ULTRASONIC ATTENUATION PROPERTIES IN FATTY RAT LIVER AS A FUNCTION OF TISSUE CONSTITUENT CONCENTRATION

BY

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THESIS

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CHAPTER 1

INTRODUCTION

Ultrasound has been widely used to image tissue and has proven to be another successful noninvasive imaging technique. Recently, there has been increased interest concerning the use of ultrasound to quantitatively characterize tissue. One means of extracting useful numbers using ultrasound has been to measure the degree by which the tissue attenuates an ultrasonic wave. The attenuation coefficient is a measure of the total loss of a wave as it passes though a medium. This loss is due to heating, reflection, scattering, diffraction, and refraction. The intent of this study was to use the radiation force balance technique to make attenuation measurements on the livers of rats that were subjected to a diet that causes a fatty buildup in the liver which mocks fatty liver disease. At present, early diagnosis of liver diseases in humans is difficult. By the time the disease is diagnosed, it is often "too far along" to be effectively treated. It is the hope of this and other studies to provide a noninvasive technique which will allow for earlier diagnosis and subsequent treatment of this disease.

A total of 1,752 insertion loss measurements were made on thirty rat specimens maintained on an orotic acid diet for varying lengths of time (from 0 to 10 days). This provided a substantial data base at four frequencies ranging between 1 and 10

MHz. In addition, the samples were measured by others using the transient thermocouple technique (TTT) to obtain an absorption coefficient at 1 MHz and the scanning laser acoustic microscope (SLAM) to obtain an attenuation coefficient and ultrasonic velocity at 100 MHz. The tissues were also biochemically analyzed to determined the water, protein, and lipid contents.

This thesis is organized as follows. Chapter 2 is a literature survey of past measurements pertinent to this study. Chapter 3 is a description of the measurement technique, including a discussion of the theory behind the radiation force balance and the insertion loss technique. Additionally, the experimental protocol will be described, including a section on the tissue handling. Chapter 4 contains an explanation of the data handling and the results of the measurements. The data are presented in tables and graphically when appropriate. The raw data will be documented by inclusion in an Appendix.

CHAPTER 2

LITERATURE SURVEY

A great number of studies have looked at the acoustic properties of liver. In this chapter, a brief overview of some of these studies will be presented, with special attention given to those studies that compared the acoustic properties to the tissue properties, either composition or pathology.

2.1 Attenuation Measurements By Various Methods

A great deal of data has been collected on liver from many different species using a number of different methods. In two compilations by Goss et al. (1978 and 1980) attenuation coefficients are presented for the following liver specimens: human, beef, cat, mouse, pig, dog, and rabbit. Acoustic methods used include pulse-echo reflection, pulse transmission, pulse reflection, Pohlman photometer, spectrum analysis, total acoustic power, time delay spectrometry, time of flight, and transient thermocouple.

Pohlhammer et al. (1981) report the values shown in Table 2-1. The tissue measured was fresh (a few hours postmortem) bovine liver stored in normal saline solution at room temperature. The measurements were made using the radiation force balance for the four lower frequencies and the SLAM at 100 MHz. The conversion factor for nepers to decibels is 8.686 dB/Np.

TABLE 2-1 Data from Pohlhammer et al. (1981)

Frequency (MHz)	Attenuation coefficient $\pm$s.d. (Np/cm)	Number of liver specimens	Total number measurements
1.37	0.069 $\pm$ 0.027	6	43
4.15	0.268 $\pm$ 0.077	5	32
6.90	0.477 $\pm$ 0.063	4	21
9.65	0.825 $\pm$ 0.205	2	12
100	15.4 $\pm$ 1.9	8	47

Parker (1983) used three techniques to measure attenuation and two to measure absorption in bovine liver. Table 2-2 contains the data using the radiation force balance technique which is of particular interest here. The data were interpolated from a graph. The tissues were stored at 4°C for as long as 4 hours and some sections were frozen and thawed prior to measurement. All measurements were made at 20°C.

Segal and O´Brien (1983) measured the attenuation of bovine, porcine, and sheep livers, spleens, and pancreases using the radiation force balance. The liver data are presented in Table 2-3. The measurements were made within 5 1/2 hours after slaughter at 24°C in saline.

Ophir et al. (1985) used a narrowband pulse-echo (C-scan) technique to measure attenuation in human liver in vivo. The center frequency of this method is 3.5 MHz. Ten experiments were run on 2 human subjects. The attenuation values measured were 1.67 $\pm$ 0.31 dB/cm and 1.77 $\pm$ 0.24 dB/cm.

2.2 Attenuation Measurements as a Function of Tissue Composition

O´Brien (1977) and Pohlhammer and O´Brien (1980) compared ultrasonic absorption, attenuation, and speed to tissue constitution and have suggested that the ultrasonic propagation properties can be modeled as a function of constituent concentration. The constituents studied were water, protein, collagen, and fat.

In a pilot study of the research in this paper, O´Brien et al. (1987) measured the ultrasonic attenuation and velocity in

TABLE 2-2 Data from Parker (1983)

Frequency (MHz)	Attenuation coefficient (Np/cm/MHz)
1.2	0.43
3.4	0.48
5.6	0.48

TABLE 2-3 Data from Segal and O´Brien (1983)

Animal	Frequency (MHz)	Attenuation coefficient (Np/cm)
Bovine	1.4	0.0597
	4.2	0.258
	7.0	0.533
	9.8	0.868
Porcine	1.4	0.116
	4.2	0.281
	7.0	0.533
	9.8	0.866
Sheep	1.4	0.122
	4.2	0.285
	7.0	0.497
	9.8	0.755

rat livers subjected to an orotic acid diet using the SLAM at 100 MHz. The livers were biochemically analyzed for lipid, water, and protein contents. Multivariant linear regression was used to determine the correlation between the ultrasonic and biochemical properties. The equations resulting from this analysis are shown in Table 2-4 where c, A, L, P, and W represent the ultrasonic properties of velocity and attenuation coefficient, and the tissue properties of lipid, protein, and water concentrations, respectively. The data are divided into 3 groups, the 8 control-fed rats, the 16 orotic acid-fed rats, and all 24 rats. For each regression, an overall F statistic and probability level was determined as well as a probability for each independent variable in the equation. The attenuation regressions proved not to be significant ($p < 0.05$) but the speed regressions for the last two groups showed that lipid and protein significantly influenced speed.

In a similar study, Tervola et al. (1985) fed diets with varying alcohol levels for 4 weeks to rats. Following slaughter the livers were quick-frozen. The samples were analyzed at room temperature using the SLAM at 100 MHz and were biochemically analyzed to determine their fat content. The data are summarized in Table 2-5. The data were fit with a least-squares analysis yielding

$$A = 10.7 + 1.08F \qquad (2.1)$$

where A is the attenuation coefficient in dB/mm and F is the fat concentration in % wet weight. The correlation coefficient is

TABLE 2-4 Data from O´Brien et al. (1987)

Treatment: Control-Fed

$$c = 1455.4 + 6.2(L) + 0.7(P) + 1.1(W) \qquad F = 0.14$$
$$p<0.004 \quad p<0.55 \quad p<0.80 \quad p<0.69 \qquad p<0.93$$

$$A = 29.3 + 0.3(L) - 0.1(P) + 0.2(W) \qquad F = 1.6$$
$$p<0.12 \quad p<0.65 \quad p<0.49 \quad p<0.27 \qquad p<0.32$$

Treatment: Orotic Acid-Fed

$$c = 1588.8 - 2.5(L) - 1.8(P) + 0.3(W) \qquad F = 24.6$$
$$p<0.0001 \quad p<0.048 \quad p<0.05 \quad p<0.76 \qquad p<0.0001$$

$$A = 85.3 - 0.2(L) - 0.6(P) - 0.9(W) \qquad F = 0.43$$
$$p<0.59 \quad p<0.93 \quad p<0.71 \quad p<0.62 \qquad p<0.73$$

Treatment: Control-Fed and Orotic Acid-Fed Combined

$$c = 1580.2 - 2.4(L) - 1.6(P) + 0.4(W) \qquad F = 36.2$$
$$p<0.0001 \quad p<0.056 \quad p<0.084 \quad p<0.70 \qquad p<0.0001$$

$$A = 62.0 + 0.1(L) - 0.4(P) - 0.6(W) \qquad F = 1.8$$
$$p<0.52 \quad p<0.93 \quad p<0.71 \quad p<0.58 \qquad p<0.18$$

TABLE 2-5 Data from Tervola et al. (1985)

Diet	Diet Fat (%)	Ethanol conc. (%)	Number of specimens	Fat conc. (%)	Attenuation coefficient (dB/mm)	Velocity (m/s)
1	8	0	4	3.0	13.0	1500
1	8	30	4	3.8	15.1	1548
2	19	0	4	4.0	15.6	1553
2	19	30	4	4.8	17.6	1542
LD	18.7	0	7	5.2	14.8	1546
LD	18.7	36	5	11.0	23.6	1532

0.69. The analysis also yielded

$$c = 1557 - 2.3F \qquad (2.2)$$

where V is the velocity in m/s. The correlation coefficient is -0.61. This study supports the hypothesis that as tissue fat concentration increases, ultrasonic attenuation increases and velocity decreases.

Bamber et al. (1981) compared speed, attenuation coefficient, and backscattering with measurements of water, fat, and collagen concentration. The results of this study suggest that velocity decreases with increasing water and fat contents, although water content seems to have the greater influence. An increase in water content decreases attenuation and backscattering coefficients, while these acoustic properties increase as fat increases. For collagen, barely significant positive correlations were found for attenuation coefficient and backscattering and no dependence was shown for velocity.

2.3 Attenuation Measurements as a Function of Tissue Pathology

A number of studies have been conducted comparing attenuation measurements with the pathology of the liver. Many different diseases of the liver have been considered. This section will briefly look at the results of some of these papers.

Narayana and Ophir (1983) used a multifrequency narrowband pulse echo substitution method to make attenuation measurements on human livers after autopsy over the frequency range of 1 to 6 MHz. Two normal, two moderately fatty, and one massively fatty livers were studied. The fatty livers showed higher attenuation over most of the frequency range. It was also shown that the fatty livers showed greater nonlinear ultrasonic properties than the normal livers.

Bamber and Hill (1981) in a companion paper to the one previously mentioned, showed that, on average, ultrasound travels about 1.5% slower, is attenuated by about 20% less at 3 MHz, and is backscattered by about 80% less at 3 MHz in liver tumor specimens than in normal liver. Livers with diffuse malignant disease possessed quite different ultrasonic properties than normal liver but the study had insufficient data to draw conclusions.

Kuc (1980) compared in vivo attenuation coefficient measurements with the results of needle biopsies for 14 patients. He concluded that the fatty livers (with one exception) produced lower attenuation values than those for cirrhotic livers.

Maklad et al. (1984) gathered data on 39 normal patients and 35 patients with diffuse liver disease. These results are shown in Table 2-6. The authors suggest that attenuation measurements might be useful in distinguishing between different types of cirrhosis and hepatitis.

Wilson et al. (1984) made similar comparisons between liver pathology and attenuation. These results are shown in Table 2-7. This study produced higher attenuation for all pathologies except mucin-secreting carcinomas.

King et al. (1985) considered three parameters, attenuation, heterogeneity of scatterers, and local scattering strength, to

TABLE 2-6 Data from Maklad et al. (1984)

Diffuse Liver Disease	No. of Patients	Attenuation coeff. (dB/cm/MHz)
Cirrhosis		
Alcoholic	5	Range 0.72 - 0.92
		Mean 0.83 ± 0.0 9
Biliary	2	0.40 & 0.4 1
Postnecrotic	2	0.56 & 0.5 7
Cardiac	4	Mean 0.66 ± 0.07
Hepatitis		
Viral	5	Mean 0.52 ± 0.04
Chronic active	2	0.40 & 0.4 3
Chronic persistent	2	0.49 & 0.5 3
Alcoholic	4	Mean 0.42 ± 0.05
Fatty Infiltration	5	Range 0.37 - 0.66
Diffuse Infiltration		
Lymphoma	1	0.39
Leukemia	1	0.44
Hepatic Artery Infusion	2	0.58 & 0.60

TABLE 2-7 Data from Wilson et al (1984)

Pathology	Number	Attenuation Coefficient (dB/cm/MHz) Range	Average
Normal	12	0.38-0.63	0.53
Cirrhosis	9	0.39-0.87	0.64
Metastases:			
Mucin-secreting	4	0.30-0.40	0.35
Non secreting	2	0.62-0.82	0.72
Fatty change	3	0.47-1.34	0.87
Iron excess	2	0.88-1.18	1.03

successfully categorize 23 of 24 patients with widely varying liver pathologies. Their analysis has been coined quantitative microstructural sonography.

Taylor et al. (1986) showed that it is the fatty nature of cirrhotic livers that causes an increase in attenuation and not the fibrosis usually associated with the disease.

Garra et al. (1987) measured the attenuation in patients with chronic hepatitis and Gaucher´s disease. The hepatitis group (29 patients) formed a bimodal distribution, some with higher and some with lower than normal attenuation coefficients. Six patients with type I glycogen storage disease and fatty infiltration of the liver had high attenuation values. Unlike other studies, cirrhotic patients had normal attenuation values.

CHAPTER 3

MEASUREMENT TECHNIQUES

The attenuation coefficient measurement can be made using many different techniques, as shown in the previous chapter. This chapter will briefly explain the theory behind the radiation force balance technique and describe the apparatus used. The experimental protocol will also be discussed including the tissue handling procedure. To aid the discussion, a block diagram of a simplified version of the apparatus is shown in Figure 3-1. This diagram shows only the measuring tank; the electronics used to run the system will be shown in a later figure.

3.1 Acoustic Theory

This study uses the radiation force balance to perform insertion loss measurements on varying thicknesses of tissue. From these measurements, an attenuation coefficient can be calculated from the slope of the graph of insertion loss vs. thickness.

3.1.1 Radiation Force

The force measured with the apparatus is a result of a phenomenon known as the Langevin radiation pressure. When an ultrasonic wave impinges upon a target, the Langevin pressure exerts a force upon it. If the target is perfectly absorbing, the Langevin radiation pressure on the target is

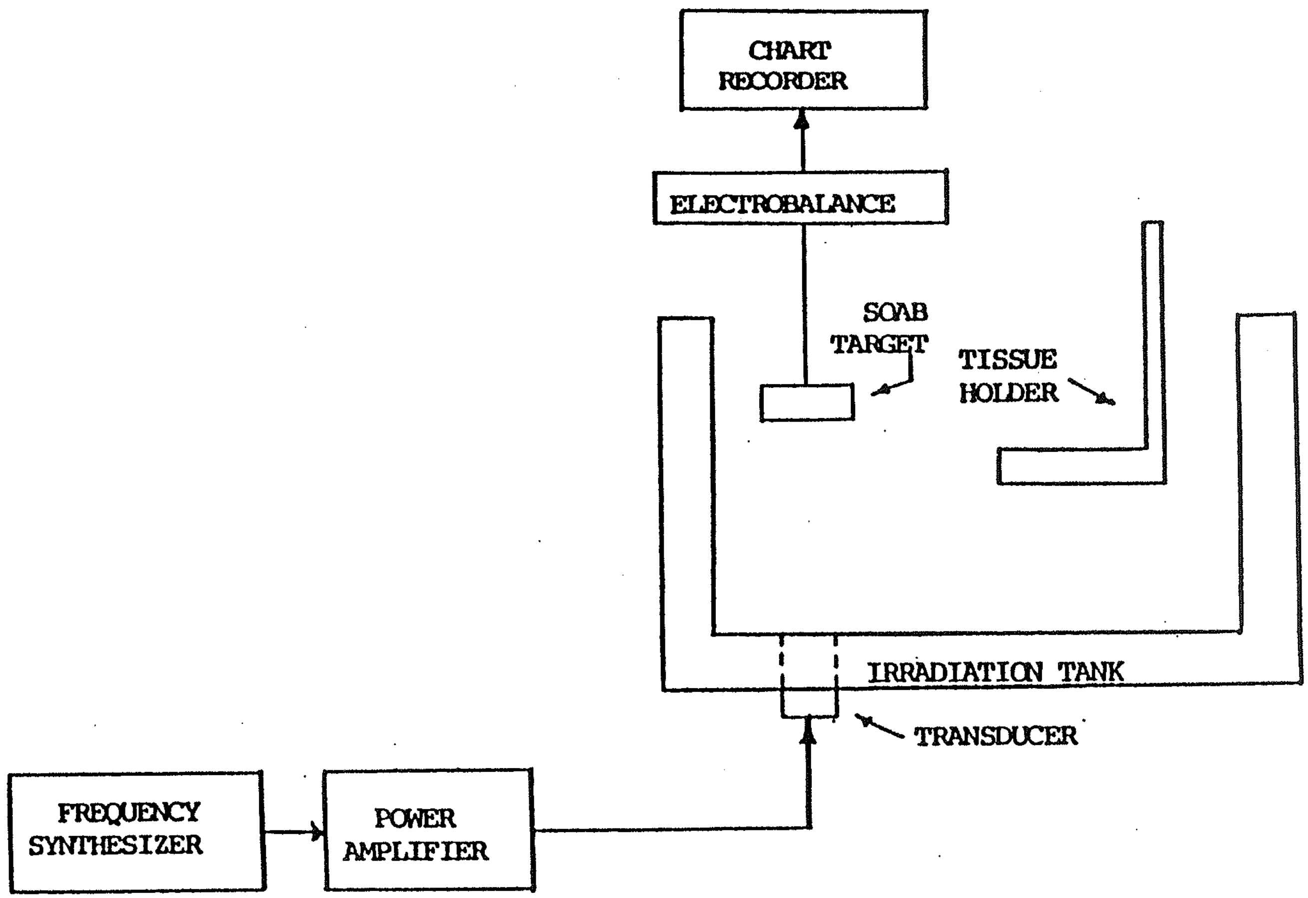

FIGURE 3-1 BLOCK DIAGRAM OF A SIMPLIFIED VERSION OF THE RADAITION FORCE BALANCE. Adapted from Segal (1984)

$$P_L = I/c_o \qquad (3.1)$$

where I is the acoustic intensity of the wave and c_o is the speed of sound in the medium. If the target intercepts the entire ultrasonic wave, the force on the target is equal to the product of the Langevin pressure (P_L) and the area of the beam (S). That is,

$$F_L = SP_L = SI/c_o = W_a/c_o \qquad (3.2)$$

where I is the temporal average intensity of the sound beam and W_a is the total temporal average acoustic power. Therefore, the power transmitted to the target can be determined by measuring the force exerted on it. That is the purpose of the balance used in this system.

A sound absorbing target made of special rubber (SOAB) is suspended from a sensitive electrobalance in the beampath of a piezoelectric transducer. The transducer, when driven by an rf voltage, emits an ultrasonic sound wave. The target is centered so that it intercepts the entire wave. Under ideal conditions, the characteristic acoustic impedance of the target matches that of the medium (water or saline) so that there is no reflection at the target surface. Segal (1984) has reported that the power reflection coefficient has been measured to be 0.014. Ultrasound attenuates very strongly in the SOAB, so virtually no acoustic energy is transmitted through it. The target, under the influence of the radiation force, is deflected upward, thus reducing its effective weight. This change is measured by the electrobalance and the temporal average acoustic power (W_a) impinging on the target can then be calculated. Since it is the power and not the pressure that is measured by the balance, phase cancellation is not a problem. Therefore, the attenuation coefficient measured is phase-insensitive.

3.1.2 Insertion Loss

The theory behind insertion loss measurements is relatively simple. Measurements are made with and without the sample in the beam path. The difference between the two represents the loss due to the sample. More specifically for the radiation force balance, the general apparatus used is shown in Figure 3-1. The setup consists of a transmitter (the piezoelectric transducer) facing a receiver (the SOAB target) with some means provided for moving the sample in and out of the sound beam. The attenuation coefficient is determined by comparing the two power measurements.

Acoustic field intensity decreases with distance x as it propagates through a lossy field according to

$$I_s = I_o e^{-2Ax} \tag{3.3}$$

where I_o is the intensity at the transmitter, and A is the attenuation coefficient. If a sample of thickness d and attenuation coefficient A is placed between a transmitting and receiving transducer pair separated by the distance d and is acoustically coupled to them, then the intensity at the receiving transducer is

$$I_s = I_o e^{-2Ax}. \qquad (3.4)$$

If the sample is replaced by a lossless medium, then the received intensity will equal the transmitted intensity (I_o). Of course, a completely lossless medium cannot be ideally achieved, so the received intensity is always slightly less than I_o. For application to a system as proposed in Figure 3-1, it is initially assumed that the attenuation coefficient of the solution used in the tank (usually water or saline) is negligible and that there are no reflections at the sample-solution interface. Under these conditions, the received intensity without the sample in the beampath will be I_o and with the sample in the beampath, I_s. The insertion loss of the sample (in decibels) is defined to be 10 times the log of the ratio of I_o/I_s. Manipulating equation (3.4) yields the following relation:

$$IL(dB) = 10\log(I_o/I_s) = 8.686Ad \qquad (3.5)$$

Because it is the ratio of the intensities that matters and not their absolute values, and since the radiation force is proportional to the intensity, the intensities need not be calculated and the ratio of forces can be used.

Therefore, if the assumption that there is no reflection at the sample-solution interface holds, then the insertion loss is proportional to the thickness. At this point, the attenuation coefficient can be calculated in decibels per unit length by dividing the insertion loss by the thickness. However, generally there are some reflections at the interface. These reflective losses can be taken into account using the fact that the reflections are constant with varying thicknesses of the sample. The insertion loss measurements are made for several thicknesses and a plot is made of insertion loss vs. thickness (see Figure 3-2). The resulting graph will ideally be a straight line with positive slope and a positive y-intercept. The intercept represents the loss through a sample of zero thickness which is the reflective loss. The slope represents the attenuation coefficient in decibels per unit length and is corrected for the reflective loss.

Standing waves between the transmitter and receiver can result from the reflections at the sample-solution and target-solution interfaces. This will decrease the output of the transducer when the sample is in the sound path. However, the insertion loss technique assumes that the power output of the transducer remains constant whether or not the sample is in place. Therefore, only samples with acoustic impedances reasonably close to that of the solution can be measured with insertion loss. Matching the impedances reduces the reflections and the standing wave problem.

3.2 Measurement Apparatus

The radiation force balance setup used in this study is the result of many years of development at the Bioacoustics Research

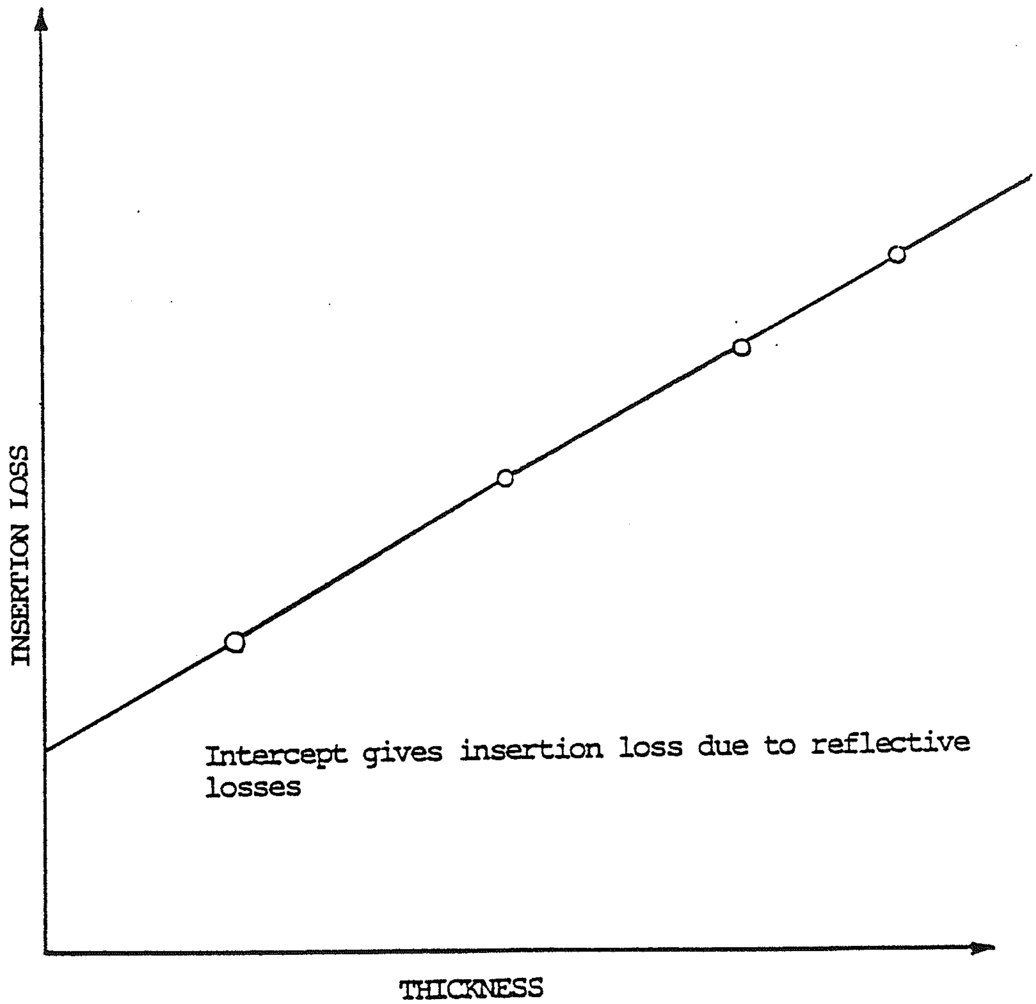

FIGURE 3-2 STRAIGHT LINE FIT OF INSERTION LOSS VS. THICKNESS. Adapted from May (1986)

Laboratory at the University of Illinois. Initially established by Nider (1978), it was improved by Segal (1984), and further automated by May (1986). The system currently used is equivalent to May´s, with some minor adjustments made to handle the particulars of this study. Figure 3-3 is a block diagram of the entire system.

