 |
| 3.25 | 3.158 | 59.24 | 960.8 | 297.1 | 6.357 | 1.0243 |
| 3.50 | 3.163 | 59.24 | 960.7 | 297.1 | 6.362 | 1.0251 |
| 3.75 | 3.166 | 59.24 | 960.6 | 296.0 | 6.366 | 1.0258 |
| 4.00 | 3.171 | 59.24 | 960.6 | 296.2 | 6.352 | 1.0235 |
| 4.00 | 3.243 | 98.74 | 960.55 | 296.2 | 6.470 | 1.0425 |
| 5.00 | 3.326 | 98.74 | 960.10 | 296.3 | 6.562 | 1.0574 |
| 5.00 | 3.303 | 79.0 | 960.10 | 296.3 | 6.516 | 1.0500 |
| 5.50 | 3.305 | 79.0 | 960.10 | 296.3 | 6.518 | 1.0503 |
| 5.50 | 3.283 | 59.24 | 960.10 | 296.3 | 6.474 | 1.0432 |
| 6.00 | 3.288 | 59.24 | 960.20 | 296.2 | 6.476 | 1.0435 |
| 6.00 | 3.268 | 39.5 | 960.20 | 296.2 | 6.4[illegible]4 | 1.0367 |
| 6.50 | 3.260 | 39.5 | 960.20 | 296.1 | 6.424 | 1.0351 |
| 6.50 | 3.246 | 19.75 | 960.20 | 296.1 | 6.388 | 1.0293 |
| 7.00 | 3.238 | 19.75 | 960.20 | 296.1 | 6.380 | 1.0280 |

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Test #14 Date: 15 February 1977
Tetroon Type: T-PR102-6.000
Tetroon Weight: 2.944 kg
Tare Weight: .0135 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T (°K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 3.213 | 5 | 974.4 | 295.3 | 6.230 | 1.0000 |
| 0 | 3.310 | 79.0 | 974.45 | 295.3 | 6.406 | 1.0283 |
| .25 | 3.310 | 79.0 | 974.6 | 295.5 | 6.409 | 1.0287 |
| .50 | 3.316 | 79.0 | 974.6 | 295.5 | 6.415 | 1.0297 |
| .75 | 3.316 | 79.0 | 974.6 | 295.7 | 6.419 | 1.0303 |
| 1.00 | 3.318 | 79.0 | 974.5 | 295.5 | 6.418 | 1.0302 |
| 1.25 | 3.313 | 79.0 | 974.5 | 296.0 | 6.424 | 1.0311 |
| 1.50 | 3.313 | 79.0 | 974.5 | 296.0 | 6.424 | 1.0311 |
| 1.75 | 3.321 | 79.0 | 974.45 | 296.0 | 6.432 | 1.0324 |
| 2.00 | 3.315 | 79.0 | 974.6 | 296.2 | 6.429 | 1.0319 |
| 2.25 | 3.313 | 79.0 | 974.55 | 296.3 | 6.430 | 1.0321 |
| 2.50 | 3.313 | 79.0 | 974.6 | 296.4 | 6.431 | 1.0323 |
| 2.75 | 3.308 | 79.0 | 974.5 | 296.5 | 6.429 | 1.0319 |
| 3.00 | 3.303 | 79.0 | 974.55 | 296.8 | 6.430 | 1.0321 |
| 3.25 | 3.306 | 79.0 | 974.5 | 296.9 | 6.436 | 1.0331 |
| 3.50 | 3.308 | 79.0 | 974.3 | 296.8 | 6.437 | 1.0332 |
| 3.75 | 3.305 | 79.0 | 974.1 | 296.9 | 6.437 | 1.0332 |
| 4.00 | 3.310 | 79.0 | 974.0 | 297.0 | 6.445 | 1.0345 |
| 4.00 | 3.331 | 98.74 | 974.0 | 296.8 | 6.484 | 1.0408 |
| 5.00 | 3.382 | 98.74 | 973.2 | 296.9 | 6.554 | 1.0520 |
| 5.00 | 3.357 | 79.0 | 973.2 | 296.9 | 6.497 | 1.0429 |
| 5.50 | 3.357 | 79.0 | 972.8 | 297.0 | 6.502 | 1.0437 |
| 5.50 | 3.331 | 59.24 | 972.8 | 297.0 | 6.454 | 1.0360 |
| 6.00 | 3.315 | 59.24 | 972.5 | 297.7 | 6.455 | 1.0361 |
| 6.00 | 3.290 | 39.50 | 972.5 | 297.7 | 6.408 | 1.0286 |
| 6.50 | 3.280 | 39.50 | 972.35 | 297.8 | 6.401 | 1.0274 |
| 6.50 | 3.255 | 19.75 | 972.35 | 297.8 | 6.354 | 1.0199 |
| 7.00 | 3.274 | 19.75 | 972.30 | 297.0 | 6.357 | 1.0204 |