3.2.1 Basic Apparatus

The tank is constructed of plexiglass and is identical to that in Figure 3-1 with the following exceptions. The transducer is mounted on the side of the tank and the sound is directed at a 45° reflecting block, which reflects the beam at the target. Functionally, this is equivalent to the setup in Figure 3-1. The SOAB target is enclosed in a shielding cylinder of plexiglass which protects it from water currents, which could cause oscillations not due to radiation force and could push the target out of the sound path. An acoustic window (a piece of cellophane, which is acoustically transparent) is mounted on the bottom of the shielding cylinder to prevent acoustic streaming. Streaming is another effect of radiation force as it acts upon the solution which is not totally lossless. The solution in the sound field would flow as a result and cause inaccurate deflections on the target. The cellophane is glued to a wire frame which holds the window onto the cylinder.

The sample holder is also constructed of plexiglass and cellophane and is shown in Figure 3-4. The cellophane is stretched

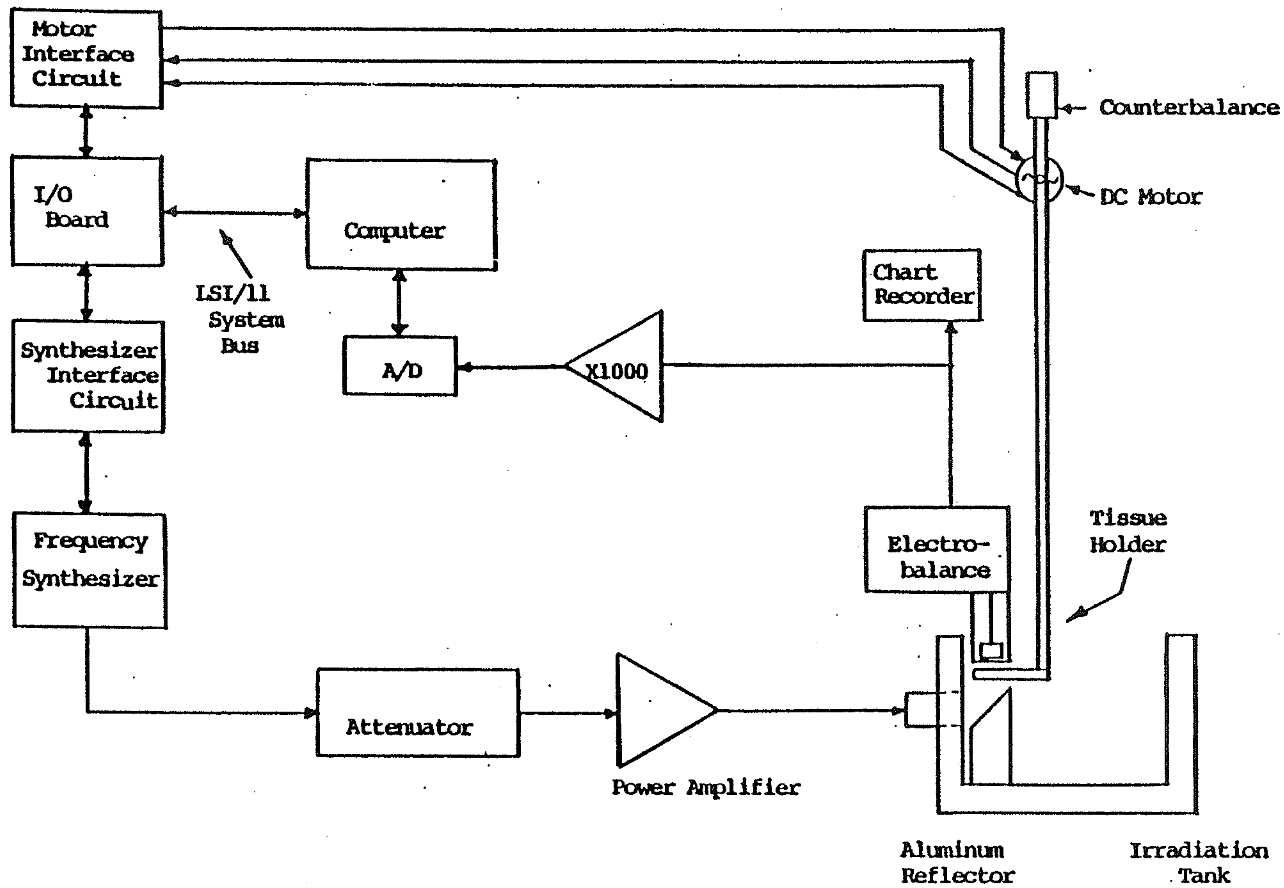

FIGURE 3-3 BLOCK DIAGRAM OF AUTOMATED RADIATION FORCE BALANCE SYSTEM. Adapted from May (1986)

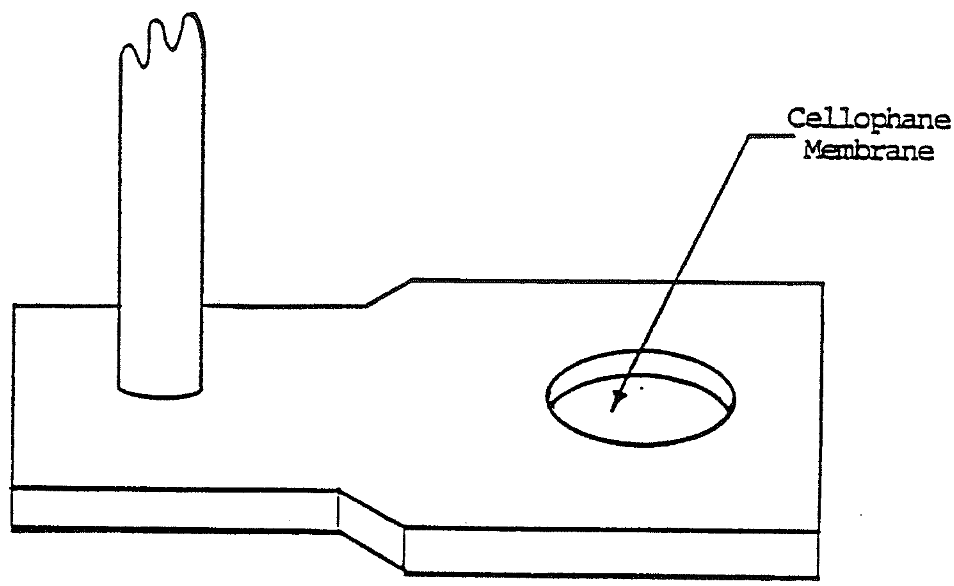

FIGURE 3-4 TISSUE SAMPLE HOLDER.
Adapted from May (1986)

across the bottom of the plexiglass and taped into place. Due to the small size of the liver specimens, a ring of modeling clay needed to be placed around the inner edge of the sample holder to reduce the size of the hole. Measurements were made with no sample in the holder to ensure that the clay was not in the beam path, thus causing additional undesired attenuation. The results of this trial showed that the clay did not have an effect. The data from this trial are included the Appendix. After the sample is prepared, it is laid on top of the cellophane and is held in place by gravity. The sample holder arm is also different than in Figure 3-1 in order to accommodate the automation. Its design will be explained in the next section.

The piezoelectric transducer is driven by the output of a Hewlett-Packard 8660B synthesized signal generator after it is fed into a Kay Elemetrics adjustable precision attenuator, followed by amplification by a wideband rf power amplifier made by Electronic Navigation Industries, model 310L. The attenuator is used to protect the transducer and amplifier from damage from too large a signal output from the signal generator. The transducer is driven at four frequencies, namely, 1.385 MHz, 4.210 MHz, 7.015 MHz, and 9.820 MHz.

The SOAB target is suspended from a Cahn Electrobalance, model RG. When a step force is applied to the target, the balance arm is momentarily deflected. This deflection is detected by a phototube sensor in the balance which creates a feedback signal which attempts to restore the arm to its original position. The feedback signal is processed and applied to a torque servomotor which restores the arm to its equilibrium position. The current that drives the motor is proportional to the force applied. It is converted to a voltage by the electrobalance (and adjusted as per the balance´s calibration). The output voltage of the balance is recorded on a Houston Electronics chart recorder, model 2000, and by an analog-to-digital converter to be processed by a computer (explained in the next section).

In the unautomated version of the system, the insertion loss measurements were made from the chart recorder tracings. Figure 3-5 shows a typical chart recording. The deflections from the baseline (D_o and D_s) are proportional to the intensities (I_o and I_s). The insertion loss can be calculated using the ratio of deflections in Equation (3.5).

The electrobalance was designed to bear a maximum weight of 1 gram. Since the SOAB target weighs substantially more than this, a piece of cork was glued to the top of it. This makes the target somewhat buoyant and reduces its effective weight in solution to less than 1 gram. One problem with the balance-target system can be seen in Figure 3-5. The large oscillations in the chart recorder output are a result of the large effective mass of the target. It is not practical to wait for the oscillations to die out completely before making the measurements; therefore, measurements are taken to be the values at the center of the oscillations. It is feasible that by changing some of the electronics inside the electrobalance, to reduce the oscillations.

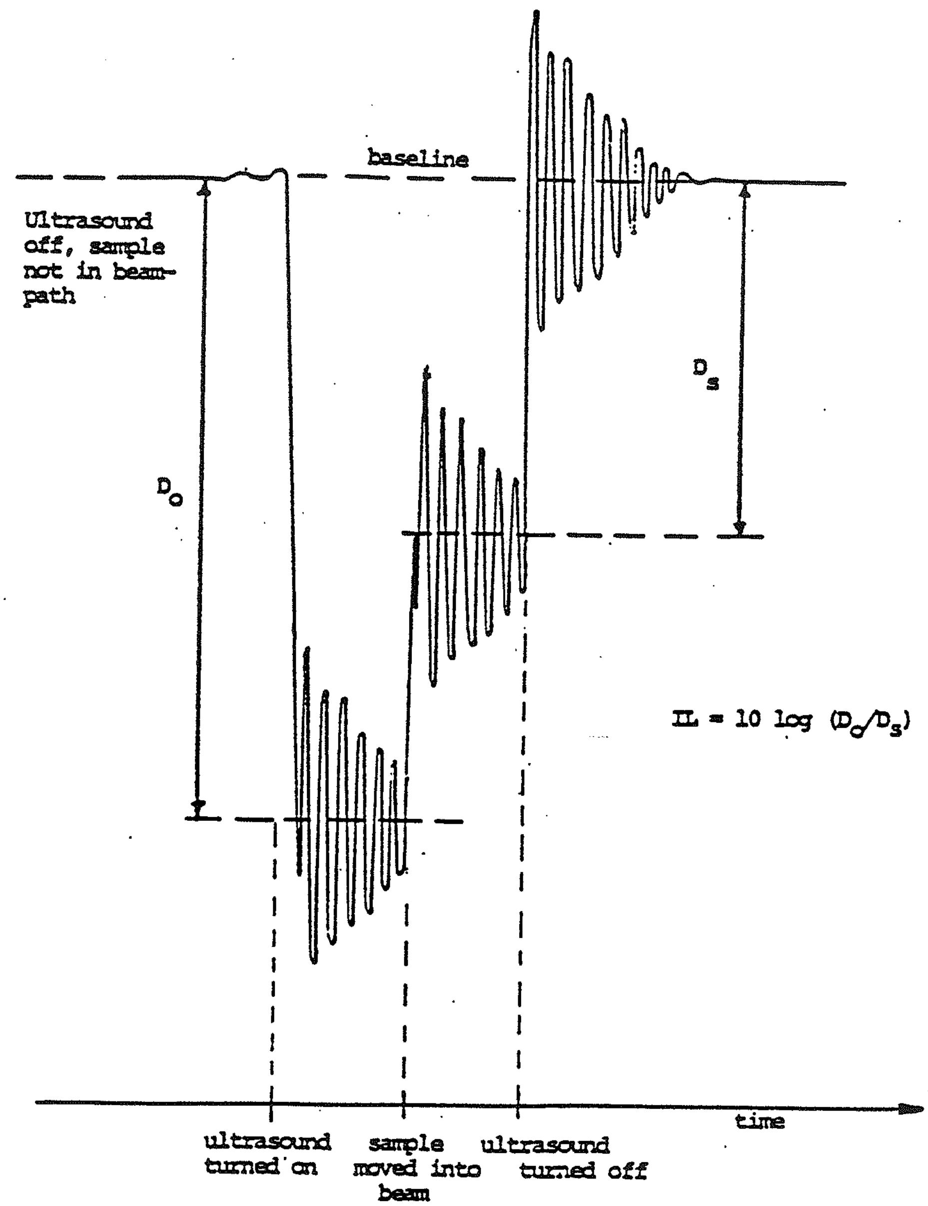

FIGURE 3-5 DETERMINATION OF INSERTION LOSS FROM CHART RECORDER READING. Adapted from May (1986)

3.2.2 Computer Control

The automation of the system does not alter the already described acoustics. The automation speeds the rate at which trials can be run and data can be collected. The computer controls the three following processes: the control of the signal generator by switching the sound on and off, the frequencies, and the output level; the movement of the sample holder in and out of the beampath; and the data collection by interfacing with an analog-to-digital converter. The computer used is the LSI-11/23 in conjunction with a DLV-11J Input/Output board and an ADV-11C analog-to-digital converter board. The computer and the plug-in boards are made by Digital Equipment Corporation (DEC). The main control program is written in FORTRAN and calls a number of subroutines written in both FORTRAN and assembly language. The assembly language routines communicate directly with the hardware.

The main program follows the flowchart in Figure 3-6. The sequence of steps was designed to reduce the amount of oscillations in the output by minimizing movement of the sample holder, thus reducing water movement. A typical chart tracing for one iteration of the program is shown in Figure 3-7. This was iterated three times for each sample thickness, thus producing twelve insertion loss measurements (three measurements at four frequencies). The signal generator is run in remote mode and the appropriate subroutines send it information concerning frequency, output levels, and output enable. The motor control subroutines and

```
INITIALIZE
  STORE THE 4 FREQUENCIES AND CORRESPONDING AMPLITUDE SETTINGS
    FOR THE HP FREQUENCY GENERATOR IN ARRAYS
  GET FILENAME FROM USER AND OPEN OUTPUT FILE

GET THICKNESS OF SAMPLE
DO 5 TRIALS
   DO 2 TIMES
      IF 1ST TIME THEN
         MOVE SAMPLE OUT OF BEAMPATH
      ELSE
         MOVE SAMPLE INTO BEAMPATH
      DO 4 TIMES, ONCE FOR EACH FREQUENCY
         TURN FREQUENCY GENERATOR OUTPUT OFF
         SET FREQUENCY
         TAKE 6 SECONDS OF A/D DATA
         TAKE AVERAGE OF WAVEFORM OSCILLATIONS
         TURN FREQUENCY GENERATOR OUTPUT ON
         TAKE 6 SECONDS OF A/D DATA
         TAKE AVERAGE OF WAVEFORM OSCILLATIONS
      END DO
      CALCULATE DEFLECTIONS
    END DO
    CALCULATE INSERTION LOSS AT EACH FREQUENCY
    SAVE EACH INSERTION LOSS IN A DISK FILE
END DO
ASK USER IF ANOTHER SAMPLE
   IF YES
      THEN GO BACK AND DO AGAIN.
   ELSE
      DONE, CLOSE DISK FILE
```

FIGURE 3-6 PSEUDOCODE FOR AUTOMATION CONTROL PROGRAM ATTENU. Adapted from May (1986)

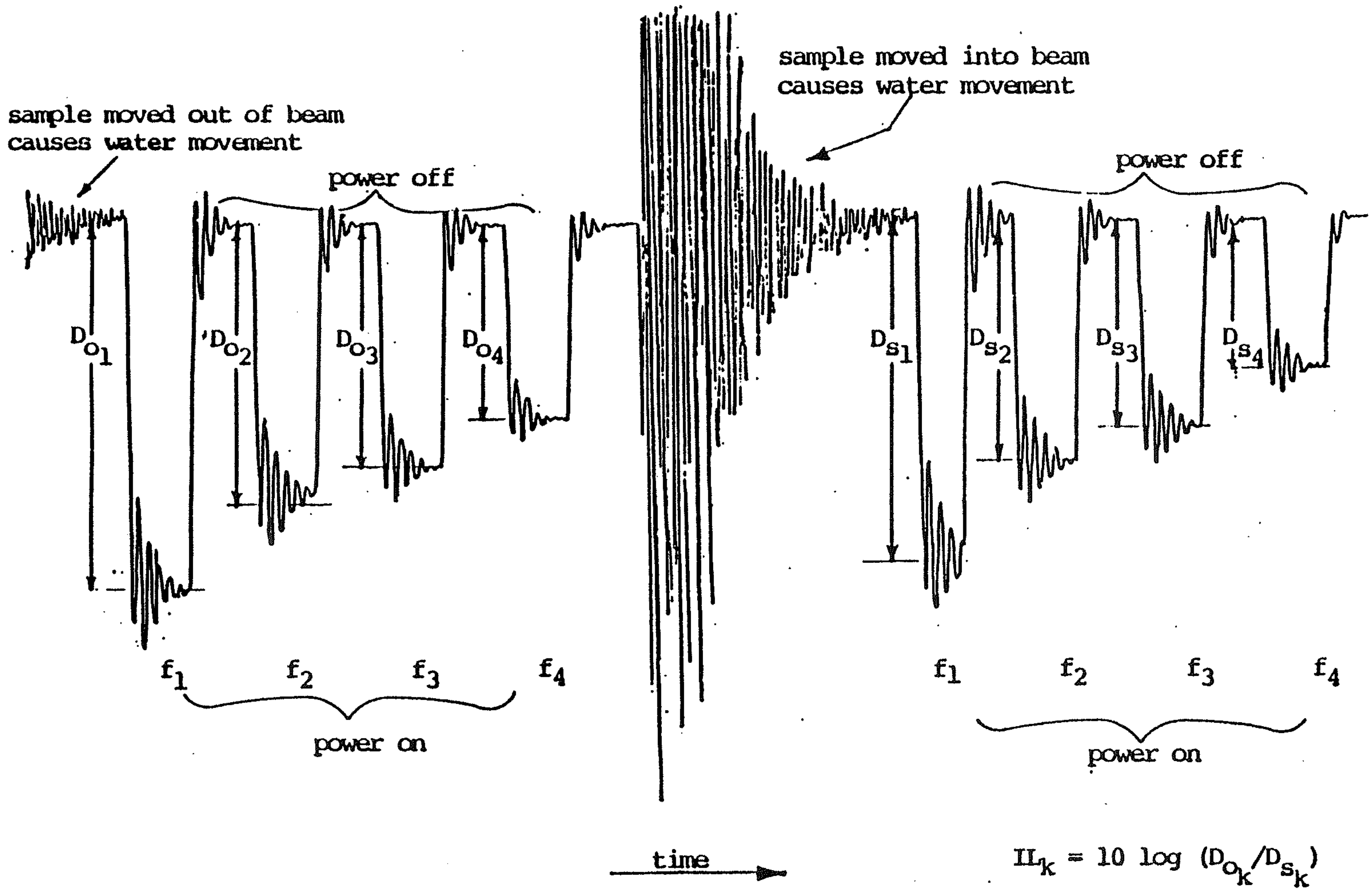

FIGURE 3-7 OUTPUT OF ELECTROBALANCE WITH AUTOMATED SYSTEM.
Adapted from May (1986)

motor interface circuit move the sample arm as shown in Figure 3-8. The analog-to-digital converter output is sampled by subroutines at a rate of 15 Hz. The subroutine SETTLE forces the computer to wait for the target oscillations to die out after the sample holder has been moved. The subroutine AVERAG computes a single value from the oscillating A/D output to be used to calculate the deflections. A sample of the output of the program is shown in Table 3-1 for one sample run at four thicknesses (for a total of 48 insertion loss measurements). More details of the automation are in May (1986) which includes the program listings and control circuit diagrams.

3.3 Experimental Protocol

Care was taken to handle each specimen in a similar manner. The following sections describe how the tissue was handled and the protocol followed in using the radiation force balance.

3.3.1 Tissue Handling

The rat livers arrived from Mayo Clinic one or two days after the animals were killed and stored on ice in plastic specimen bags (Whirl-Paks). The largest lobe of the liver was used for this study. The other major lobe of the liver was used for the TTT and SLAM measurements. In all but one case (liver 17), the lobe was sectioned into quarters (liver 17 was cut into thirds) as shown in Figure 3-9. This was done using a sharp razor blade. Each liver was removed from the ice just prior to making the

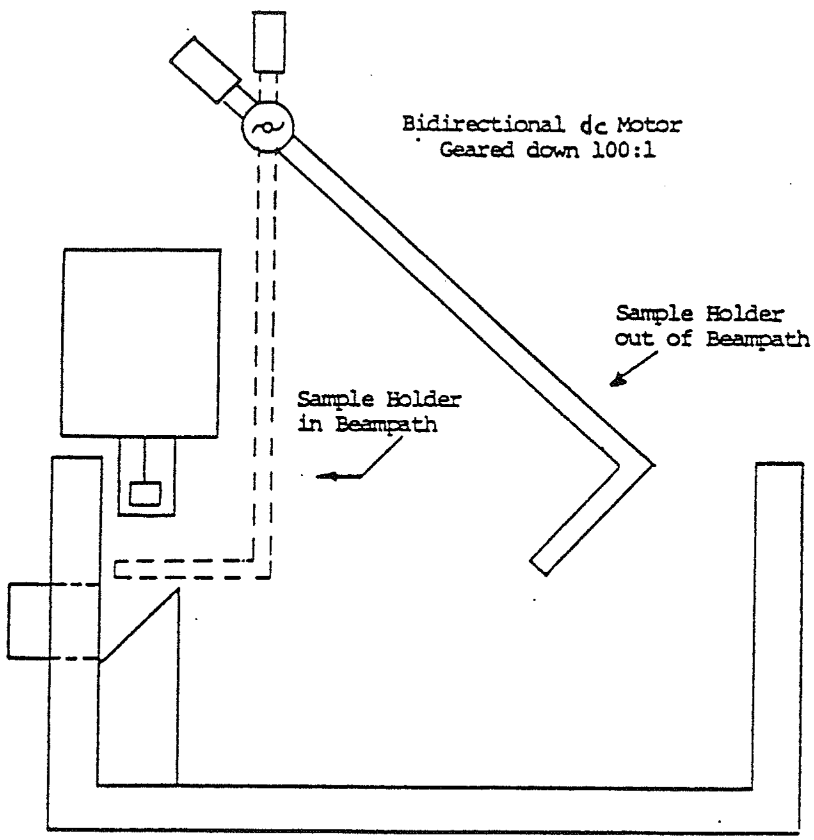

FIGURE 3-8 MOVEMENT OF SAMPLE HOLDER ARM.
Adapted from May (1986)

TABLE 3-1 Output of Program ATTENU

LIVER FROM MAYO #R02 RUN BY M. ELLENBY

THICKNESS (CM)	FREQUENCY (MHz)	IO	IS	INSERTION LOSS (dB)	AVERAGE IL (dB)	DATE
0.33	1.385	2.125	2.004	0.25		07-Jun-87
0.33	1.385	2.122	2.032	0.19		07-Jun-87
0.33	1.385	2.134	2.030	0.22	0.22	07-Jun-87
0.33	4.210	1.585	1.392	0.56		07-Jun-87
0.33	4.210	1.588	1.397	0.56		07-Jun-87
0.33	4.210	1.595	1.383	0.60	0.57	07-Jun-87
0.33	7.015	1.559	1.256	0.94		07-Jun-87
0.33	7.015	1.565	1.254	0.96		07-Jun-87
0.33	7.015	1.585	1.243	1.06	0.99	07-Jun-87
0.33	9.820	1.491	1.038	1.57		07-Jun-87
0.33	9.820	1.493	1.088	1.37		07-Jun-87
0.33	9.820	1.500	1.073	1.45	1.47	07-Jun-87
0.68	1.385	2.161	1.822	0.74		07-Jun-87
0.68	1.385	2.157	1.912	0.52		07-Jun-87
0.68	1.385	2.230	1.999	0.47	0.58	07-Jun-87
0.68	4.210	1.593	1.213	1.18		07-Jun-87
0.68	4.210	1.595	1.213	1.19		07-Jun-87
0.68	4.210	1.653	1.268	1.15	1.17	07-Jun-87
0.68	7.015	1.574	0.921	2.33		07-Jun-87
0.68	7.015	1.575	0.896	2.45		07-Jun-87
0.68	7.015	1.646	0.964	2.32	2.37	07-Jun-87
0.68	9.820	1.495	0.722	3.16		07-Jun-87
0.68	9.820	1.505	0.735	3.11		07-Jun-87
0.68	9.820	1.542	0.747	3.15	3.14	07-Jun-87
1.00	1.385	2.250	1.877	0.79		07-Jun-87
1.00	1.385	2.238	1.867	0.79		07-Jun-87
1.00	1.385	2.233	1.863	0.79	0.79	07-Jun-87
1.00	4.210	1.577	1.082	1.64		07-Jun-87
1.00	4.210	1.632	1.077	1.81		07-Jun-87
1.00	4.210	1.630	1.099	1.71	1.72	07-Jun-87
1.00	7.015	1.626	0.762	3.29		07-Jun-87
1.00	7.015	1.622	0.748	3.36		07-Jun-87
1.00	7.015	1.625	0.760	3.30	3.32	07-Jun-87
1.00	9.820	1.550	0.566	4.38		07-Jun-87
1.00	9.820	1.547	0.557	4.44		07-Jun-87
1.00	9.820	1.535	0.553	4.43	4.42	07-Jun-87
1.33	1.385	2.218	1.789	0.93		07-Jun-87
1.33	1.385	2.177	1.758	0.93		07-Jun-87
1.33	1.385	2.174	1.762	0.91	0.92	07-Jun-87
1.33	4.210	1.621	0.973	2.22		07-Jun-87
1.33	4.210	1.603	0.962	2.22		07-Jun-87
1.33	4.210	1.591	0.955	2.17	2.20	07-Jun-87
1.33	7.015	1.604	0.620	4.13		07-Jun-87
1.33	7.015	1.594	0.606	4.20		07-Jun-87
1.33	7.015	1.594	0.618	4.11	4.15	07-Jun-87
1.33	9.820	1.528	0.441	5.40		07-Jun-87
1.33	9.820	1.510	0.439	5.37		07-Jun-87
1.33	9.820	1.510	0.441	5.35	5.37	07-Jun-87

measurements and was stored in degassed cat ringer's solution to prevent them from drying out during the procedure. Following the sectioning, the thickness of each quartered piece was measured by placing it between two pieces of metal. The thickness of the three layers was measured with a micrometer and the thickness of the two pieces of metal was subtracted out to give the sample thickness. Because the samples did not have parallel sides (see Figure 3-10), the measurement was made at the middle of the section which was assumed to be the average thickness. The metal pieces were used to provide a definite surface for the micrometer to come down on and to prevent tissue damage by overtightening of the micrometer on the liver.

After all the acoustic measurements were made, the biochemical analysis was performed by Tammy Hebner. The moisture content was determined gravimetrically. The liver tissue was weighed first and then dried overnight in a 90°C oven. The livers were reweighed and a percent water was determined. The lipid analysis followed the procedure of Folch et al. (1957).

3.3.2 Radiation Force Balance Protocol

The radiation force balance system was set up as follows. The measuring tank was filled with degassed cat ringer's solution, which has ion concentrations similar to those in mammalian extracellular fluid. The use of this solution prevents osmotic flux which could potentially change the content of the tissue and, therefore, the ultrasonic measurements. The bath was then

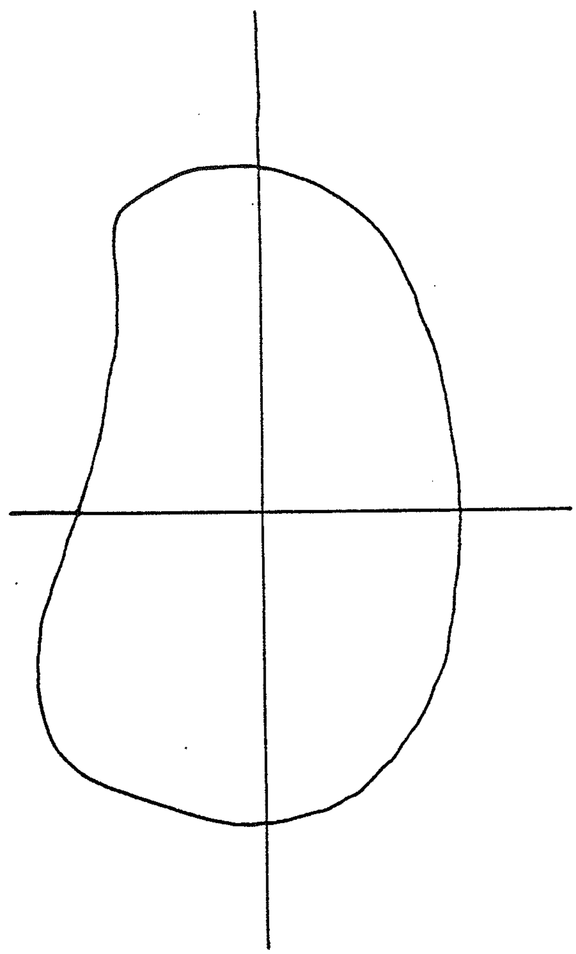

FIGURE 3-9 SECTIONING OF LIVER SAMPLE.

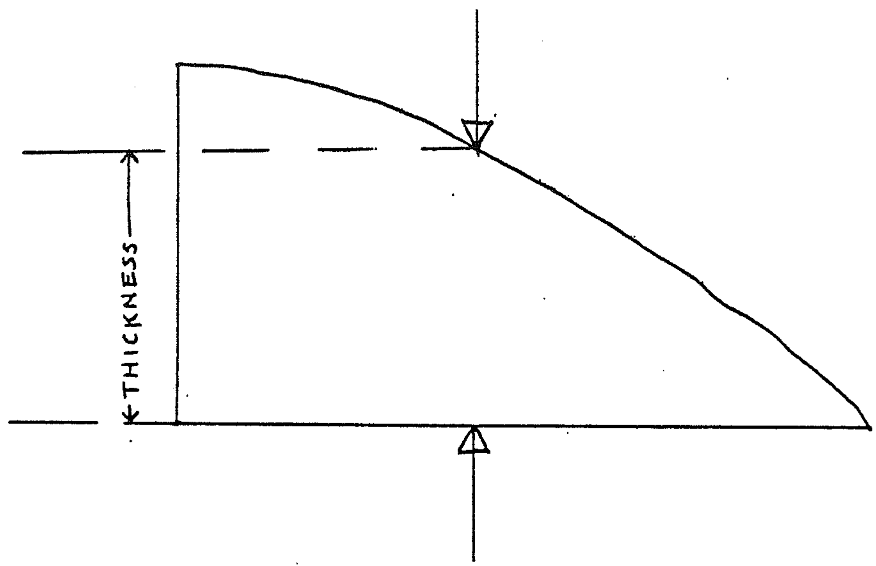

FIGURE 3-10 CROSS-SECTION OF LIVER SAMPLE.

raised to and maintained at a temperature of 37°C $\pm$ 0.1°C. One sample was placed in the sample holder and the holder arm was lowered into the tank and attached to the motor shaft after it was positioned. All equipment was turned on and calibrated. The main computer program was booted and the datafile was specified. The sample thickness was entered, the time recorded, and at this point the automation took over the process.

Following the run at the first thickness, another sample thickness was placed on top of the first sample in the holder. This layering of samples was done because all four quarters of the specimen were of similar thickness. In order to obtain an accurate value for the attenuation coefficient from the plot of insertion loss vs. thickness, a range of thicknesses is required. Therefore, the samples were layered one by one until the stack was four high. Each thickness run took between 10 and 15 minutes to run and each sample was usually finished in under an hour. The samples were then removed from the tank and placed back in their storage bag and re-iced. The next sample was sectioned and measured for thickness while the previous sample was in the tank.

The same ringer's solution was used for approximately 6 hours before it had to be discarded. This was necessary because the solution absorbed atmospheric gasses during the course of the experiment. This will cause the solution to become more and more lossy which reduces the accuracy of the measurements. The progress of this process was tracked by observing the intensity levels of the signals with no sample in the beampath. Once these values decreased below a certain level, the solution was replaced.

CHAPTER 4
DATA HANDLING AND RESULTS

This research studies the effects of fatty liver buildup on the attenuation coefficient in rat livers. This chapter will look at the data handling procedures and the results derived. The attenuation coefficient will be looked at as a function of the water, fat, and protein content of the livers. In addition, other ultrasonic properties will be discussed.

4.1 Data Handling

A number of steps were used to manipulate the data into a form from which conclusions could be drawn. This section will detail these steps.

4.1.1 Data Taking

As described in the previous chapter, the main computer program does the data taking by reading the signal from the electrobalance after it has been digitized. A sample output of the program is shown in Table 3-1. I_o represents the deflection of the electrobalance with no sample in the beampath and I_s represents the same but with the sample in place. The program then determines the insertion loss in decibels by using Eq. (3.5). This is repeated three times for each of the four frequencies (1.385, 4.210, 7.015, and 9.820 MHz) to increase the size and quality of the database. An average insertion loss is calculated for the three trials at each frequency. These data were written to a datafile. In this study, the datafiles were named LIV# (where # is the specimen number). After being repeated for the different thicknesses, the datafile was closed. The thickness of the samples ranged up to 1.50 cm.

It should be noted that the measurements were repeated for some of the samples (so noted with an R following the animal number) for a number of reasons. Obviously erroneous data (animals 2 and 30 had negative attenuation coefficients for some frequencies) were omitted and the measurements were repeated. Repetitions were performed when the data that did not exhibit the trend of increasing insertion loss with increasing frequency and increasing thickness (this first run data was kept, however, and used throughout the analysis along with the second run data). Measurements made early in the experiment were repeated to determine if there was consistency in the technique over time (animal 17, for example, for which the repeated measurements did indeed fall within the confidence intervals of the initial data). It was reported that animal 29 did not receive a similar treatment as the others following slaughter, and when the first run turned up obviously erroneous data, it was decided to omit it completely from consideration.

4.1.2 Data Processing

After the control program produced the datafile and saved it on disk, the file was transferred from the LSI-11/23 computer to the Bioacoustic Research Laboratory's VAX 11/370 computer (Digital Equipment Corporation) using the program VTCOM, a commercial data communication program for DEC computers. The file was then used as input for a statistical program called COMP which is nearly identical to the one used by May (1986) and Segal (1984). COMP performed a linear regression analysis to calculate the slope (which is the attenuation coefficient) of the insertion loss vs. thickness graph. The program output also includes the means and standard deviation of the three repeated insertion loss measurements made at each frequency and thickness, the intercepts of the graph (which represent the reflective loss), the 95% confidence limits of the slopes and intercepts, and the correlation coefficient of the lines graphed. The program output is documented for all the animals in the Appendix and is summarized in Table 4-1. Also included in this table is a summary of the length of time the animals were subjected to the diet (days on diet) and the time at which the measurements were made after the start of the experiment (in hours after 12 midnight, Monday, June 1).

COMP also processes the data to give the attenuation coefficient as a function of frequency. A sample plot of this relationship for animal 2 is shown in Figure 4-1. COMP performs this analysis by first converting the attenuation coefficients to nepers per centimeter by dividing by 8.686. The data are then fit to the standard attenuation coefficient versus frequency model of

TABLE 4-1 <u>COMP</u> Results for Attenuation Coeffecients and Intercepts

ANIMAL #	DAYS ON DIET	TIME OF MEASURE	FREQUENCY	SLOPE (dB/cm)	95% CONF. INTERVAL		INTERCEPT (dB)	95% CONF. INTERVAL	
2R	0	158:35	1.385	0.70	0.55	0.85	0.04	-0.10	0.18
2R	0		4.210	1.63	1.55	1.72	0.05	-0.02	0.13
2R	0		7.015	3.15	2.90	3.40	0.08	-0.15	0.31
2R	0		9.820	3.92	3.60	4.23	0.33	0.04	0.62
7	0	94:22	1.385	0.33	0.03	0.64	0.45	0.19	0.71
7	0		4.210	0.89	0.64	1.15	0.75	0.53	0.97
7	0		7.015	1.59	0.93	2.25	1.21	0.64	1.78
7	0		9.820	2.13	1.25	3.00	1.30	0.54	2.05
14	0	118:55	1.385	0.47	0.30	0.63	0.35	0.20	0.50
14	0		4.210	1.50	1.31	1.69	-0.02	-0.18	0.15
14	0		7.015	2.98	2.61	3.35	-0.21	-0.53	0.12
14	0		9.820	3.90	3.35	4.45	-0.20	-0.69	0.28
17	0	65:35	1.385	0.78	0.59	0.97	0.25	0.11	0.38
17	0		4.210	1.50	1.25	1.75	0.29	0.11	0.46
17	0		7.015	2.33	0.75	3.91	0.79	-0.31	1.90
17	0		9.820	3.34	1.25	5.42	0.67	-0.78	2.13
17R	0	159:23	1.385	0.62	0.57	0.68	0.26	0.22	0.30
17R	0		4.210	1.49	1.22	1.77	0.46	0.27	0.66
17R	0		7.015	2.84	2.63	3.06	0.84	0.69	1.00
17R	0		9.820	3.60	3.29	3.92	1.15	0.92	1.37
24	0	112:15	1.385	0.48	0.35	0.61	0.74	0.64	0.84
24	0		4.210	0.85	0.43	1.28	0.87	0.54	1.20
24	0		7.015	1.78	1.36	2.21	1.14	0.81	1.48
24	0		9.820	3.06	2.28	3.85	1.00	0.39	1.61
30R	2	163:33	1.385	0.40	0.35	0.46	0.33	0.28	0.38
30R	2		4.210	1.23	1.03	1.44	0.23	0.04	0.42
30R	2		7.015	2.66	2.36	2.97	0.20	-0.09	0.49
30R	2		9.820	3.35	3.03	3.67	0.44	0.14	0.74
25	2	95:09	1.385	0.44	0.35	0.53	0.39	0.31	0.47
25	2		4.210	1.10	0.80	1.41	0.38	0.11	0.65
25	2		7.015	2.38	1.80	2.95	0.16	-0.35	0.67
25	2		9.820	2.77	1.88	3.65	0.07	-0.71	0.86
28	3	130:34	1.385	0.32	-0.06	0.71	0.25	-0.05	0.56
28	3		4.210	1.06	0.47	1.66	0.32	-0.15	0.79
28	3		7.015	2.09	1.30	2.89	0.54	-0.09	1.17
28	3		9.820	2.76	2.28	3.24	1.04	0.66	1.42

TABLE 4-1 Continued

ANIMAL #	DAYS ON DIET	TIME OF MEASURE	FREQUENCY	SLOPE (dB/cm)	95% CONF. INTERVAL		INTERCEPT (dB)	95% CONF. INTERVAL	
27	3	69:25	1.385	0.44	0.27	0.62	0.33	0.16	0.51
27	3		4.210	1.29	0.66	1.93	0.57	-0.05	1.18
27	3		7.015	2.07	1.34	2.80	1.16	0.45	1.87
27	3		9.820	2.44	1.63	3.24	1.26	0.47	2.04
27R	3	162:35	1.385	0.30	0.24	0.36	0.43	0.38	0.48
27R	3		4.210	1.15	1.00	1.30	0.33	0.19	0.46
27R	3		7.015	2.31	2.07	2.55	0.55	0.34	0.75
27R	3		9.820	2.94	2.70	3.18	0.90	0.69	1.10
26	3	99:48	1.385	0.74	0.50	0.99	-0.16	-0.38	0.05
26	3		4.210	2.19	1.58	2.80	-0.43	-0.95	0.09
26	3		7.015	3.86	3.18	4.50	-0.43	-1.01	0.15
26	3		9.820	3.53	2.55	4.52	0.09	-0.74	0.93
22	3	97:16	1.385	0.39	0.19	0.59	0.47	0.31	0.63
22	3		4.210	0.92	0.21	1.62	0.70	0.14	1.26
22	3		7.015	2.16	1.29	3.02	1.19	·0.49	1.88
22	3		9.820	3.05	1.63	4.47	1.13	-0.01	2.27
22R	3	161:54	1.385	0.35	0.27	0.43	0.39	0.32	0.46
22R	3		4.210	1.23	1.00	1.47	0.33	0.13	0.53
22R	3		7.015	2.65	2.28	3.02	0.32	0.00	0.63
22R	3		9.820	2.82	2.22	3.42	1.22	0.71	1.73
23	4	70:42	1.385	0.39	0.14	0.65	0.32	0.06	0.57
23	4		4.210	1.27	0.89	1.65	0.46	0.08	0.84
23	4		7.015	2.59	1.69	3.43	0.19	-0.68	1.07
23	4		9.820	2.52	1.66	3.39	0.73	-0.14	1.60
18	4	98:08	1.385	0.51	0.13	0.89	0.42	0.06	0.78
18	4		4.210	1.16	0.51	1.81	0.56	-0.05	1.18
18	4		7.015	2.51	1.93	3.09	0.93	0.41	1.45
18	4		9.820	3.08	2.19	3.96	1.12	0.28	1.95
21	5	131:15	1.385	0.68	0.55	0.81	0.11	0.01	0.22
21	5		4.210	1.80	1.33	2.27	-0.01	-0.38	0.36
21	5		7.015	3.48	2.80	4.16	-0.01	-0.53	0.56
21	5		9.820	4.70	3.95	5.45	0.10	-0.50	0.71
20	5	84:11	1.385	0.24	-0.14	0.61	0.51	0.13	0.89
20	5		4.210	1.14	0.70	1.57	0.41	-0.02	0.85
20	5		7.015	2.46	1.67	3.24	0.81	0.02	1.61
20	5		9.820	3.65	3.14	4.16	0.56	0.05	1.07

TABLE 4-1 Continued

ANIMAL #	DAYS ON DIET	TIME OF MEASURE	FREQUENCY	SLOPE (dB/cm)	95% CONF. INTERVAL		INTERCEPT (dB)	95% CONF. INTERVAL	
19	5	111:28	1.385	0.64	0.52	0.76	0.43	0.33	0.54
19	5		4.210	1.23	0.83	1.62	0.35	-0.02	0.72
19	5		7.015	2.33	1.56	3.10	0.15	-0.57	0.87
19	5		9.820	3.27	2.38	4.16	-0.08	-0.92	0.76
15	5	98:57	1.385	0.44	0.14	0.73	0.31	0.07	0.55
15	5		4.210	1.73	0.90	2.56	0.23	-0.49	0.94
15	5		7.015	2.35	1.60	3.11	0.60	-0.02	1.22
15	5		9.820	3.14	2.15	4.13	0.30	-0.52	1.12
16	6	88:03	1.385	0.79	0.68	0.90	0.37	0.26	0.49
16	6		4.210	2.75	2.36	3.14	0.52	0.13	0.94
16	6		7.015	4.34	3.20	5.49	1.46	0.30	2.62
16	6		9.820	5.75	5.08	6.41	1.66	0.98	2.33
13	7	132:00	1.385	0.60	0.48	0.71	0.54	0.44	0.65
13	7		4.210	1.80	1.33	2.27	1.04	0.61	1.46
13	7		7.015	3.20	2.39	4.00	1.88	1.15	2.61
13	7		9.820	3.76	2.77	4.75	2.61	1.72	3.51
12	7	88:44	1.385	1.00	0.81	1.19	0.39	0.21	0.57
12	7		4.210	3.54	3.15	3.93	0.26	-0.11	0.64
12	7		7.015	6.15	5.43	6.88	0.74	0.05	1.44
12	7		9.820	7.32	6.37	8.27	1.04	0.13	1.95
11	7	113:47	1.385	0.23	0.18	0.28	0.90	0.85	0.95
11	7		4.210	0.55	0.40	0.70	1.08	0.93	1.23
11	7		7.015	1.04	0.86	1.22	1.67	1.48	1.85
11	7		9.820	1.26	1.04	1.49	2.14	1.92	2.37
10	7	132:50	1.385	0.89	0.80	0.98	0.18	0.12	0.25
10	7		4.210	2.88	2.55	3.21	-0.19	-0.44	0.06
10	7		7.015	5.17	4.70	5.65	-0.24	-0.61	0.12
10	7		9.820	6.33	5.66	7.00	-0.02	-0.53	0.49
9	8	92:25	1.385	1.10	0.97	1.24	0.19	0.07	0.31
9	8		4.210	3.58	3.20	3.96	-0.17	-0.49	0.16
9	8		7.015	6.00	5.45	6.55	-0.48	-0.96	-0.01
9	8		9.820	6.17	5.50	6.84	-0.23	-0.80	0.34
8	8	114:45	1.385	0.75	0.60	0.90	0.95	0.78	1.11
8	8		4.210	1.90	1.35	2.44	1.63	1.03	2.23
8	8		7.015	2.81	1.86	3.75	2.91	1.86	3.96
8	8		9.820	3.11	1.81	4.41	3.55	2.11	4.99

TABLE 4-1 Continued

ANIMAL #	DAYS ON DIET	TIME OF MEASURE	FREQUENCY	SLOPE (dB/cm)	95% CONF. INTERVAL		INTERCEPT (dB)	95% CONF. INTERVAL	
8R	8	161:04	1.385	1.18	1.04	1.32	0.26	0.12	0.41
8R	8		4.210	3.81	3.22	4.41	-0.06	-0.70	0.58
8R	8		7.015	5.97	5.12	6.82	0.21	-0.70	1.12
8R	8		9.820	5.37	4.30	6.43	1.20	0.07	2.34
6	9	134:30	1.385	0.97	0.82	1.13	0.08	-0.06	0.22
6	9		4.210	2.42	2.17	2.67	0.29	0.06	0.51
6	9		7.015	4.25	3.86	4.63	0.43	0.08	0.78
6	9		9.820	5.37	4.97	5.77	0.70	0.33	1.07
5	9	93:33	1.385	1.16	0.93	1.40	0.25	0.01	0.50
5	9		4.210	3.34	2.74	3.94	0.11	-0.54	0.75
5	9		7.015	5.25	4.27	6.23	0.42	-0.63	1.47
5	9		9.820	5.04	4.27	5.80	1.22	0.40	2.03
4	9	118:00	1.385	0.67	0.42	0.92	0.41	0.15	0.66
4	9		4.210	2.29	1.58	2.99	-0.17	-0.89	0.54
4	9		7.015	3.92	2.87	4.97	-0.12	-1.18	0.95
4	9		9.820	4.33	3.01	5.65	0.03	-1.31	1.37
4R	9	160:23	1.385	0.50	0.37	0.63	0.38	0.25	0.51
4R	9		4.210	1.37	1.02	1.72	0.79	0.44	1.14
4R	9		7.015	2.39	1.81	2.97	1.28	0.70	1.86
4R	9		9.820	2.67	2.10	3.25	1.81	1.24	2.38
3	9	133:40	1.385	1.08	0.79	1.37	0.35	0.07	0.63
3	9		4.210	3.58	2.93	4.22	0.77	0.14	1.39
3	9		7.015	5.35	4.43	6.28	1.72	0.82	2.62
3	9		9.820	5.25	4.32	6.17	2.88	1.99	3.78
1	10	135:27	1.385	0.59	0.37	0.81	0.34	0.12	0.55
1	10		4.210	1.74	1.13	2.35	0.66	0.06	1.25
1	10		7.015	2.94	1.92	3.95	1.10	0.12	2.09
1	10		9.820	3.84	2.59	5.10	1.52	0.30	2.73

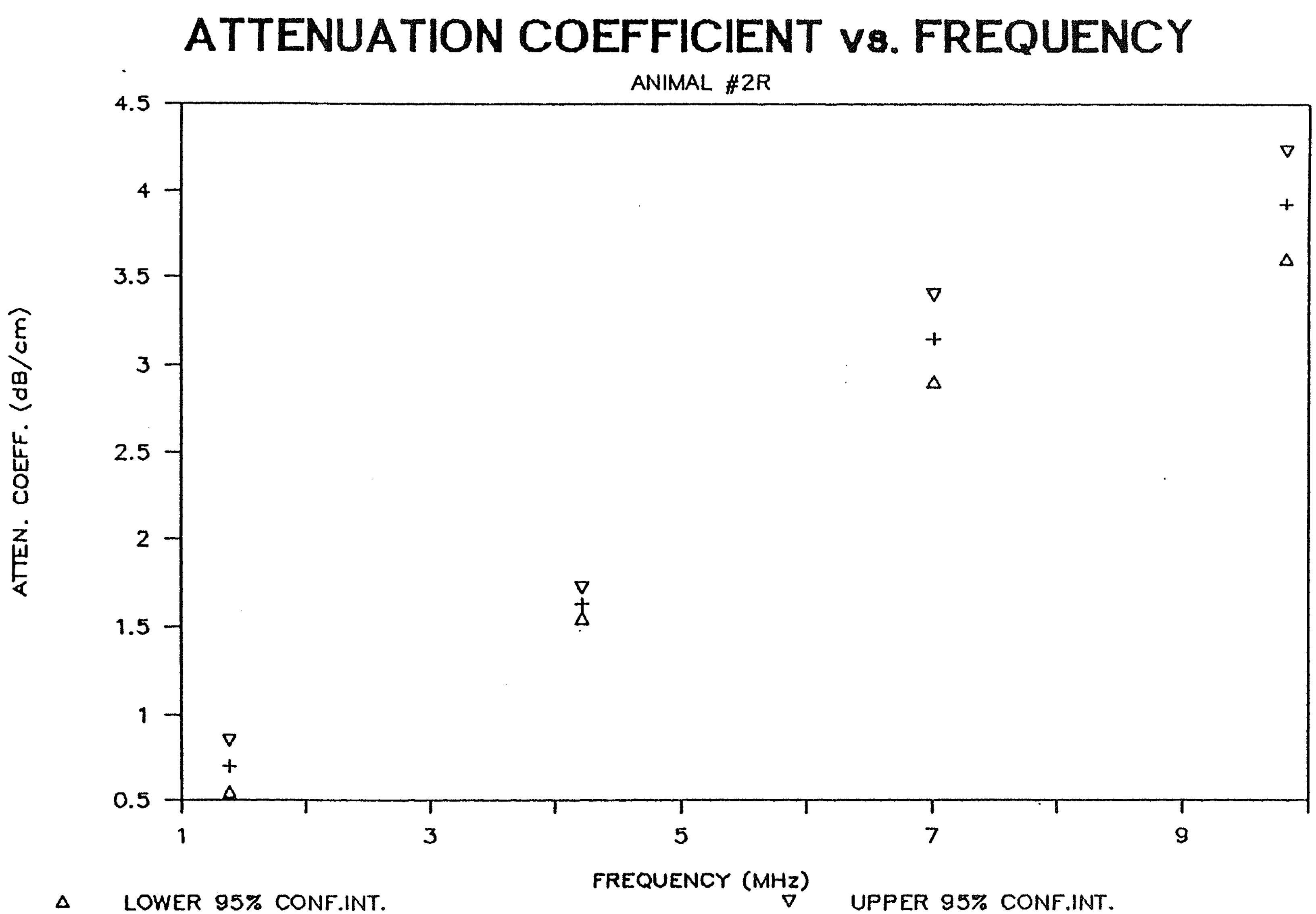

FIGURE 4-1 ATTENUATION COEFFICIENT vs. FREQUENCY.

$$A = A_o f^n \qquad (4.1)$$

where A and A_o are in nepers per centimeter, f is in megahertz, and n is dimensionless. If the log of both sides is taken,

$$\log A = \log A_o + n \log f, \qquad (4.2)$$

then the fit becomes a straight line on a log-log plot. Therefore, a linear regression can be used to fit the data to the model. COMP performs this regression and computes A_o and n, along with their 95% confidence limits and the correlation coefficient of the fit. These data are found at the bottom of the outputs in the Appendix and are presented in Table 4-2.