Test #15 Date: 16 February 1977

Tetroon Type: T-PR102-6.000

Tetroon Weight: 2.929 kg

Tare Weight: .0035 kg

| Time (hr) | Scale (kg) | ΔP (mb) | $P_a$ (mb) | T ($^0$K) | V ($m^3$) | $V/V_o$ |
|---|---|---|---|---|---|---|
| Initial | 3.033 | 5 | 950.5 | 296.4 | 6.198 | 1.0000 |
| 0 | 3.175 | 98.74 | 950.5 | 296.6 | 6.451 | 1.0408 |
| .25 | 3.213 | 98.74 | 950.45 | 296.6 | 6.492 | 1.0474 |
| .50 | 3.237 | 98.74 | 950.45 | 296.5 | 6.515 | 1.0511 |
| .75 | 3.255 | 98.74 | 950.45 | 296.7 | 6.538 | 1.0549 |
| 1.00 | 3.270 | 98.74 | 950.45 | 296.7 | 6.554 | 1.0574 |
| 1.25 | 3.273 | 98.74 | 950.5 | 296.7 | 6.557 | 1.0579 |
| 1.50 | 3.283 | 98.74 | 950.5 | 296.8 | 6.570 | 1.0600 |
| 1.75 | 3.297 | 98.74 | 950.5 | 296.8 | 6.585 | 1.0624 |
| 2.00 | 3.310 | 98.74 | 950.5 | 296.8 | 6.598 | 1.0645 |
| 2.25 | 3.313 | 98.74 | 950.6 | 296.8 | 6.601 | 1.0650 |
| 2.50 | 3.312 | 98.74 | 950.8 | 297.0 | 6.603 | 1.0653 |
| 2.75 | 3.309 | 98.74 | 951.0 | 297.2 | 6.603 | 1.0653 |
| 3.00 | 3.305 | 98.74 | 951.0 | 297.5 | 6.605 | 1.0657 |
| 3.25 | 3.335 | 98.74 | 951.5 | 296.4 | 6.609 | 1.0663 |
| 3.50 | 3.353 | 98.74 | 951.7 | 296.1 | 6.620 | 1.0681 |
| 3.75 | 3.370 | 98.74 | 951.9 | 295.8 | 6.629 | 1.0695 |
| 4.00 | 3.340 | 98.74 | 951.9 | 297.0 | 6.625 | 1.0689 |
| 5.00 | 3.378 | 98.74 | 952.9 | 296.1 | 6.638 | 1.0710 |
| 5.00 | 3.362 | 79.0 | 952.9 | 296.1 | 6.598 | 1.0645 |
| 5.50 | 3.362 | 79.0 | 953.2 | 296.3 | 6.601 | 1.0650 |
| 5.50 | 3.338 | 59.24 | 953.2 | 296.3 | 6.554 | 1.0574 |
| 6.00 | 3.324 | 59.24 | 954.0 | 297.1 | 6.551 | 1.0570 |
| 6.00 | 3.313 | 39.5 | 954.0 | 297.1 | 6.518 | 1.0516 |
| 6.50 | 3.327 | 39.5 | 955.0 | 296.3 | 6.508 | 1.0500 |
| 6.50 | 3.310 | 19.75 | 955.0 | 296.3 | 6.469 | 1.0437 |
| 7.00 | 3.297 | 19.75 | 955.1 | 296.2 | 6.452 | 1.0410 |