The results of the biochemical analyses are shown in Table 4-3. The tissue constituent concentrations are reported as a percentage.

4.1.3 Graphical treatment

To determine the effect of the diet on the livers of the rats, the constituent concentrations were plotted against the number of days that the rat was on the diet. These graphs are Figures 4-2, 4-3, and 4-4.

Plots were made of attenuation coefficient versus the constituent concentration for each frequency and each constituent. Figures 4-5, 4-6, 4-7, and 4-8 are for water at 1.385, 4.210, 7.015, 9.820 MHz, respectively. Likewise, Figures 4-9, 4-10, 4-11, and 4-12 are for lipid, while Figures 4-13, 4-14, 4-15, and 4-16 are for protein.

Additional plots were made of n and A_o versus the constituent

TABLE 4-2 COMP Results for A_o and n

ANIMAL #	DAYS ON DIET	TIME OF MEASURE	Ao @ 1MHz (Np/cm)	95% CONF. INTERVAL		n	95% CONF. INTERVAL	
2R	0	158:35	0.06	0.04	0.10	0.90	0.59	1.20
7	0	94:22	0.03	0.02	0.03	0.96	0.82	1.09
14	0	118:55	0.04	0.03	0.05	1.10	0.91	1.30
17	0	65:35	0.07	0.04	0.11	0.73	0.43	1.02
17R	0	159:23	0.05	0.03	0.08	0.91	0.64	1.18
24	0	112:15	0.04	0.01	0.14	0.91	0.11	1.71
30R	2	163:33	0.03	0.02	0.05	1.11	0.80	1.42
25	2	95:09	0.04	0.02	0.07	0.98	0.57	1.38
28	3	130:34	0.03	0.02	0.03	1.11	0.94	1.29
27	3	69:25	0.04	0.03	0.06	0.89	0.66	1.12
27R	3	162:35	0.02	0.02	0.04	1.19	0.95	1.43
26	3	99:48	0.07	0.03	0.18	0.86	0.29	1.44
22	3	97:16	0.03	0.01	0.07	1.06	0.51	1.62
22R	3	161:54	0.03	0.01	0.06	1.12	0.66	1.58
23	4	70:42	0.03	0.01	0.08	1.01	0.49	1.53
18	4	98:08	0.04	0.02	0.09	0.95	0.50	1.39
21	5	131:15	0.05	0.04	0.08	1.00	0.76	1.24
20	5	84:11	0.02	0.01	0.02	1.41	1.29	1.52
19	5	111:28	0.05	0.02	0.11	0.83	0.36	1.30
15	5	98:57	0.04	0.01	0.13	1.01	0.32	1.69
16	6	88:03	0.07	0.05	0.09	1.02	0.82	1.23
13	7	132:00	0.05	0.03	0.08	0.97	0.73	1.21
12	7	88:44	0.09	0.05	0.14	1.05	0.75	1.35
11	7	113:47	0.02	0.01	0.03	0.89	0.63	1.15
10	7	132:50	0.07	0.05	0.11	1.03	0.81	1.24
9	8	92:25	0.10	0.05	0.22	0.93	0.46	1.39
8	8	114:45	0.07	0.05	0.11	0.75	0.49	1.01
8R	8	161:04	0.11	0.04	0.35	0.84	0.17	1.51
6	9	134:30	0.08	0.06	0.11	0.88	0.72	1.05
5	9	93:33	0.11	0.05	0.26	0.80	0.29	1.31
4	9	118:00	0.06	0.03	0.11	0.99	0.60	1.38
4R	9	160:23	0.04	0.03	0.07	0.89	0.62	1.17
3	9	133:40	0.10	0.04	0.27	0.86	0.27	1.44
1	10	135:27	0.05	0.04	0.06	0.97	0.89	1.06

TABLE 4-3 Biochemical Analysis Results

ANIMAL #	DAYS ON DIET	% WATER	% LIPID	% PROTEIN
2R	0	73.98	5.43	22.85
7	0	74.17	3.59	15.04
14	0	73.70	4.71	19.72
17	0	73.36	3.45	20.60
17R	0	73.36	3.45	20.60
24	0	72.86	5.20	15.65
30R	2	73.00	7.70	15.14
25	2	74.68	4.08	14.20
28	3	74.56	7.22	14.59
27	3	73.64	3.60	14.57
27R	3	73.64	3.60	14.57
26	3	74.85	4.86	18.93
22	3	75.58	4.86	14.40
22R	3	75.58	4.86	14.40
23	4	75.21	4.31	12.88
18	4	74.54	6.26	17.40
21	5	73.98	5.20	16.40
20	5	74.32	4.58	16.10
19	5	74.24	6.66	18.73
15	5	75.60	5.80	15.85
16	6	71.73	9.78	16.25
13	7	70.69	8.88	20.13
12	7	73.16	8.63	10.90
11	7	71.70	9.02	12.60
10	7	70.54	11.02	10.96
9	8	68.09	11.67	13.67
8	8	69.84	11.93	18.00
8R	8	69.84	11.93	18.00
6	9	71.22	9.66	15.78
5	9	69.26	10.21	11.63
4	9	66.47	16.00	15.23
4R	9	66.47	16.00	15.23
3	9	67.71	14.85	18.10
1	10	67.24	14.14	14.13

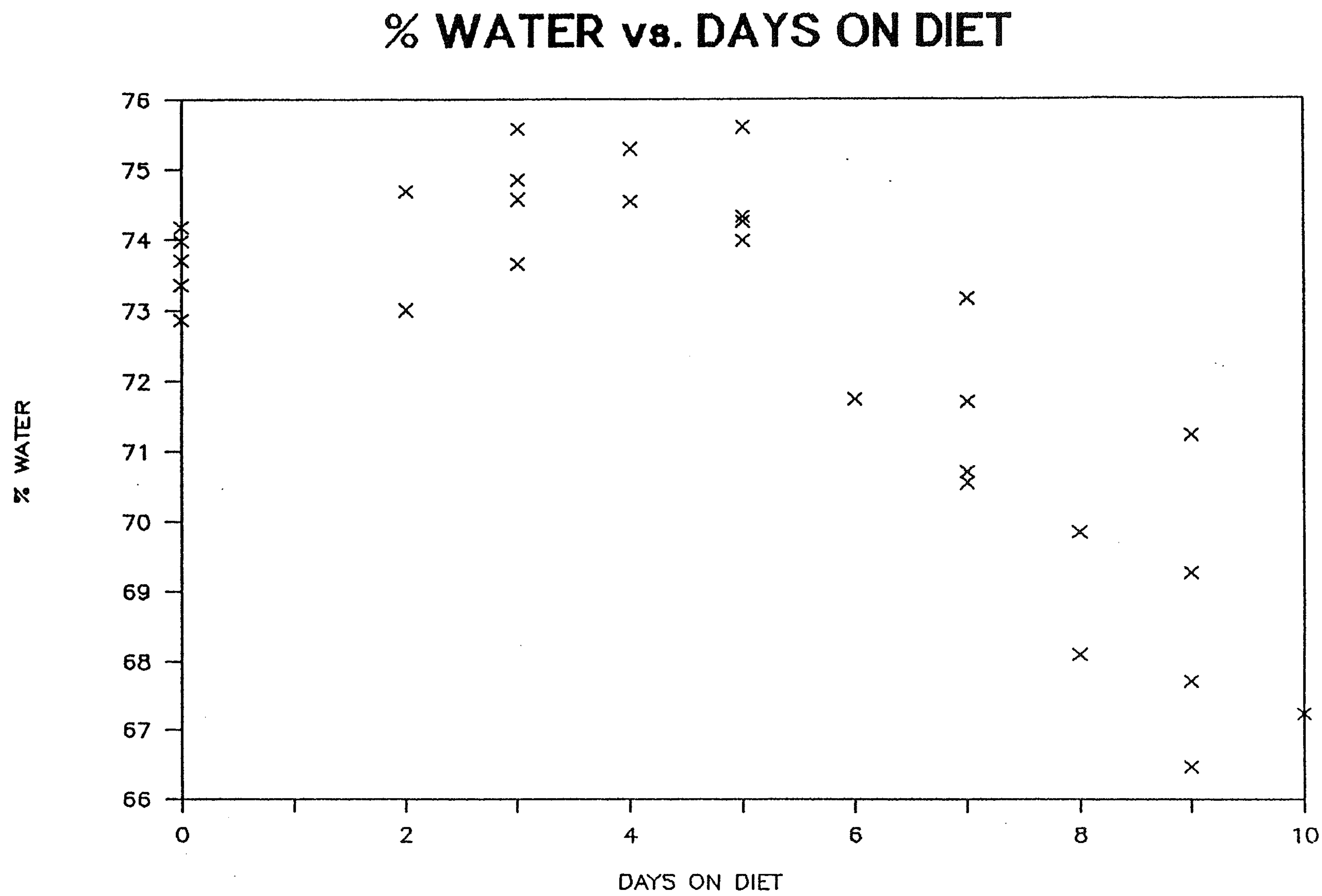

FIGURE 4-2 PERCENT WATER vs. DAYS ON DIET.

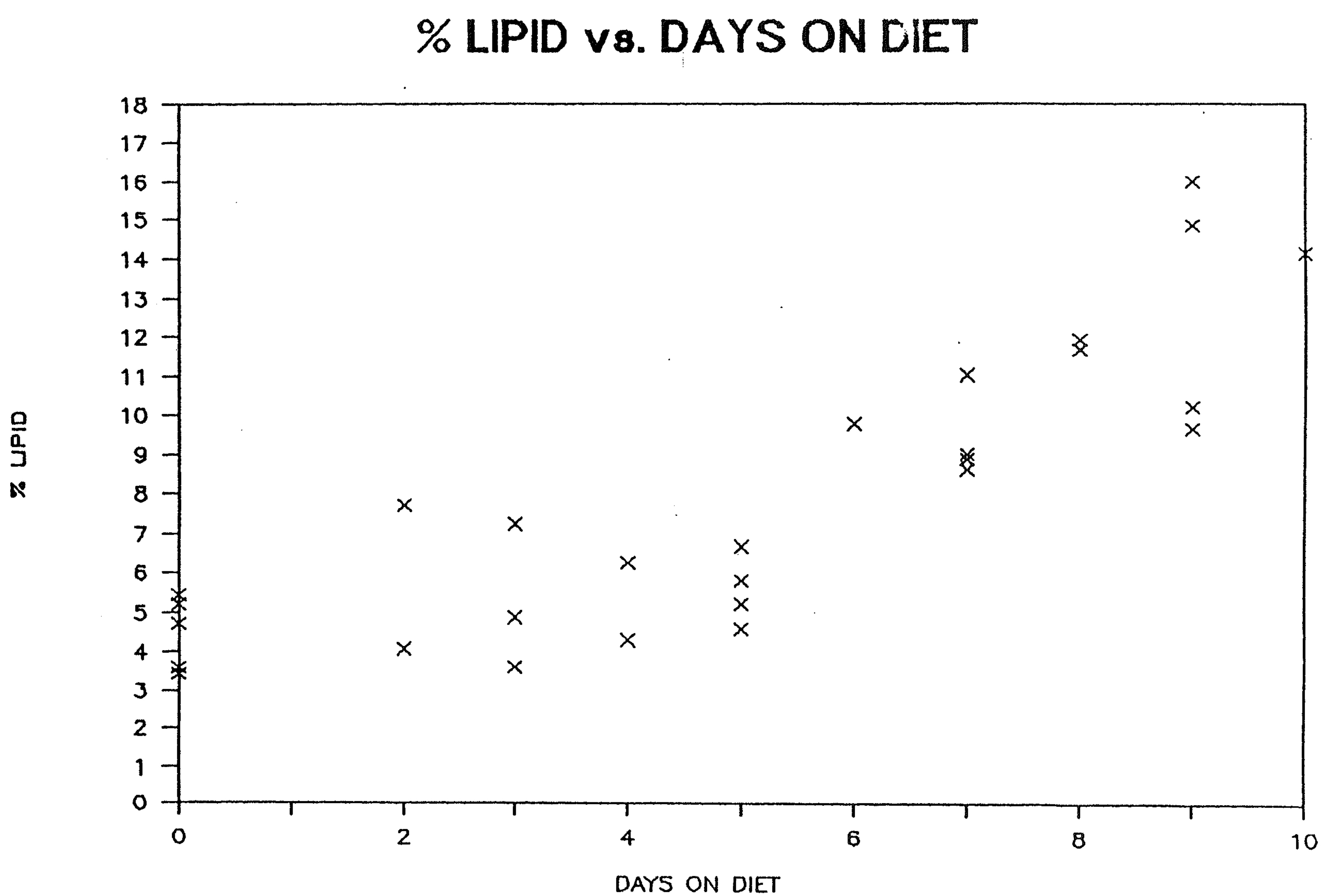

FIGURE 4-3 PERCENT LIPID vs. DAYS ON DIET.

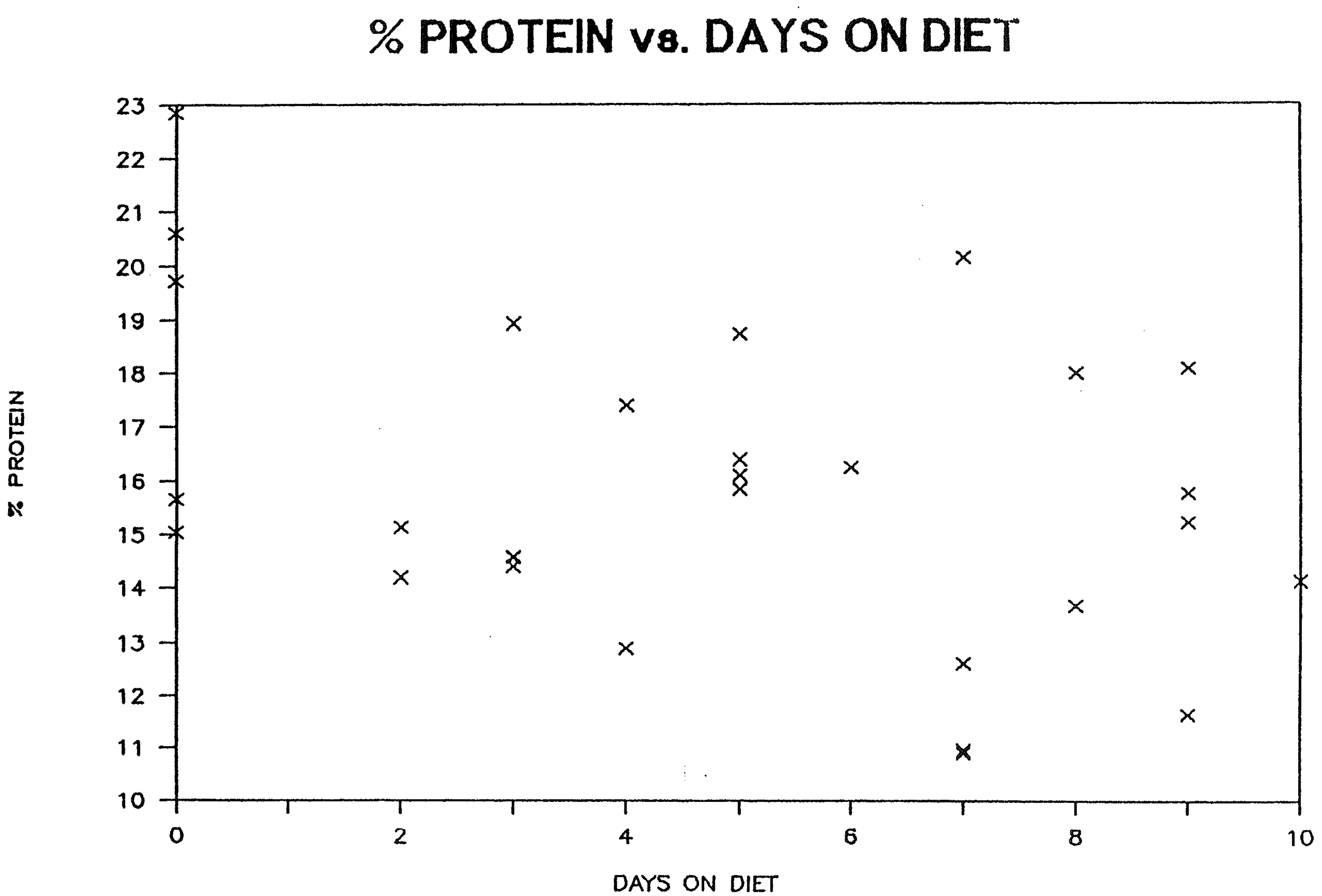

FIGURE 4-4 PERCENT PROTEIN vs. DAYS ON DIET.

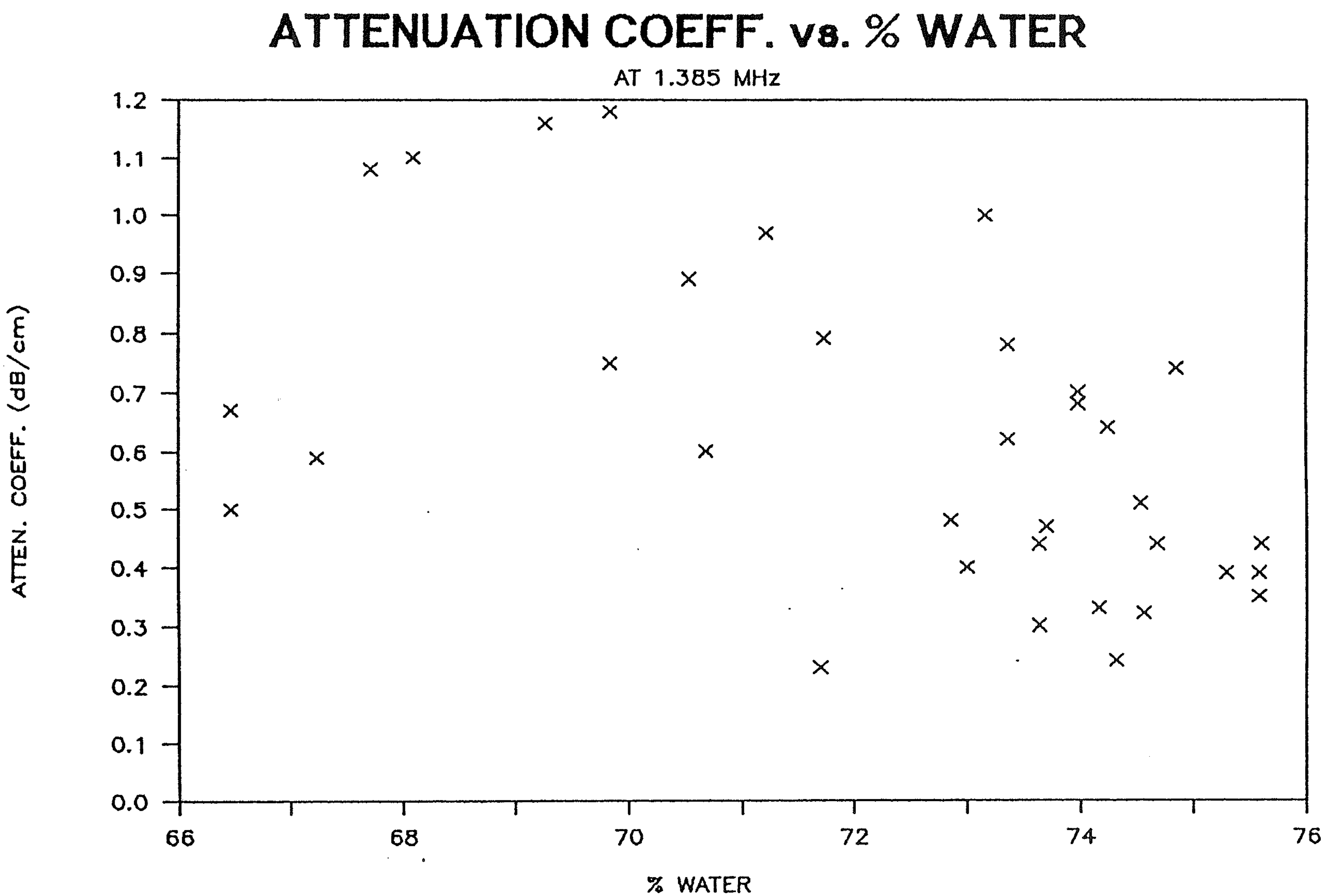

FIGURE 4-5 ATTENUATION COEFFICIENT vs. % WATER AT 1.385 MHz.

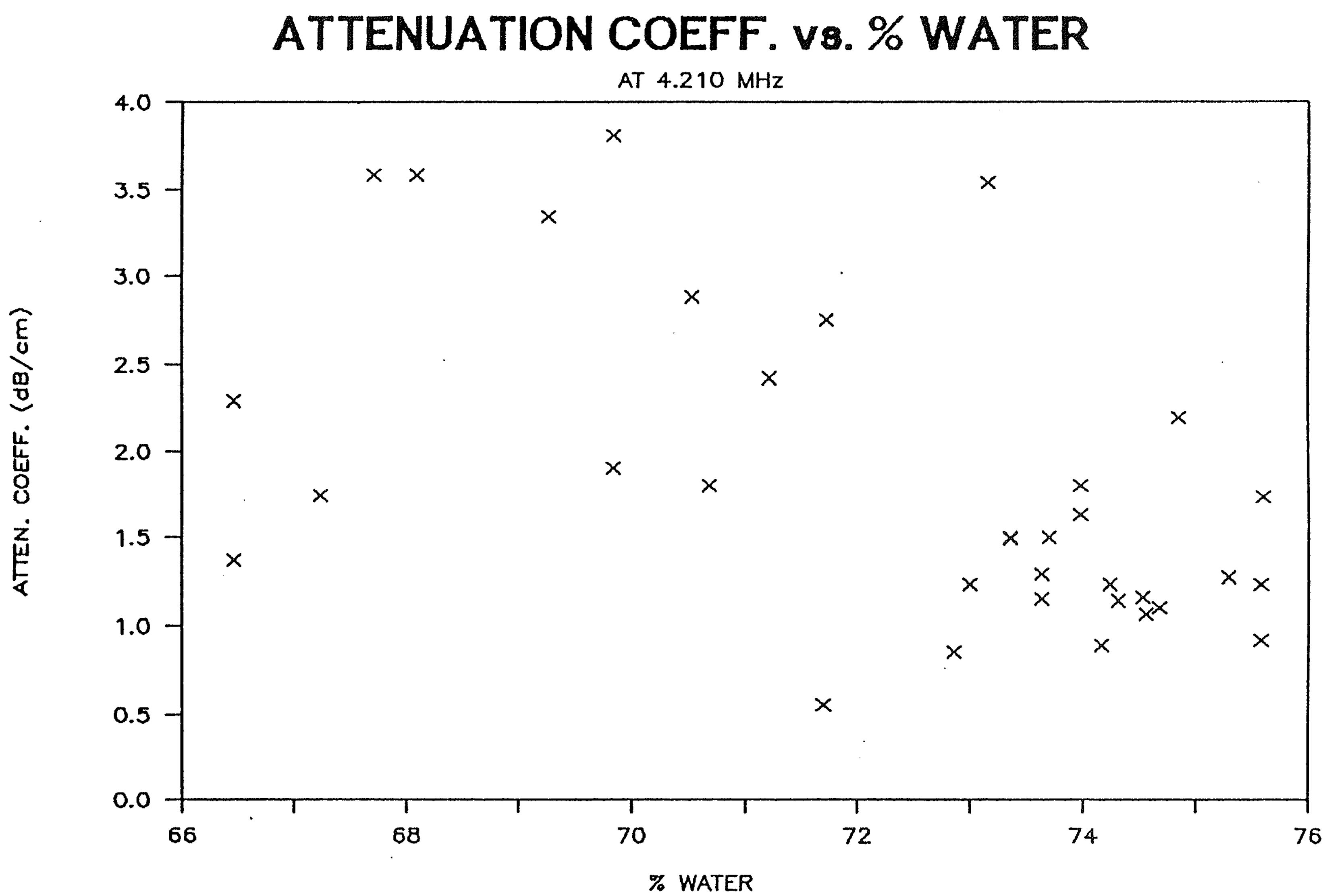

FIGURE 4-6 ATTENUATION COEFFICIENT vs. % WATER AT 4.210 MHz.

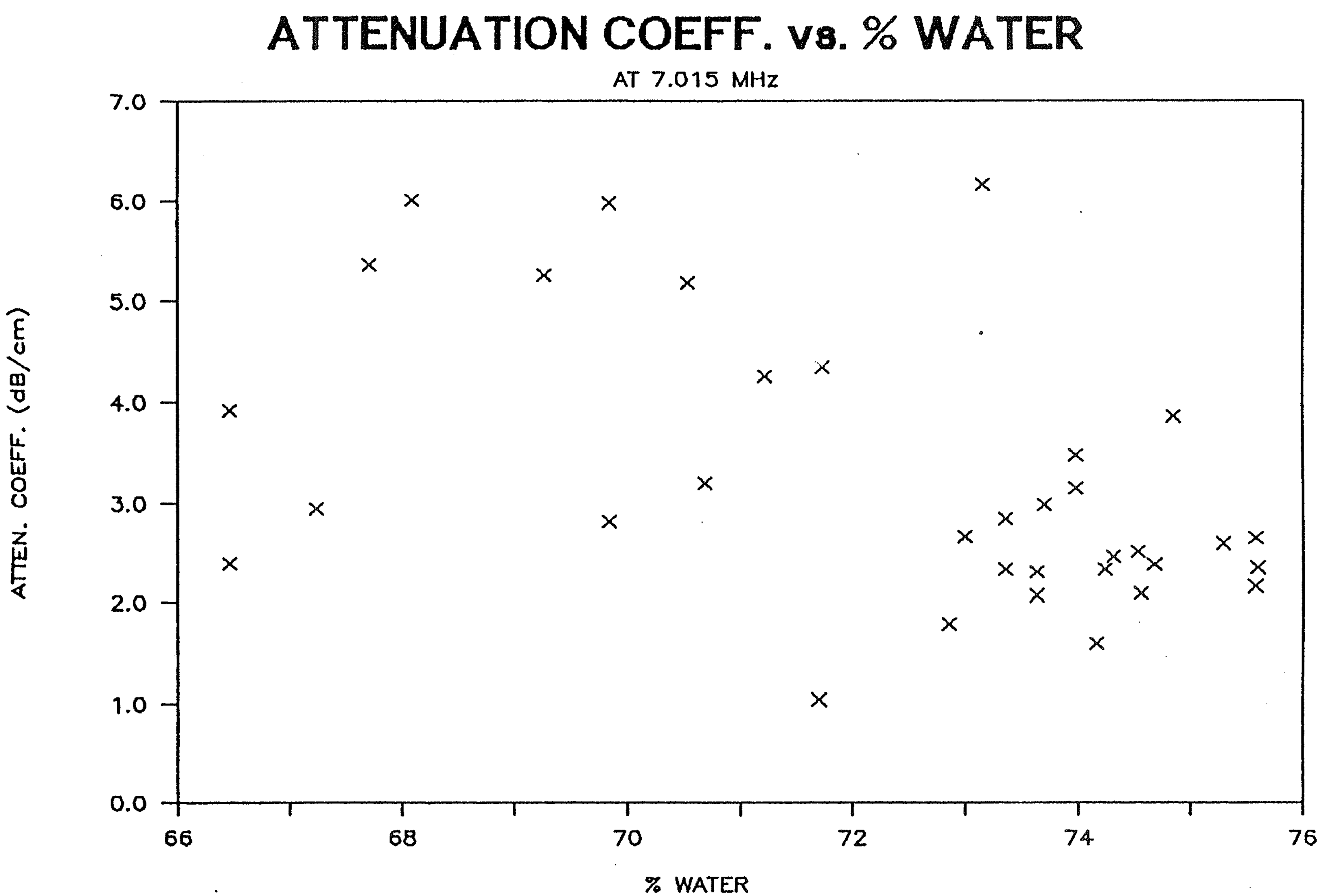

FIGURE 4-7 ATTENUATION COEFFICIENT vs. % WATER AT 7.015 MHz.

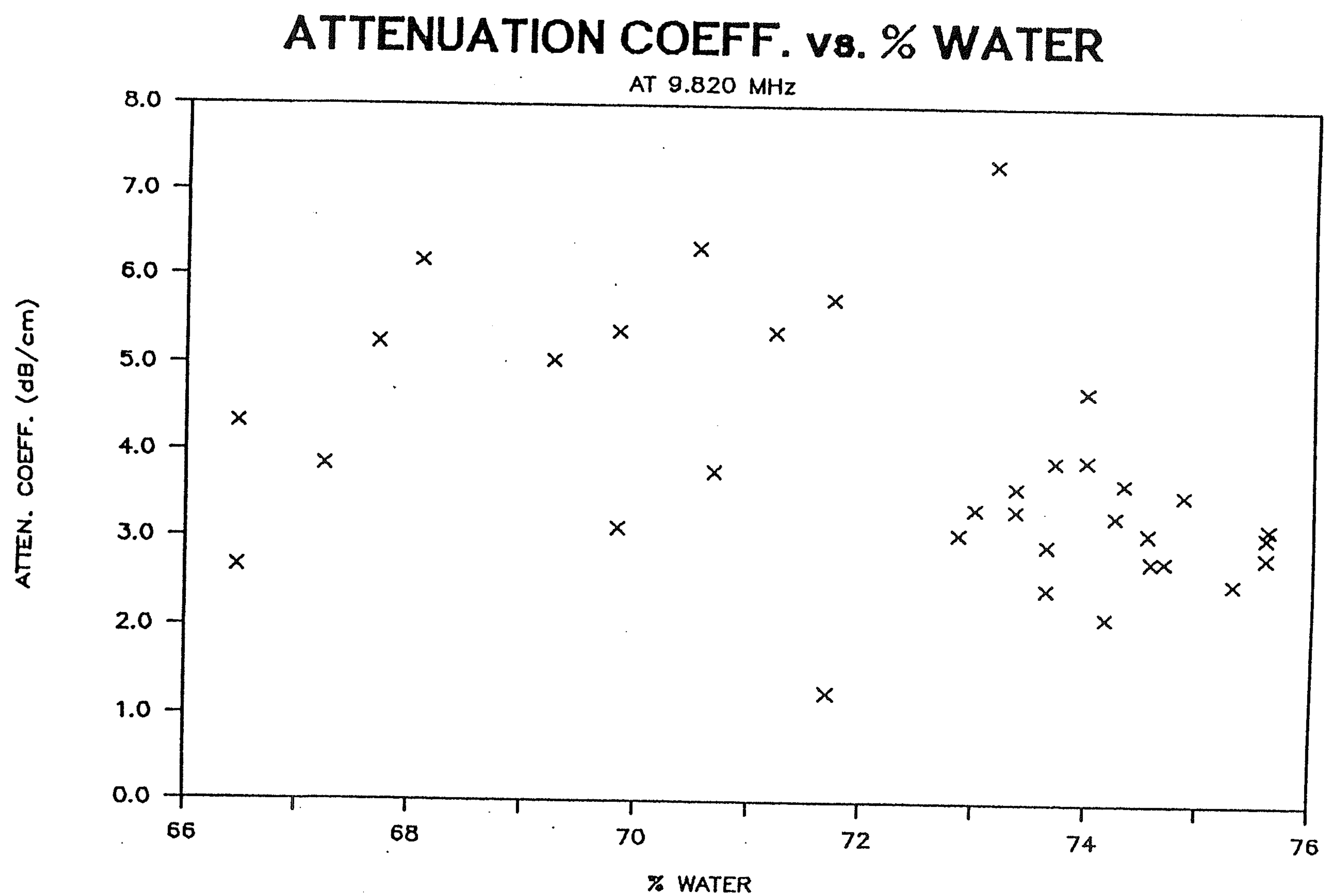

FIGURE 4-8 ATTENUATION COEFFICIENT vs. % WATER AT 9.820 MHz.

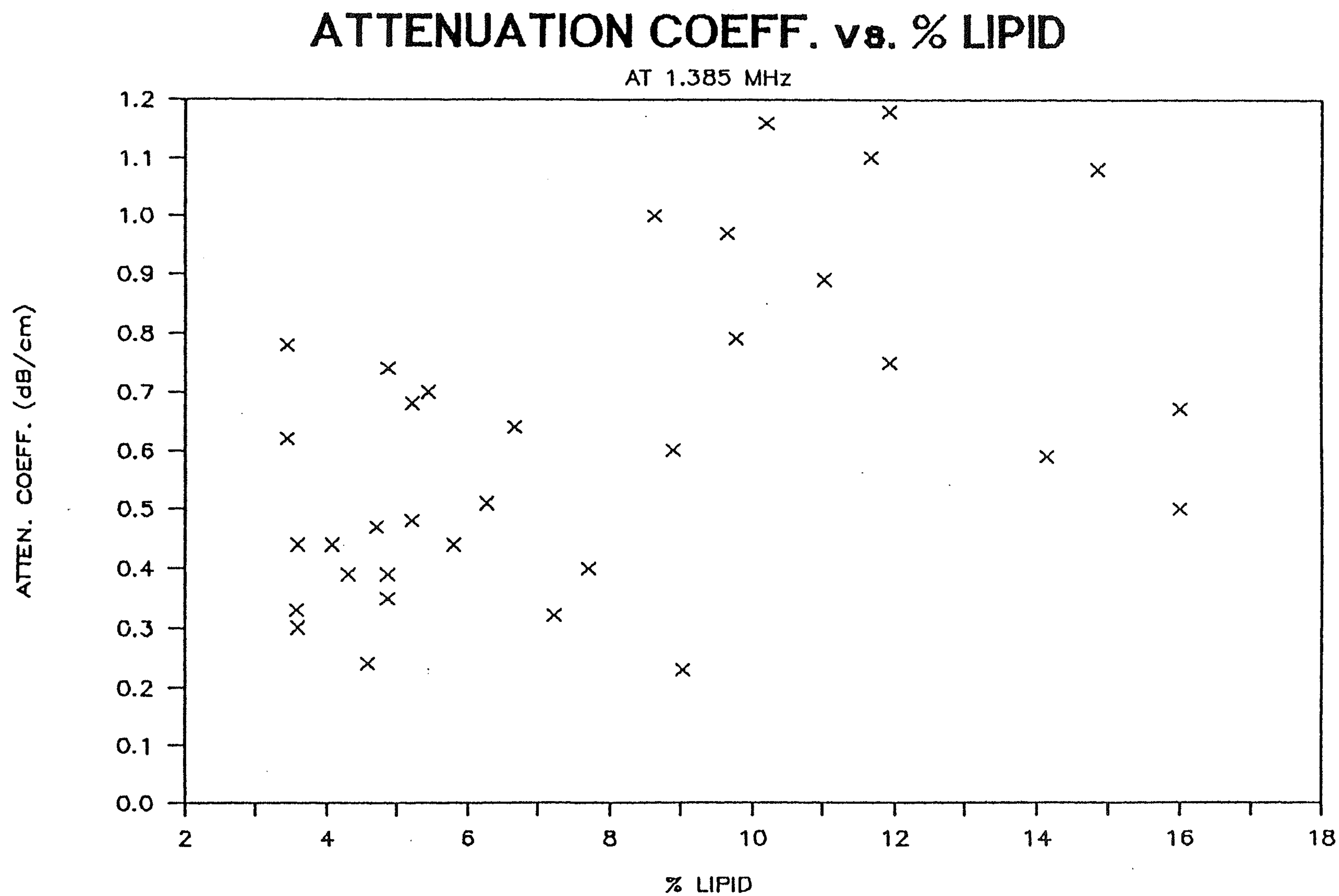

FIGURE 4-9 ATTENUATION COEFFICIENT vs. % LIPID AT 1.385 MHz.

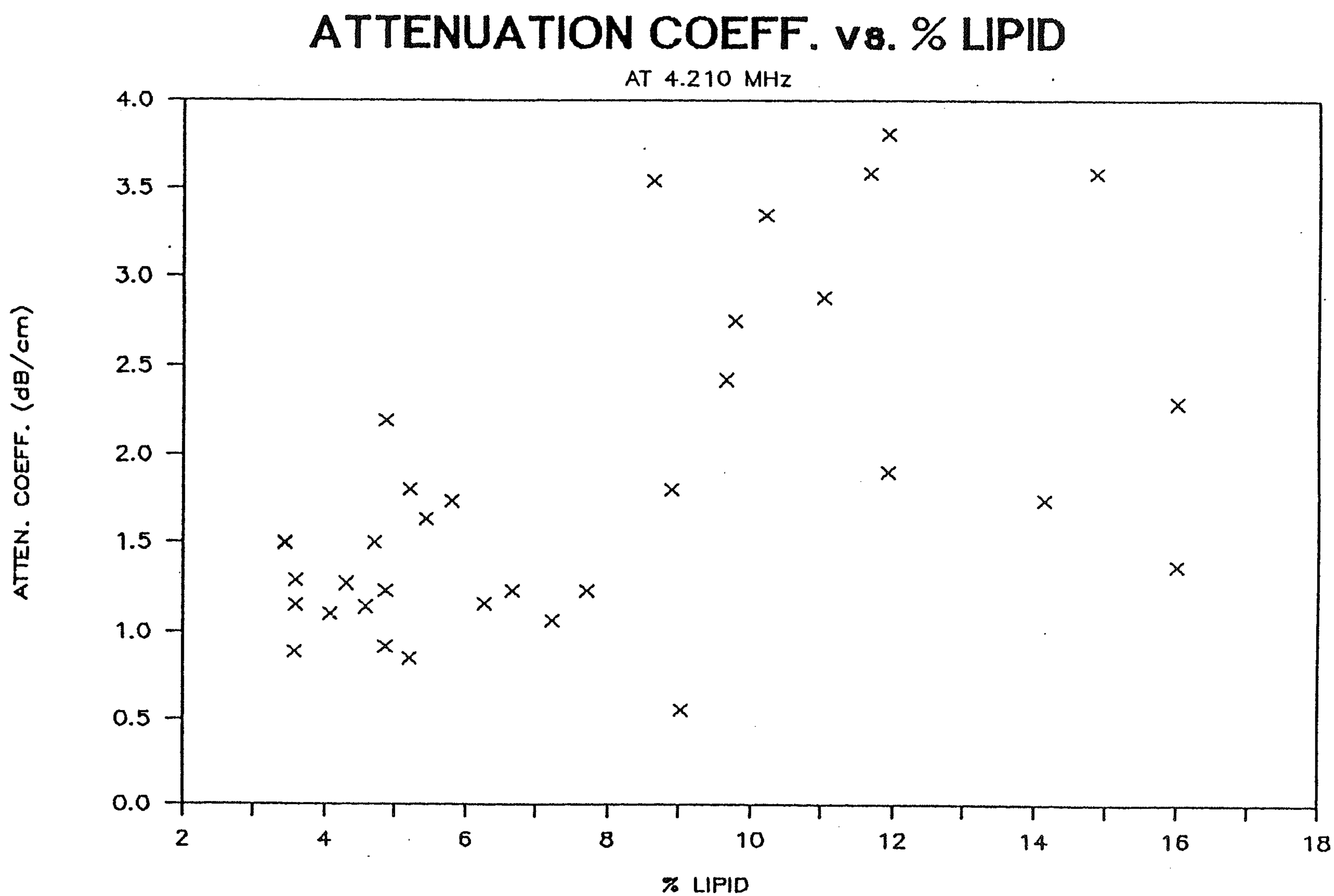

FIGURE 4-10 ATTENUATION COEFFICIENT vs. % LIPID AT 4.210 MHz.

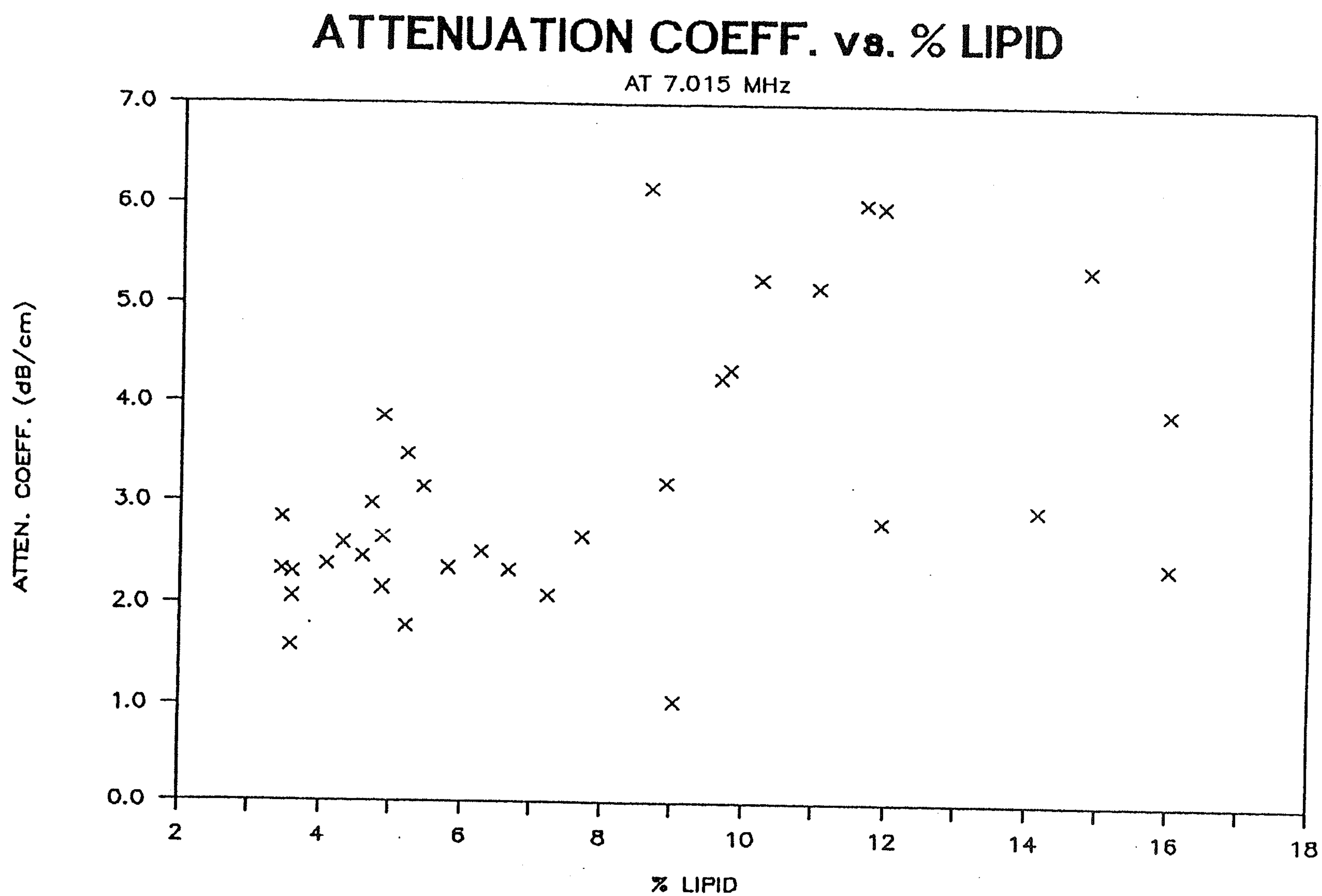

FIGURE 4-11 ATTENUATION COEFFICIENT vs. % LIPID AT 7.015 MHz.

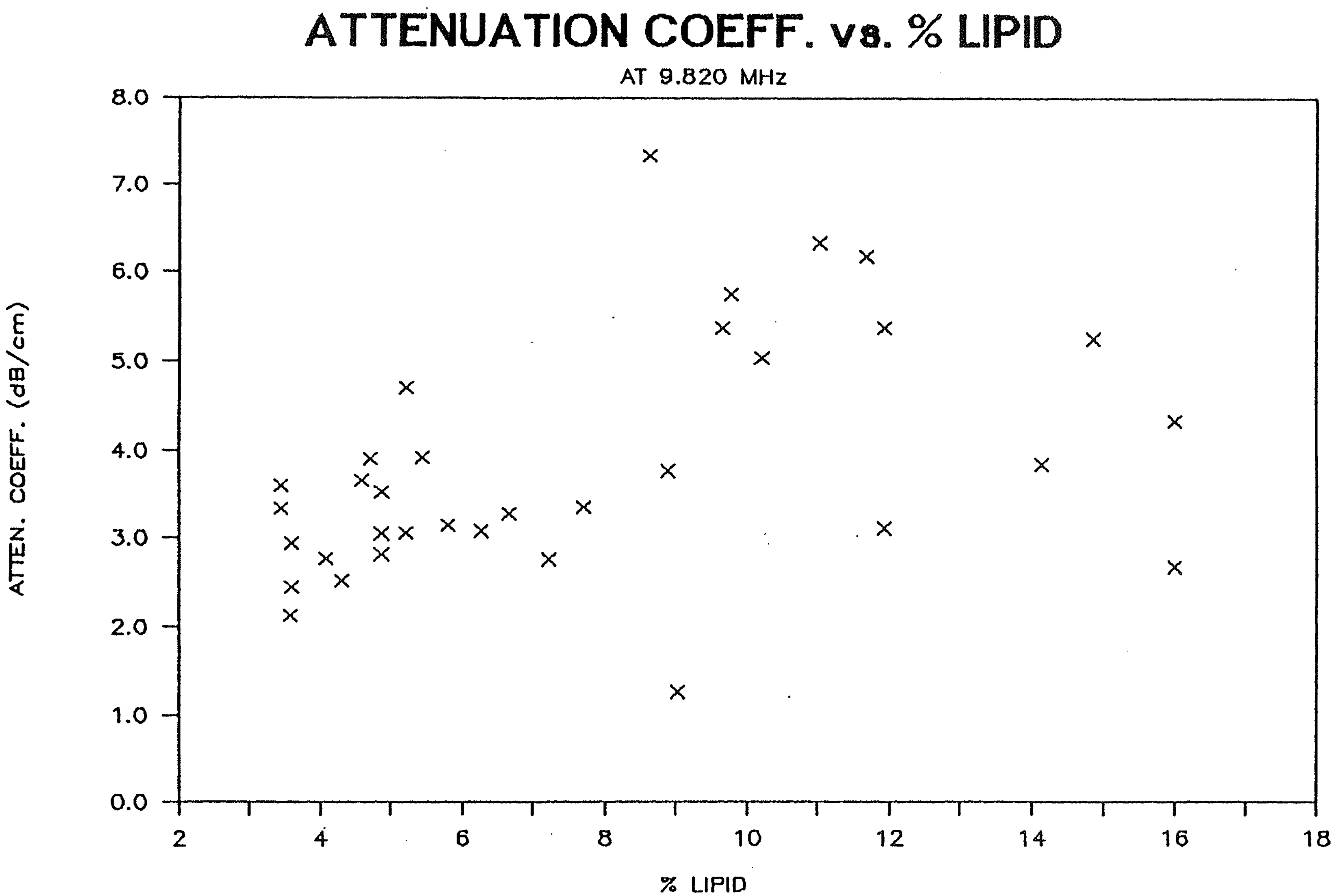

FIGURE 4-12 ATTENUATION COEFFICIENT vs. % LIPID AT 9.820 MHz.

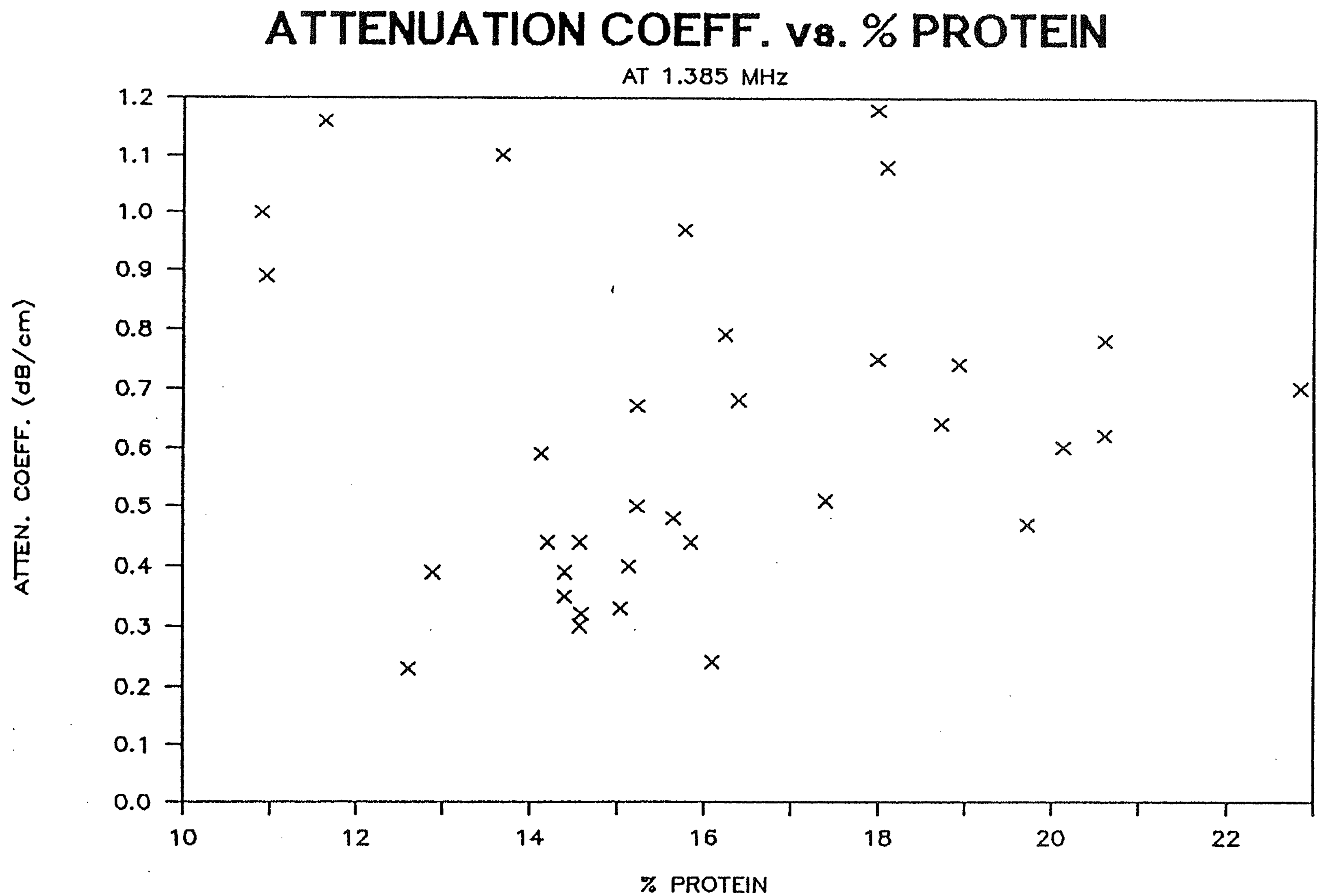

FIGURE 4-13 ATTENUATION COEFFICIENT vs. % PROTEIN AT 1.385 MHz.

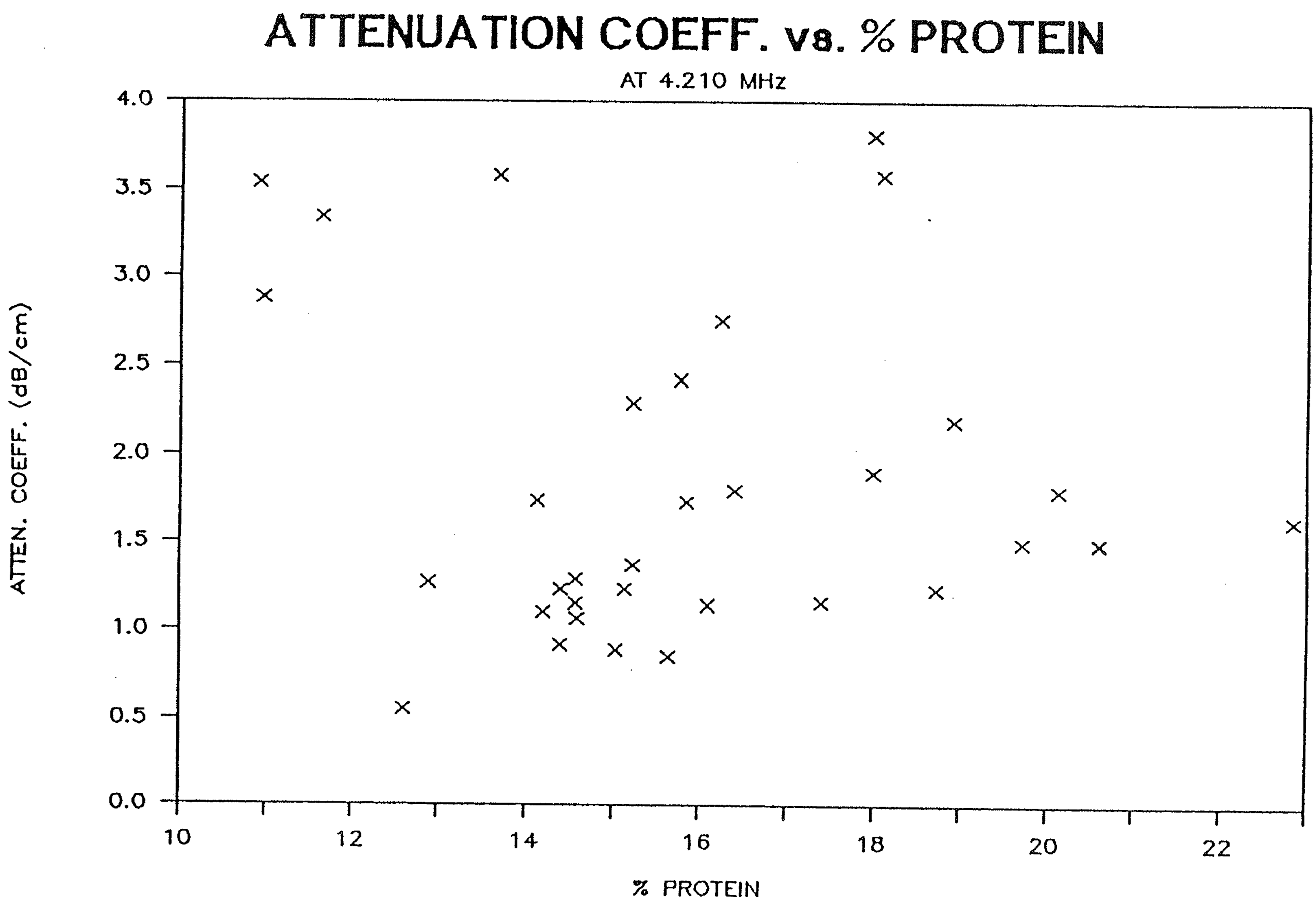

FIGURE 4-14 ATTENUATION COEFFICIENT vs. % PROTEIN AT 4.210 MHz.

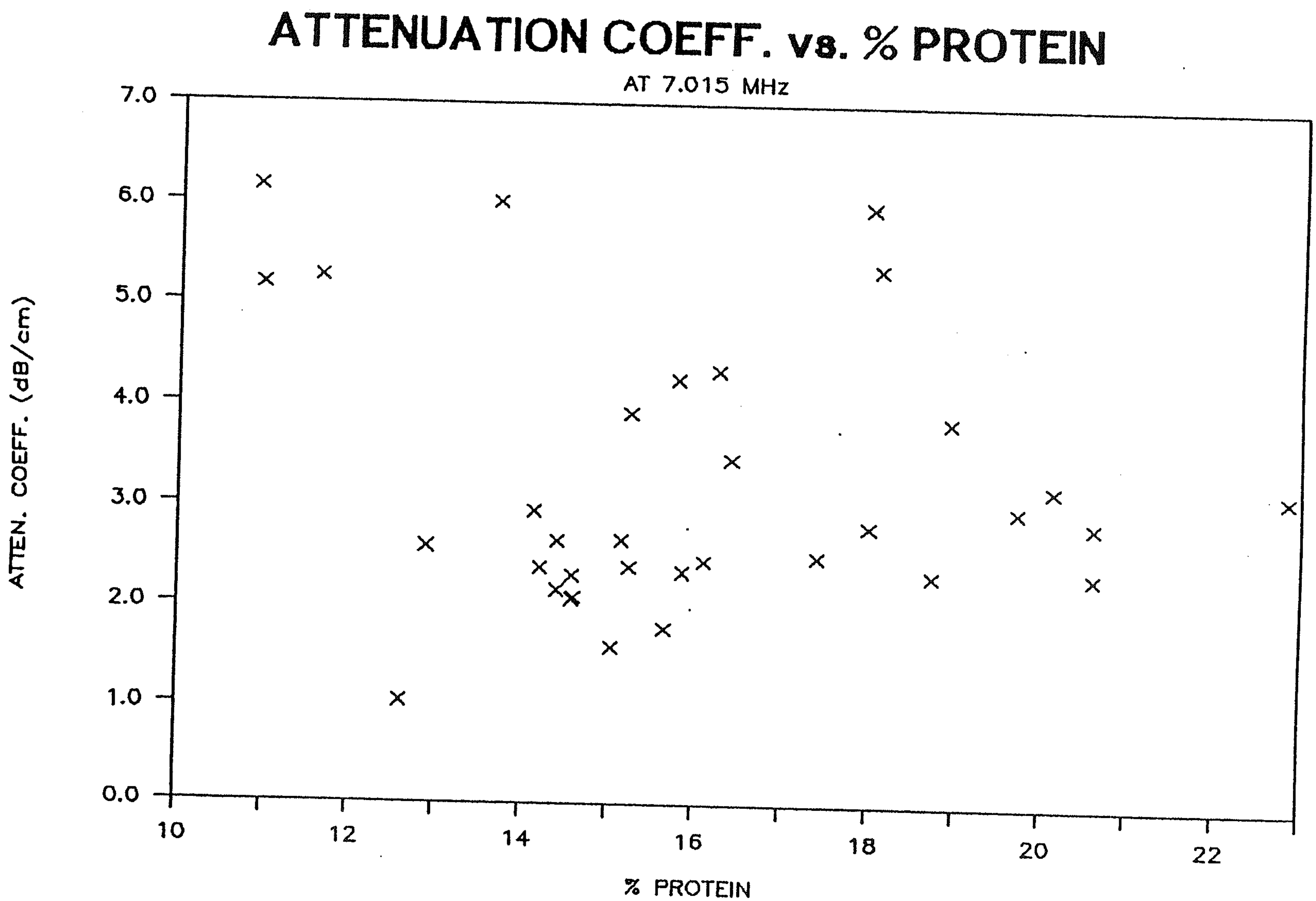

FIGURE 4-15 ATTENUATION COEFFICIENT vs. % PROTEIN AT 7.015 MHz.

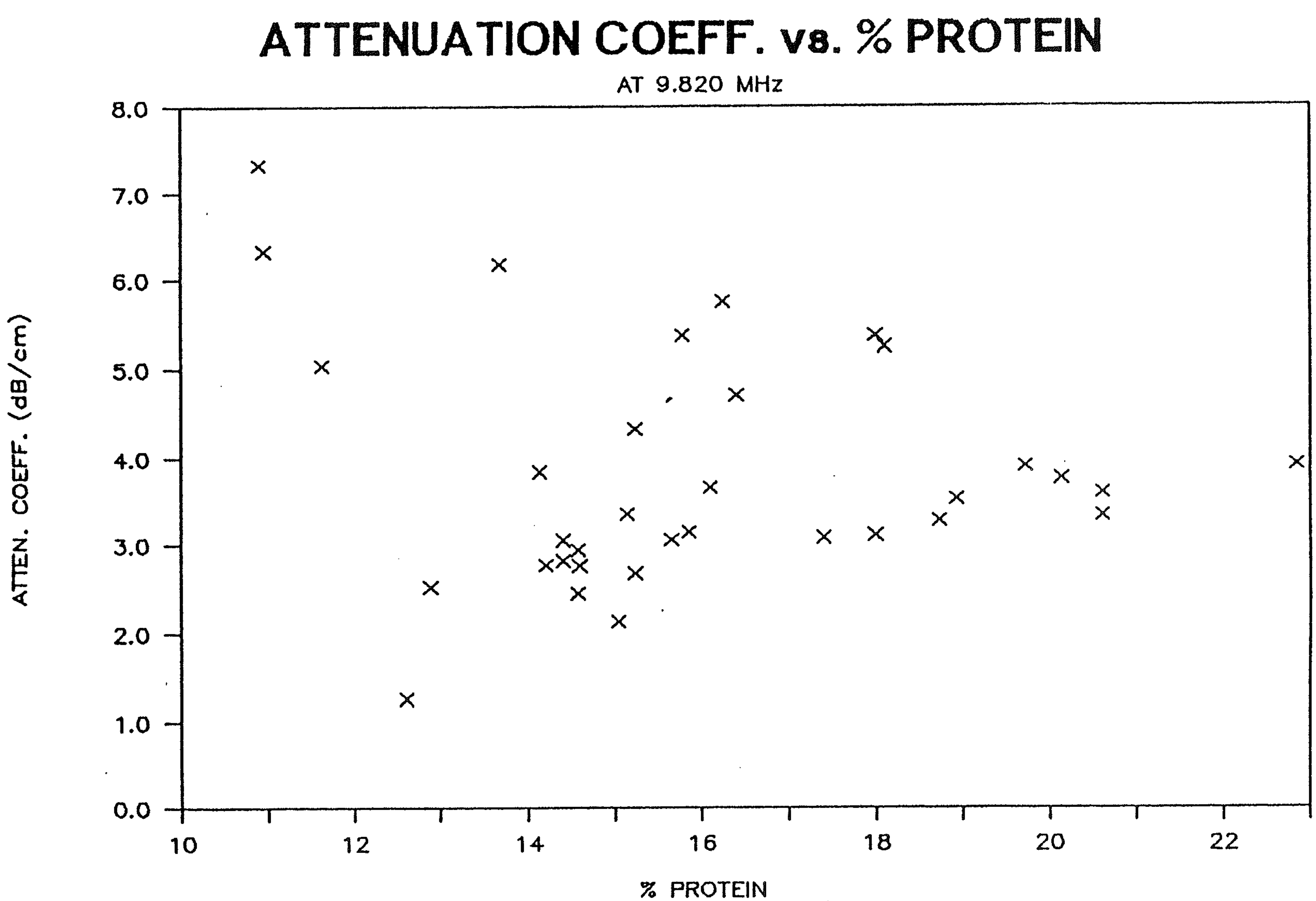

FIGURE 4-16 ATTENUATION COEFFICIENT vs. % PROTEIN AT 9.820 MHz.

concentration. Figures 4-17, 4-18, and 4-19 are graphs of n versus % water, % lipid, and % protein, respectively. Similarly, Figures 4-20, 4-21, and 4-22 are graphs for A_o.

4.1.4 Statistical treatment

The graphical treatment is helpful but is limited in that the relationship between only two variables can be studied at once. It is felt that the ultrasonic interaction with tissue is much more complex. In order to get an understanding of the attenuation relationship to all tissue properties, a more complete regression analysis was run to evaluate all the tissue constituent effects at once.

The regression procedure used is called STEPWISE and is supplied by the SAS Institute. Table 4-4 shows the output of this model for each frequency. The equations represent the effect each tissue property (W for water, L for lipid, and P for protein) had on the attenuation coefficient A. For each regression, an overall F statistic and probability level were determined, as well as a probability level for each independent variable in the equation. This was done to determine how significant each constituent was in affecting the attenuation.

4.2 Results

The graphs showing the effect of the diet on the liver (Figures 4-2, 4-3, and 4-4) clearly show that orotic acid over time decreases liver water content and increases liver lipid content.

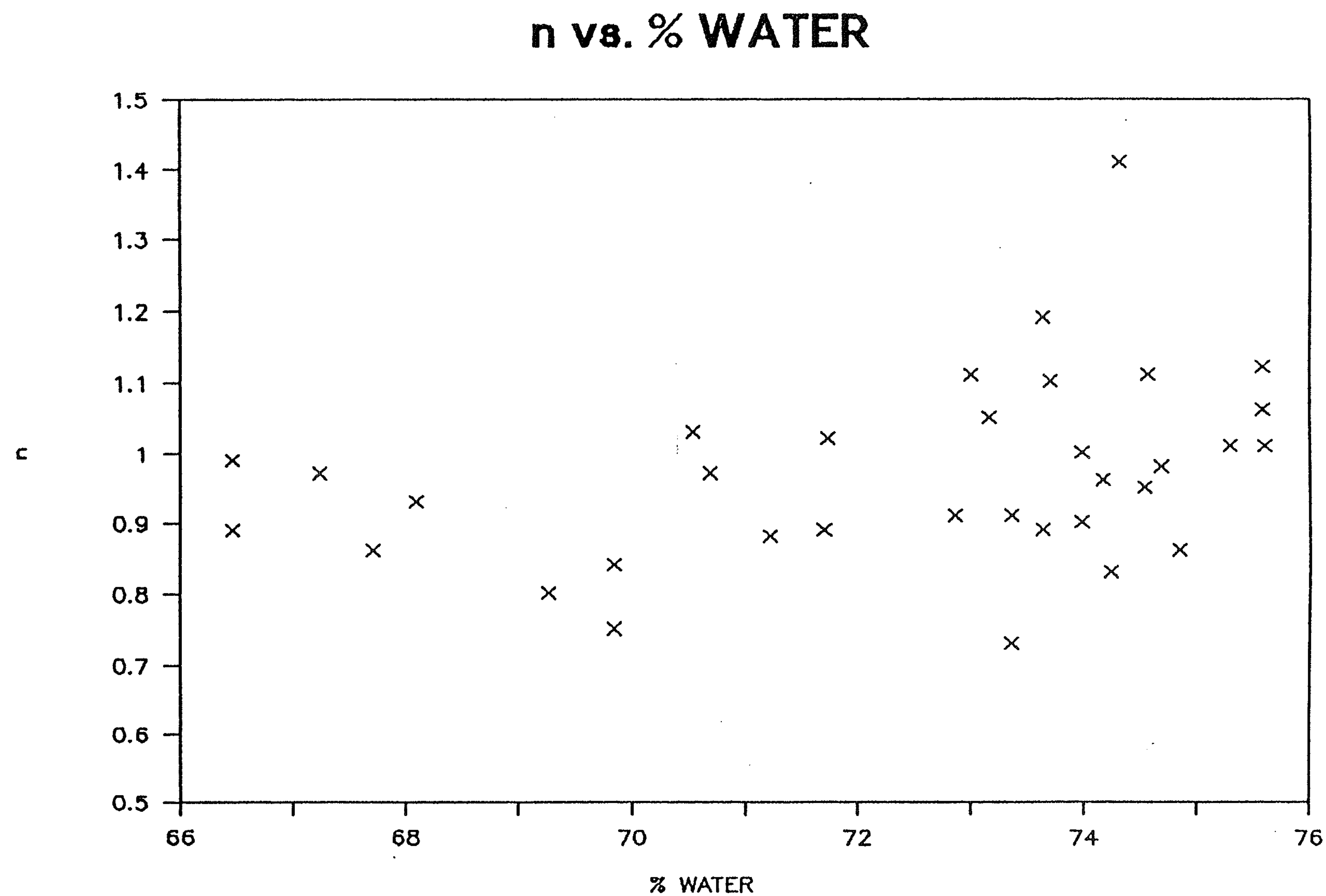

FIGURE 4-17 n vs. % WATER.

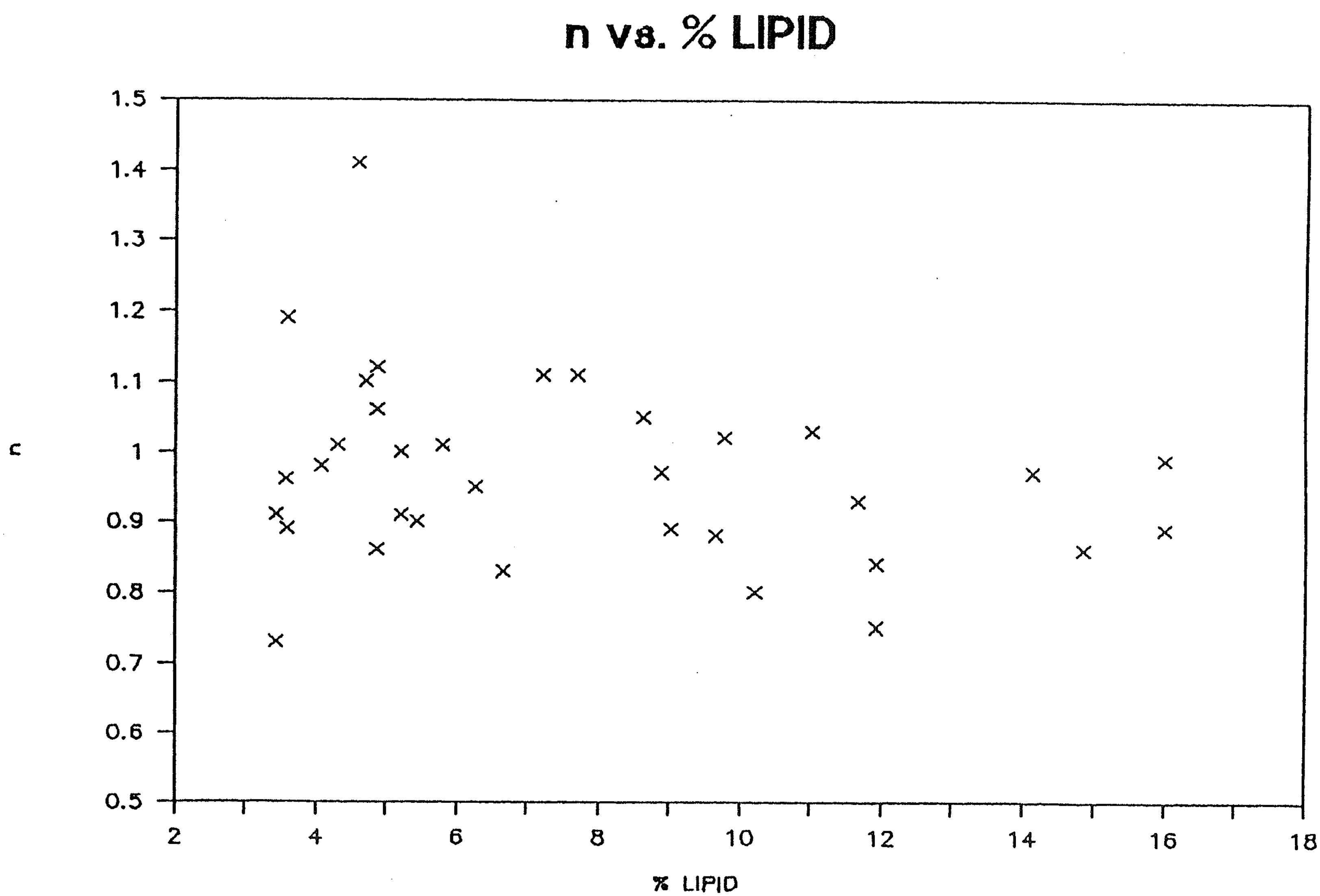

FIGURE 4-18 n vs. % LIPID.

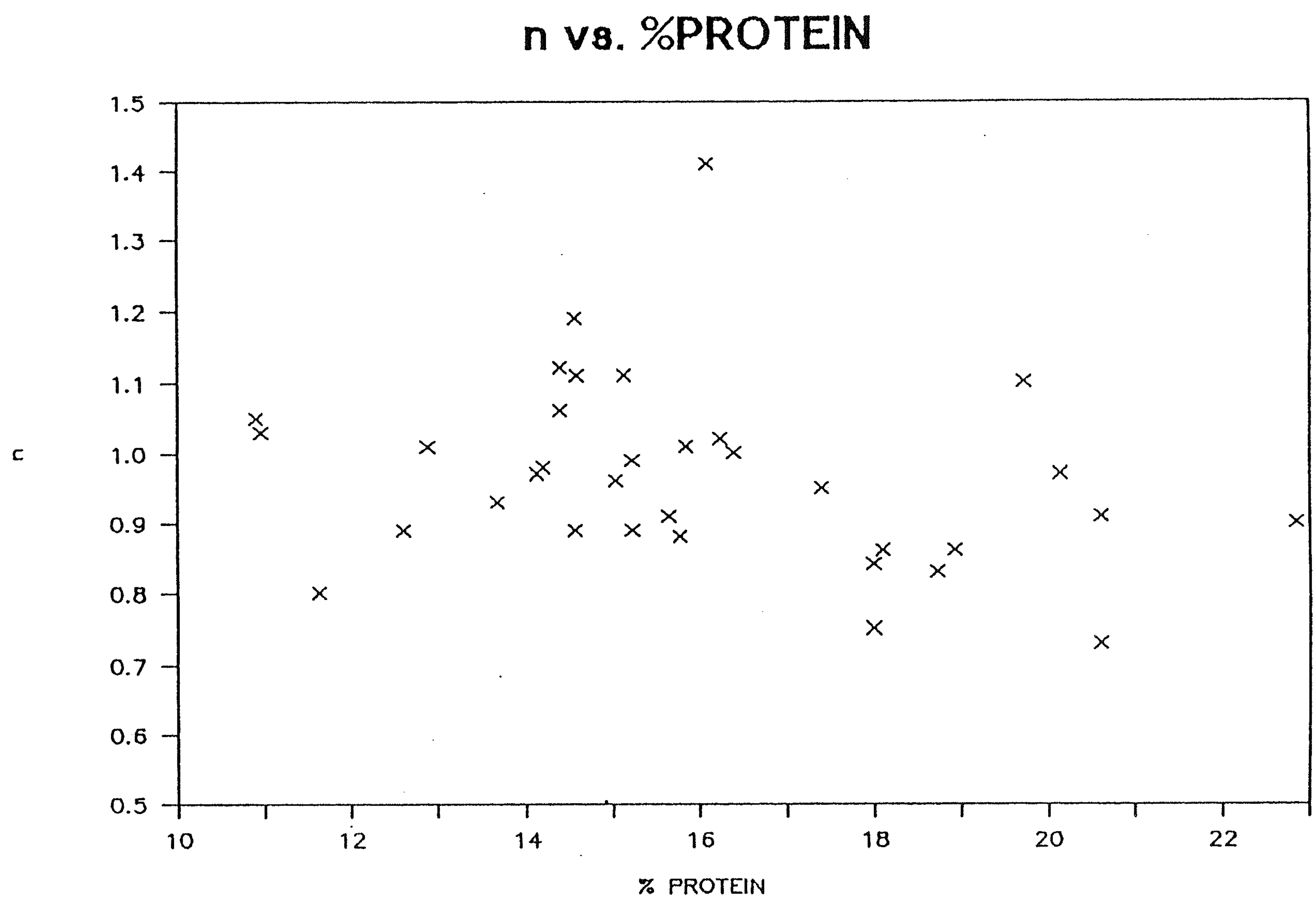

FIGURE 4-19 n vs. % PROTEIN.

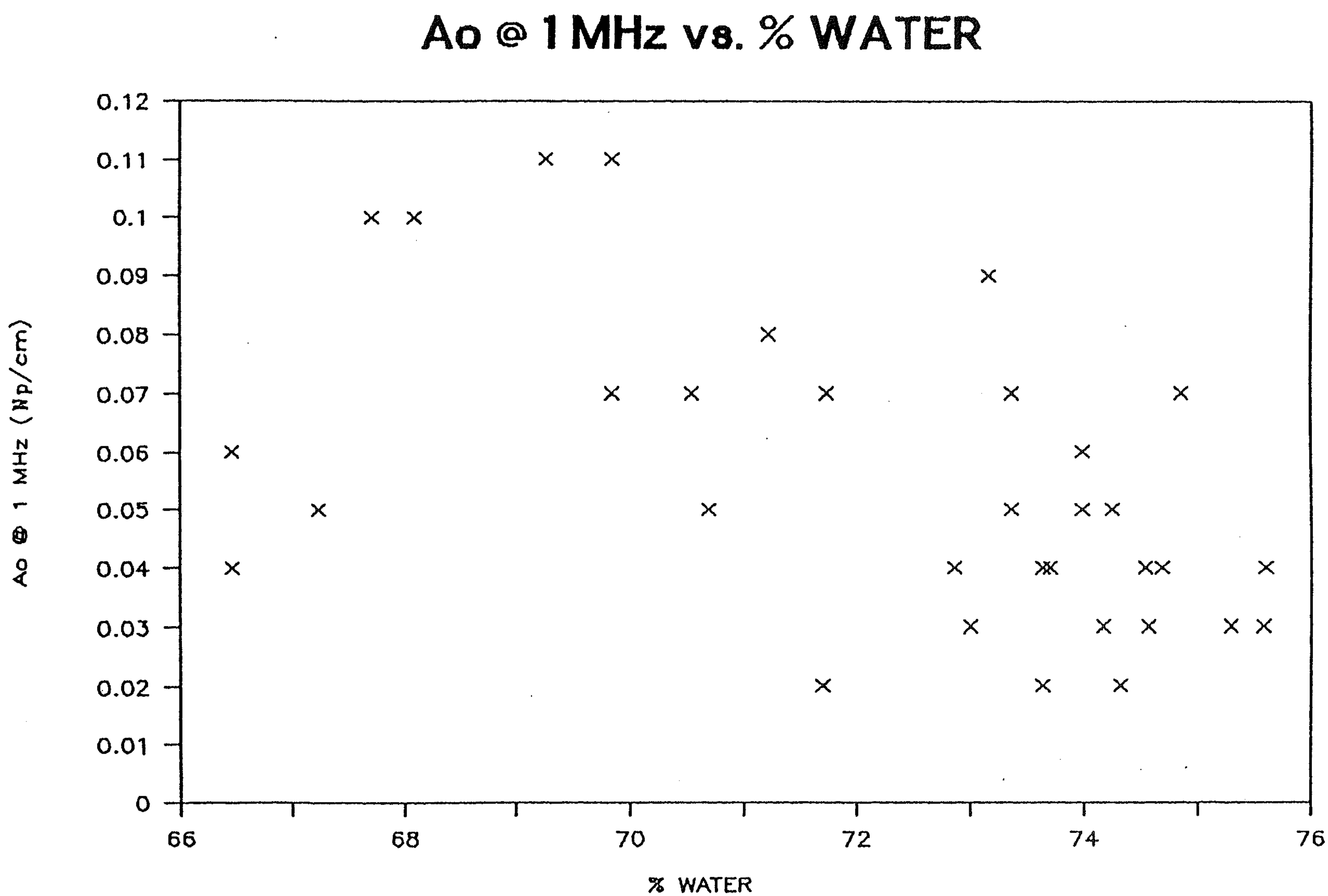

FIGURE 4-20 A_o vs. % WATER.

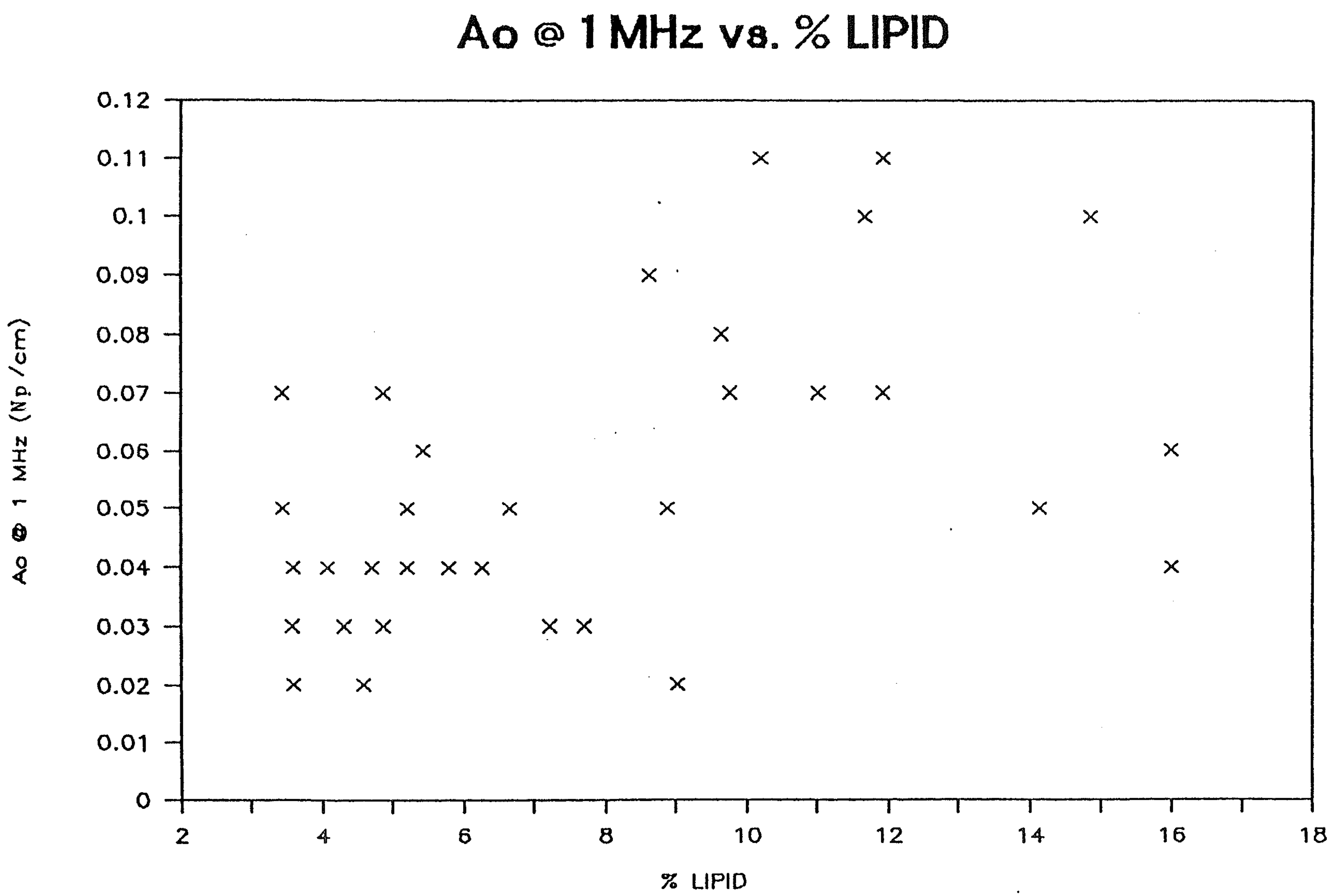

FIGURE 4-21 A_o vs. % LIPID.

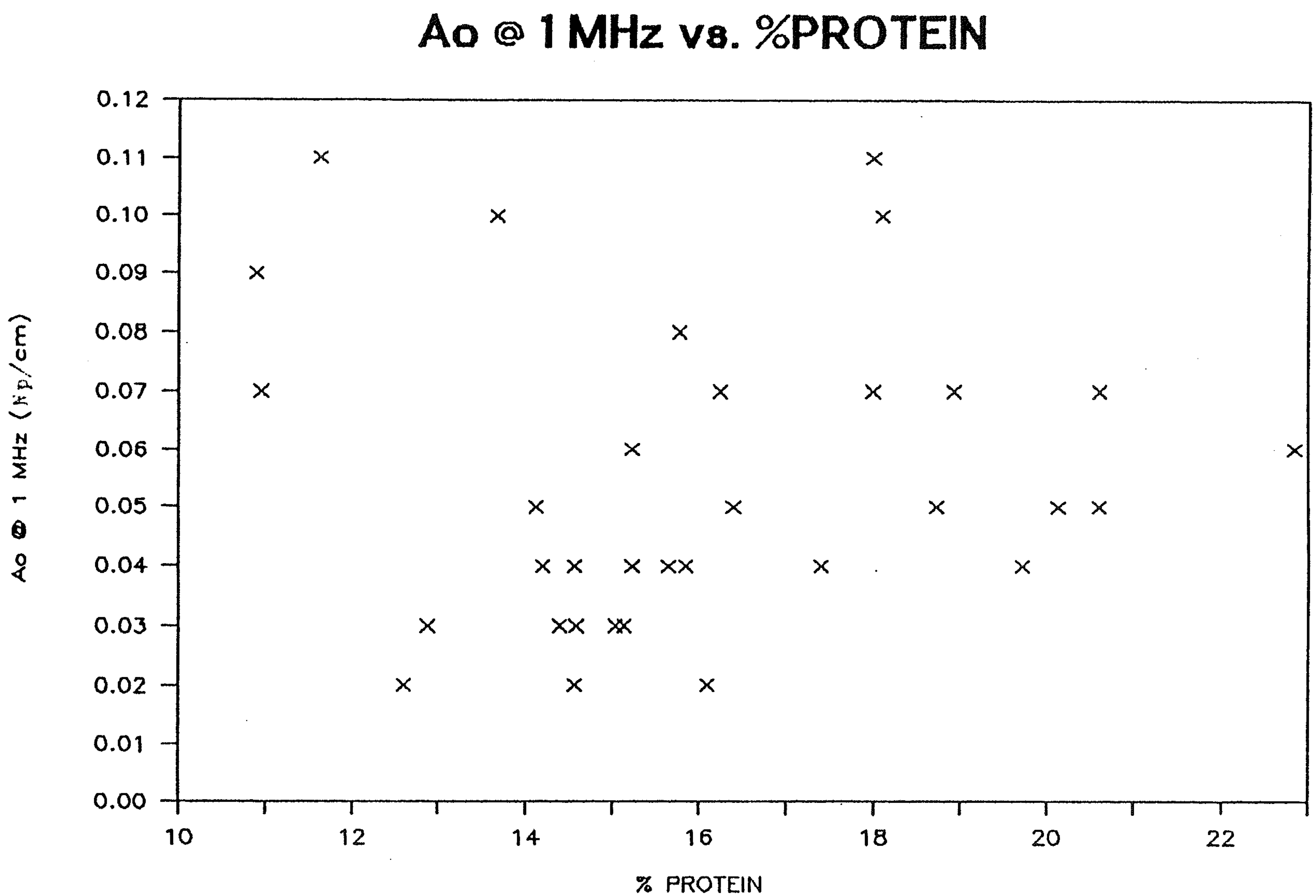

FIGURE 4-22 A_o vs. % PROTEIN.

TABLE 4-4 Output of STEPWISE

FREQUENCY = 1.385 MHz

$$A = 2.71 + \underset{p<0.57}{0.01(L)} - \underset{p<0.39}{0.03(W)} + \underset{p<0.38}{0.01(P)} \qquad \underset{p<0.0113}{F = 4.38}$$

FREQUENCY = 4.210 MHz

$$A = 3.93 + \underset{p<0.24}{0.11(L)} - \underset{p<0.74}{0.04(W)} \qquad \underset{p<0.0022}{F = 7.54}$$

FREQUENCY = 7.015 MHz

$$A = 4.67 + \underset{p<0.29}{0.16(L)} - \underset{p<0.88}{0.03(W)} - \underset{P<0.76}{0.02(P)} \qquad \underset{p<0.0243}{F = 3.62}$$

FREQUENCY = 9.820 MHz

$$A = 3.09 + \underset{p<0.02}{0.14(L)} - \underset{p<0.75}{0.03(P)} \qquad \underset{p<0.0421}{F = 3.52}$$

Its effect on protein content, if any, cannot be determined from these data.

The graphs of attenuation coefficient versus tissue content (Figures 4-5 to 4-16) show the following trends. As expected, it appears that as water content increases, attenuation decreases. Also, as lipid content increases, attenuation increases. For protein content, no trend is seen. It is important to note that these are trends and their significance cannot be stated just from these graphs.

The graphs of n and A_o (Figures 4-17 to 4-22) do not appear to show any influence of tissue content upon these values.

In analyzing the statistical output, it should be noted that significance is reserved for variables with a p value of less than 0.05. At 1.385 MHz, the overall equation shows significance ($p < 0.0113$) but none of the independent variables significantly affect attenuation. At 4.210 MHz, the overall equation shows significance ($p < 0.0022$) but again none of the independent variables shows significance. In fact, protein showed such little effect on the model that the program did not include it. At 7.015 MHz , the analysis results similarly (overall $p < 0.0243$ with no significant independent variables). At 9.820 MHz, while water did not enter the model, lipid does show significance in affecting attenuation ($p < 0.0118$). The overall equation is also significant ($p < 0.0421$).

In order to compare the results of this research with previous studies, a graph of attenuation coefficient vs. frequency was prepared for the radiation force balance data in Tables 2-1 and 2-3. The attenuation coefficients from Pohlhammer et al. (1981) and Segal and O´Brien (1983) were converted from Np/cm to dB/cm by multiplying them by 8.686 dB/Np. The data in this paper were averaged into two groups: all the animals together and all the animals that were not on the diet. Figure 4-23 is the graph of this compiled data. From this plot it can be seen that the data from this study is slightly lower in value than the previous work. However, the difference is small and could very well be due to the different origins of the tissues. The general trend is similar for all three studies.

This study adds to a growing database on the topic of ultrasonic liver characterization. From the statistical analysis, it is clear that while some interaction between ultrasonic measurements and tissue properties is occurring, the involvement is complex and difficult to pin down. The interaction between lipid and water concentration and attenuation appears to be important but more work needs to be done to better quantify it.

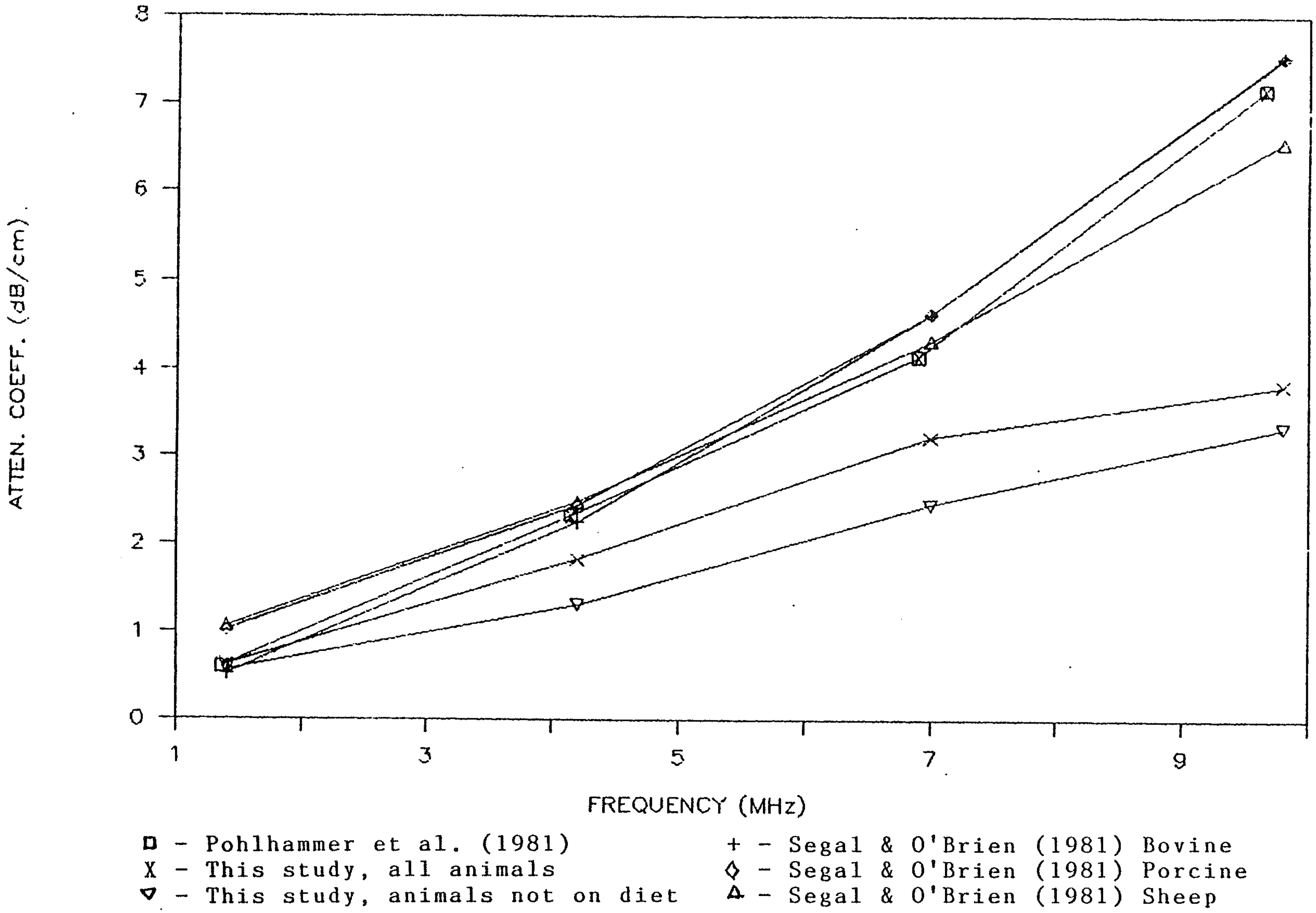

FIGURE 4-23 COMPARISON OF ATTENUATION DATA

APPENDIX

DATA DOCUMENTATION

This appendix contains the output of program COMP for each animal and the repeated runs. Each page represents one animal. The top four sections of the output contain the insertion loss measurements and the slope and intercept determined from them. The bottom section of the output contains the information from the regression of attenuation coefficient versus frequency. The "frequency component" is n and the "fitted alpha at 1 MHz" is A_o. The last page is the output when no tissue was in the sample holder.

COMP Output - Animal 01

AT 1.385 MHZ

SLOPE: 0.59 DB/CM — 95% CONFIDENCE LIMITS — LOWER: 0.37 DB/CM — UPPER: 0.81 DB/CM

INTERCEPT: 0.34 DB — 95% CONFIDENCE LIMITS — LOWER: 0.12 DB — UPPER: 0.55 DB

CORRELATION COEFFICIENT: 0.8822

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.36	0.48	0.04	3
0.70	0.72	0.01	3
1.00	1.12	0.09	3
1.46	1.08	0.00	3

AT 4.210 MHZ

SLOPE: 1.74 DB/CM — 95% CONFIDENCE LIMITS — LOWER: 1.13 DB/CM — UPPER: 2.35 DB/CM

INTERCEPT: 0.66 DB — 95% CONFIDENCE LIMITS — LOWER: 0.06 DB — UPPER: 1.25 DB

CORRELATION COEFFICIENT: 0.8946

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.36	1.07	0.03	3
0.70	1.84	0.02	3
1.00	2.96	0.10	3
1.46	2.88	0.11	3

AT 7.015 MHZ

SLOPE: 2.94 DB/CM — 95% CONFIDENCE LIMITS — LOWER: 1.92 DB/CM — UPPER: 3.95 DB/CM

INTERCEPT: 1.10 DB — 95% CONFIDENCE LIMITS — LOWER: 0.12 DB — UPPER: 2.09 DB

CORRELATION COEFFICIENT: 0.8976

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.36	1.74	0.00	3
0.70	3.21	0.03	3
1.00	4.96	0.11	3
1.46	4.84	0.08	3

AT 9.820 MHZ

SLOPE: 3.84 DB/CM — 95% CONFIDENCE LIMITS — LOWER: 2.59 DB/CM — UPPER: 5.10 DB/CM

INTERCEPT: 1.52 DB — 95% CONFIDENCE LIMITS — LOWER: 0.30 DB — UPPER: 2.73 DB

CORRELATION COEFFICIENT: 0.9075

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.36	2.43	0.07	3
.0.70	4.19	0.04	3
1.00	6.53	0.15	3
1.46	6.46	0.04	3

FREQUENCY VS ATTENUATION COEFFICIENT

FREQUENCY COMPONENT: 0.97

95% CONFIDENCE LIMITS: LOWER: 0.89

UPPER: 1.06

FREQUENCY MULTIPLIER: -1.31

95% CONFIDENCE LIMITS: LOWER: -1.37

UPPER: -1.24

CORRELATION COEFFICIENT: 0.9996

FITTED ALPHA AT 1 MHZ: 0.05

95% CONFIDENCE LIMITS: LOWER: 0.04

UPPER: 0.06

FITTED ALPHA AT 10 MHZ: 0.46

COMP Output - Animal 02R

```
AT  1.385 MHZ
SLOPE:    0.70 DB/CM   `     95% CONFIDENCE LIMITS
                               LOWER:    0.55 DB/CM
                               UPPER:    0.85 DB/CM
INTERCEPT:    0.04 DB        95% CONFIDENCE LIMITS
                               LOWER:   -0.10 DB
                               UPPER:    0.18 DB
CORRELATION COEFFICIENT: 0.9562
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.33            0.22            0.02            3
   0.68            0.58            0.12            3
   1.00            0.79            0.00            3
   1.33            0.92            0.01            3

AT  4.210 MHZ
SLOPE:    1.63 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    1.55 DB/CM
                               UPPER:    1.72 DB/CM
INTERCEPT:    0.05 DB        95% CONFIDENCE LIMITS
                               LOWER:   -0.02 DB
                               UPPER:    0.13 DB
CORRELATION COEFFICIENT: 0.9973
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.33            0.58            0.02            3
   0.68            1.18            0.02            3
   1.00            1.71            0.07            3
   1.33            2.20            0.02            3

AT  7.015 MHZ
SLOPE:    3.15 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    2.90 DB/CM
                               UPPER:    3.40 DB/CM
INTERCEPT:    0.08 DB        95% CONFIDENCE LIMITS
                               LOWER:   -0.15 DB
                               UPPER:    0.31 DB
CORRELATION COEFFICIENT: 0.9937
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.33            0.99            0.05            3
   0.68            2.37            0.06            3
   1.00            3.32            0.03            3
   1.33            4.15            0.04            3

AT  9.820 MHZ
SLOPE:    3.92 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    3.60 DB/CM
                               UPPER:    4.23 DB/CM
INTERCEPT:    0.33 DB        95% CONFIDENCE LIMITS
                               LOWER:    0.04 DB
                               UPPER:    0.62 DB
CORRELATION COEFFICIENT: 0.9935
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.33            1.46            0.08            3
   0.68            3.14            0.02            3
   1.00            4.41            0.03            3
   1.33            5.37            0.02            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      0.90
   95% CONFIDENCE LIMITS:   LOWER:     0.59


                            UPPER:     1.20
FREQUENCY MULTIPLIER:  --1.24
   95% CONFIDENCE LIMITS:   LOWER:    -1.45
                            UPPER:    -1.02
CORRELATION COEFFICIENT:   0.9939
FITTED ALPHA AT 1 MHZ:    0.06
   95% CONFIDENCE LIMITS:   LOWER:     0.04
                            UPPER:     0.10
FITTED ALPHA AT 10 MHZ:    0.46
```

COMP Output - Animal 03

```
   1.385 MHZ
SLOPE:     1.08 DB/CM         95% CONFIDENCE LIMITS
                                LOWER:    0.79 DB/CM
                                UPPER:    1.37 DB/CM
               0 35 DB        95% CONFIDENCE LIMITS
                                LOWER:    0.07 DB
                                UPPER:    0.63 DB
CORRELATION COEFFICIENT: 0 9353
THICKNESS  AVERAGE INSERTION      STANDARD            N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.31           0.71              0.08              3
   0.65           0.91              0.27              3
   1.01           1.60              0.02              3
   1.50           1.91              0.06              3

AT  4.?? MHZ
SLOPE:     3.58 DB/CM         95% CONFIDENCE LIMITS
                                LOWER:    2.93 DB/CM
                                UPPER:    4.22 DB/CM
INTERCEPT:    0.77 DB         95% CONFIDENCE LIMITS
                                LOWER:    0.14 DB
                                UPPER:    1.39 DB
CORRELATION COEFFICIENT: 0.9690
THICKNESS  AVERAGE INSERTION      STANDARD            N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.31           1.77              0.15              3
   0.65           2.97              0.56              3
   1.01           4.85              0.02              3
   1.50           5.89              0.05              3

AT  7.015 MHZ
SLOPE:     5.35 DB/CM         95% CONFIDENCE LIMITS
                                LOWER:    4.43 DB/CM
                                UPPER:    6.28 DB/CM
INTERCEPT:    1.72 DB         95% CONFIDENCE LIMITS
                                LOWER:    0.82 DB
                                UPPER:    2.62 DB
CORRELATION COEFFICIENT: 0.9712
THICKNESS  AVERAGE INSERTION      STANDARD            N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.31           2.84              0.20              3
   0.65           5.65              0.43              3
   1.01           7.63              0.33              3
   1.50           9.32              0.29              3

AT  9.820 MHZ
SLOPE:     5.25 DB/CM         95% CONFIDENCE LIMITS
                                LOWER:    4.32 DB/CM
                                UPPER:    6.17 DB/CM
INTERCEPT:    2.88 DB         95% CONFIDENCE LIMITS
                                LOWER:    1.99 DB
                                UPPER:    3.78 DB
CORRELATION COEFFICIENT: 0.9702
THICKNESS  AVERAGE INSERTION      STANDARD            N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.31           4.00              0.21              3
   0.65           6.56              0.07              3
   1.01           8.95              0.03              3
   1.50          10.22              0.29              3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:     0.86
   95% CONFIDENCE LIMITS:  LOWER:    0.27


                           UPPER:    1.44
FREQUENCY MULTIPLIER:  -0.99
   95% CONFIDENCE LIMITS:  LOWER:   -1.41
                           UPPER:   -0.56
CORRELATION COEFFICIENT:   0.9756
FITTED ALPHA AT 1 MHZ:   0.10
   95% CONFIDENCE LIMITS:  LOWER:    0.04
                           UPPER:    0.27
FITTED ALPHA AT 10 MHZ:    0.74
```

COMP Output - Animal 04

```
AT  1.385 MHZ
SLOPE:    0.67 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    0.42 DB/CM
                                UPPER:    0.92 DB/CM
INTERCEPT:    0.41 DB         95% CONFIDENCE LIMITS
                                LOWER:    0.15 DB
                                UPPER:    0.66 DB
CORRELATION COEFFICIENT:  0.8816
THICKNESS  AVERAGE INSERTION     STANDARD         N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.34           0.55             0.06           3
   0.74           1.11             0.11           3
   1.12           1.03             0.10           3
   1.48           1.42             0.01           3

AT  4.210 MHZ
SLOPE.    2.29 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    1.58 DB/CM
                                UPPER:    2.99 DB/CM
INTERCEPT:   -0.17 DB         95% CONFIDENCE LIMITS
                                LOWER:   -0.89 DB
                                UPPER:    0.54 DB
CORRELATION COEFFICIENT:  0.9159
THICKNESS  AVERAGE INSERTION     STANDARD         N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.34           0.37             0.07           3
   0.74           2.13             0.08           3
   1.12           1.87             0.03           3
   1.48           3.35             0.05           3

AT  7.015 MHZ
SLOPE:    3.92 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    2.87 DB/CM
                                UPPER:    4.97 DB/CM
INTERCEPT:   -0.12 DB         95% CONFIDENCE LIMITS
                                LOWER:   -1.18 DB
                                UPPER:    0.95 DB
CORRELATION COEFFICIENT:  0.9346
THICKNESS  AVERAGE INSERTION     STANDARD         N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.34           1.09             0.46           3
   0.74           3.41             0.10           3
   1.12           3.37             0.13           3
   1.48           6.08             0.06           3

AT  9.820 MHZ
SLOPE:    4.33 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    3.01 DB/CM
                                UPPER:    5.65 DB/CM
INTERCEPT:    0.03 DB         95% CONFIDENCE LIMITS
                                LOWER:   -1.31 DB
                                UPPER:    1.37 DB
CORRELATION COEFFICIENT:  0.9175
THICKNESS  AVERAGE INSERTION     STANDARD         N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.34           1.16             0.35           3
   0.74           4.26             0.30           3
   1.12           3.86             0.09           3
   1.48           6.77             0.00           3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:       0.99
   95% CONFIDENCE LIMITS:   LOWER:    0.60


                            UPPER:    1.38
FREQUENCY MULTIPLIER:   -1.23
   95% CONFIDENCE LIMITS:   LOWER:   -1.51
                            UPPER:   -0.95
CORRELATION COEFFICIENT:   0.9918
FITTED ALPHA AT 1 MHZ:    0.06
   95% CONFIDENCE LIMITS:   LOWER:    0.03
                            UPPER:    0.11
FITTED ALPHA AT 10 MHZ:    0.58
```

COMP Output - Animal 04R

```
AT  1.395 MHZ
SLOPE:    0.50 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    0.37 DB/CM
                             UPPER:    0.63 DB/CM
INTERCEPT:    0.38 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.25 DB
                             UPPER:    0.51 DB
CORRELATION COEFFICIENT: 0.9376
THICKNESS   AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.33            0.62            0.03             3
   0.73            0.62            0.02             3
   1.10            0.92            0.01             3
   1.46            1.15            0.03             3

AT  4.210 MHZ
SLOPE:    1.37 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    1.02 DB/CM
                             UPPER:    1.72 DB/CM
INTERCEPT:    0.79 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.44 DB
                             UPPER:    1.14 DB
CORRELATION COEFFICIENT: 0.9398
THICKNESS   AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.33            1.46            0.04             3
   0.73            1.45            0.02             3
   1.10            2.33            0.03             3
   1.46            2.89            0.02             3

AT  7.015 MHZ
SLOPE:    2.39 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    1.81 DB/CM
                             UPPER:    2.97 DB/CM
INTERCEPT:    1.28 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.70 DB
                             UPPER:    1.86 DB
CORRELATION COEFFICIENT: 0.9460
THICKNESS   AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.33            2.42            0.02             3
   0.73            2.48            0.02             3
   1.10            3.91            0.05             3
   1.46            4.96            0.13             3

AT  9.820 MHZ
SLOPE:    2.67 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    2.10 DB/CM
                             UPPER:    3.25 DB/CM
INTERCEPT:    1.81 DB       95% CONFIDENCE LIMITS
                             LOWER:    1.24 DB
                             UPPER:    2.38 DB
CORRELATION COEFFICIENT: 0.9566
THICKNESS   AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.33            3.01            0.02             3
   0.73            3.19            0.05             3
   1.10            4.89            0.09             3
   1.46            5.81            0.05             3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:     0.89
   95% CONFIDENCE LIMITS:   LOWER:    0.62


                            UPPER:    1.17
FREQUENCY MULTIPLIER:  -1.36
   95% CONFIDENCE LIMITS:   LOWER:   -1.56
                            UPPER:   -1.16
CORRELATION COEFFICIENT:   0.9948
FITTED ALPHA AT 1 MHZ:    0.04
   95% CONFIDENCE LIMITS:   LOWER:    0.03
                            UPPER:    0.07
FITTED ALPHA AT 10 MHZ:    0.34
```

COMP Output - Animal 05

```
AT  1.385 MHZ
SLOPE.    1.16 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    0.93 DB/CM
                                UPPER:    1.40 DB/CM
INTERCEPT:    0.25 DB         95% CONFIDENCE LIMITS
                                LOWER:    0.01 DB
                                UPPER:    0.50 DB
CORRELATION COEFFICIENT: 0.9625
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)     DEVIATION (DB)
   0.36          0.68             0.10             3
   0.74          0.98             0.06             3
   1.11          1.76             0.07             3
   1.63          2.07             0.08             3

AT  4.210 MHZ
SLOPE.   3.34 DB/CM           95% CONFIDENCE LIMITS
                                LOWER:    2.74 DB/CM
                                UPPER:    3.94 DB/CM
INTERCEPT:    0.11 DB         95% CONFIDENCE LIMITS
                                LOWER:   -0.54 DB
                                UPPER:    0.75 DB
CORRELATION COEFFICIENT: 0.9687
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)     DEVIATION (DB)
   0.36          1.38             0.18             3
   0.74          2.14             0.10             3
   1.11          4.39             0.06             3
   1.63          5.33             0.12             3

AT  7.015 MHZ
SLOPE:    5.25 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    4.27 DB/CM
                                UPPER:    6.23 DB/CM
INTERCEPT:    0.42 DB         95% CONFIDENCE LIMITS
                                LOWER:   -0.63 DB
                                UPPER:    1.47 DB
CORRELATION COEFFICIENT: 0.9665
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)     DEVIATION (DB)
   0.36          2.50             0.53             3
   0.74          3.54             0.05             3
   1.11          7.08             0.09             3
   1.63          8.71             0.15             3

AT  9.820 MHZ
SLOPE.    5.04 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    4.27 DB/CM
                                UPPER:    5.80 DB/CM
INTERCEPT:    1.22 DB         95% CONFIDENCE LIMITS
                                LOWER:    0.40 DB
                                UPPER:    2.03 DB
CORRELATION COEFFICIENT: 0.9777
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)     DEVIATION (DB)
   0.36          2.70             0.19             3
   0.74          4.77             0.16             3
   1.11          7.57             0.25             3
   1.63          8.97             0.10             3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      0.80
   95% CONFIDENCE LIMITS:  LOWER:    0.29


                             UPPER:    1.31
FREQUENCY MULTIPLIER:  -0.96
   95% CONFIDENCE LIMITS:  LOWER:   -1.33
                           UPPER:   -0.58
CORRELATION COEFFICIENT:   0.9786
FITTED ALPHA AT 1 MHZ:   0.11
   95% CONFIDENCE LIMITS:  LOWER:    0.05
                           UPPER:    0.26
FITTED ALPHA AT 10 MHZ.    0.70
```

COMP Output - Animal 06

```
AT  1.385 MHZ
SLOPE:    0.97 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    0.82 DB/CM
                              UPPER:    1.13 DB/CM
INTERCEPT:    0.08 DB       95% CONFIDENCE LIMITS
                              LOWER:   -0.06 DB
                              UPPER:    0.22 DB
CORRELATION COEFFICIENT: 0.9765
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)         LOSS (DB)       DEVIATION (DB)
  0.33           0.40             0.02             3
  0.63           0.64             0.06             3
  0.96           1.11             0.09             3
  1.37           1.37             0.02             3

AT  4.210 MHZ
SLOPE:    2.42 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    2.17 DB/CM
                              UPPER:    2.67 DB/CM
INTERCEPT:    0.29 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.06 DB
                              UPPER:    0.51 DB
CORRELATION COEFFICIENT: 0.9896
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)         LOSS (DB)       DEVIATION (DB)
  0.33           1.14             0.01             3
  0.63           1.65             0.01             3
  0.96           2.77             0.02             3
  1.37           3.56             0.13             3

AT  7.015 MHZ
SLOPE:    4.25 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    3.86 DB/CM
                              UPPER:    4.63 DB/CM
INTERCEPT:    0.43 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.08 DB
                              UPPER:    0.78 DB
CORRELATION COEFFICIENT: 0.9919
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)         LOSS (DB)       DEVIATION (DB)
  0.33           1.95             0.03             3
  0.63           2.82             0.13             3
  0.96           4.71             0.05             3
  1.37           6.20             0.13             3

AT  9.820 MHZ
SLOPE:    5.37 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    4.97 DB/CM
                              UPPER:    5.77 DB/CM
INTERCEPT:    0.70 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.33 DB
                              UPPER:    1.07 DB
CORRELATION COEFFICIENT: 0.9944
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)         LOSS (DB)       DEVIATION (DB)
  0.33           2.49             0.07             3
  0.63           3.87             0.09             3
  0.96           6.19             0.05             3
  1.37           7.91             0.04             3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:       0.88
   95% CONFIDENCE LIMITS:   LOWER:     0.72



                            UPPER:     1.05
FREQUENCY MULTIPLIER:   -1.08
   95% CONFIDENCE LIMITS:   LOWER:    -1.20
                            UPPER:    -0.96
CORRELATION COEFFICIENT:   0.9981
FITTED ALPHA AT 1 MHZ:    0.08
   95% CONFIDENCE LIMITS:   LOWER:     0.06
                            UPPER:     0.11
FITTED ALPHA AT 10 MHZ:    0.63
```

COMP Output - Animal 07

```
AT   1.385 MHZ
SLOPE:    0.33 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    0.03 DB/CM
                                UPPER:    0.64 DB/CM
INTERCEPT:    0.45 DB         95% CONFIDENCE LIMITS
                                LOWER:    0.19 DB
                                UPPER:    0.71 DB
CORRELATION COEFFICIENT: 0.6092
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.31            0.59             0.06              3
   0.56            0.50             0.20              3
   0.95            0.93             0.04              3
   1.29            0.80             0.08              3

AT   4.210 MHZ
SLOPE:    0.89 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    0.64 DB/CM
                                UPPER:    1.15 DB/CM
INTERCEPT:    0.75 DB         95% CONFIDENCE LIMITS
                                LOWER:    0.53 DB
                                UPPER:    0.97 DB
CORRELATION COEFFICIENT: 0.9273
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.31            0.96             0.04              3
   0.56            1.24             0.04              3
   0.95            1.79             0.06              3
   1.29            1.78             0.09              3

AT   7.015 MHZ
SLOPE:    1.59 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    0.93 DB/CM
                                UPPER:    2.25 DB/CM
INTERCEPT:    1.21 DB         95% CONFIDENCE LIMITS
                                LOWER:    0.64 DB
                                UPPER:    1.78 DB
CORRELATION COEFFICIENT: 0.8617
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.31            1.39             0.29              3
   0.56            2.36             0.11              3
   0.95            3.06             0.16              3
   1.29            2.97             0.07              3

AT   9.820 MHZ
SLOPE:    2.13 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    1.25 DB/CM
                                UPPER:    3.00 DB/CM
INTERCEPT:    1.30 DB         95% CONFIDENCE LIMITS
                                LOWER:    0.54 DB
                                UPPER:    2.05 DB
CORRELATION COEFFICIENT: 0.8637
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.31            1.52             0.25              3
   0.56            2.92             0.38              3
   0.95            3.65             0.23              3
   1.29            3.71             0.05              3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:       0.96
   95% CONFIDENCE LIMITS:   LOWER:    0.82


                            UPPER:    1.09
FREQUENCY MULTIPLIER:   -1.56
   95% CONFIDENCE LIMITS:   LOWER:   -1.66
                            UPPER:   -1.46
CORRELATION COEFFICIENT:   0.9989
FITTED ALPHA AT 1 MHZ:    0.03
   95% CONFIDENCE LIMITS:   LOWER:    0.02
                            UPPER:    0.03
FITTED ALPHA AT 10 MHZ:    0.25
```

COMP Output - Animal 08

```
AT  1.385 MHZ
SLOPE:    0.75 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    0.60 DB/CM
                              UPPER:    0.90 DB/CM
INTERCEPT:    0.95 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.78 DB
                              UPPER:    1.11 DB
CORRELATION COEFFICIENT: 0.9641
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.36            1.19            0.03            3
   0.79            1.50            0.01            3
   1.20            2.01            0.03            3
   1.65            2.09            0.02            3

AT  4.210 MHZ
SLOPE:    1.90 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    1.35 DB/CM
                              UPPER:    2.44 DB/CM
INTERCEPT:    1.63 DB       95% CONFIDENCE LIMITS
                              LOWER:    1.03 DB
                              UPPER:    2.23 DB
CORRELATION COEFFICIENT: 0.9267
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.36            2.15            0.03            3
   0.79            3.07            0.04            3
   1.20            4.49            0.18            3
   1.65            4.40            0.11            3

AT  7.015 MHZ
SLOPE:    2.81 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    1.86 DB/CM
                              UPPER:    3.75 DB/CM
INTERCEPT:    2.91 DB       95% CONFIDENCE LIMITS
                              LOWER:    1.86 DB
                              UPPER:    3.96 DB
CORRELATION COEFFICIENT: 0.9018
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.36            3.70            0.33            3
   0.79            4.95            0.07            3
   1.20            7.27            0.34            3
   1.65            6.96            0.10            3

AT  9.820 MHZ
SLOPE:    3.11 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    1.81 DB/CM
                              UPPER:    4.41 DB/CM
INTERCEPT:    3.55 DB       95% CONFIDENCE LIMITS
                              LOWER:    2.11 DB
                              UPPER:    4.99 DB
CORRELATION COEFFICIENT: 0.8601
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.36            4.23            0.24            3
   0.79            6.02            0.09            3
   1.20            8.50            0.83            3
   1.65            7.88            0.18            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:       0.75
   95% CONFIDENCE LIMITS:   LOWER:    0.49


                            UPPER:    1.01
FREQUENCY MULTIPLIER:   -1.15
   95% CONFIDENCE LIMITS:   LOWER:   -1.34
                            UPPER:   -0.97
CORRELATION COEFFICIENT:   0.9937
FITTED ALPHA AT 1 MHZ:    0.07
   95% CONFIDENCE LIMITS:   LOWER:    0.05
                            UPPER:    0.11
FITTED ALPHA AT 10 MHZ.    0.40
```

COMP Output - Animal 08R

```
AT   1.385 MHZ
SLOPE:     1.18 DB/CM        95% CONFIDENCE LIMITS
                               LOWER:     1.04 DB/CM
                               UPPER:     1.32 DB/CM
INTERCEPT:     0.26 DB       95% CONFIDENCE LIMITS
                               LOWER:     0.12 DB
                               UPPER:     0.41 DB
CORRELATION COEFFICIENT: 0.9865
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.39            0.67             0.02              3
   0.78            1.21             0.02              3
   1.16            1.71             0.08              3
   1.57            2.05             0.08              3

AT   4.210 MHZ
SLOPE:     3.81 DB/CM        95% CONFIDENCE LIMITS
                               LOWER:     3.22 DB/CM
                               UPPER:     4.41 DB/CM
INTERCEPT:    -0.06 DB       95% CONFIDENCE LIMITS
                               LOWER:    -0.70 DB
                               UPPER:     0.58 DB
CORRELATION COEFFICIENT: 0.9761
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.39            1.17             0.25              3
   0.78            3.06             0.15              3
   1.16            4.83             0.05              3
   1.57            5.58             0.21              3

AT   7.015 MHZ
SLOPE:     5.97 DB/CM        95% CONFIDENCE LIMITS
                               LOWER:     5.12 DB/CM
                               UPPER:     6.82 DB/CM
INTERCEPT:     0.21 DB       95% CONFIDENCE LIMITS
                               LOWER:    -0.70 DB
                               UPPER:     1.12 DB
CORRELATION COEFFICIENT: 0.9802
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.39            2.12             0.07              3
   0.78            5.14             0.06              3
   1.16            7.82             0.22              3
   1.57            9.05             0.24              3

AT   9.820 MHZ
SLOPE:     5.37 DB/CM        95% CONFIDENCE LIMITS
                               LOWER:     4.30 DB/CM
                               UPPER:     6.43 DB/CM
INTERCEPT:     1.20 DB       95% CONFIDENCE LIMITS
                               LOWER:     0.07 DB
                               UPPER:     2.34 DB
CORRELATION COEFFICIENT: 0.9627
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.39            2.69             0.04              3
   0.78            5.87             0.08              3
   1.16            8.23             0.17              3
   1.57            8.94             0.02              3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      0.84
   95% CONFIDENCE LIMITS:   LOWER:     0.17


                            UPPER:     1.51
FREQUENCY MULTIPLIER:   -0.95
   95% CONFIDENCE LIMITS:   LOWER:    -1.44
                            UPPER:    -0.46
CORRELATION COEFFICIENT:    0.9670
FITTED ALPHA AT 1 MHZ:     0.11
   95% CONFIDENCE LIMITS:   LOWER:     0.04
                            UPPER:     0.35
FITTED ALPHA AT 10 MHZ:    0.78
```

COMP Output - Animal 09

```
AT  1.385 MHZ
SLOPE:    1.10 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    0.97 DB/CM
                             UPPER:    1.24 DB/CM
INTERCEPT:    0.19 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.07 DB
                             UPPER:    0.31 DB
CORRELATION COEFFICIENT: 0.9886
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.39           0.58              0.03            2
  0.64           0.94              0.05            3
  0.96           1.26              0.06            3
  1.35           1.66              0.00            2

AT  4.210 MHZ
SLOPE:    3.38 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    3.20 DB/CM
                             UPPER:    3.96 DB/CM
INTERCEPT.   -0.17 DB       95% CONFIDENCE LIMITS
                             LOWER:   -0.49 DB
                             UPPER:    0.16 DB
CORRELATION COEFFICIENT: 0.9901
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.39           1.25              0.03            3
  0.64           2.22              0.15            3
  0.96           3.04              0.04            3
  1.35           4.84              0.06            2

AT  7.015 MHZ
SLOPE:    6.00 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    5.45 DB/CM
                             UPPER.    6.55 DB/CM
INTERCEPT:   -0.48 DB       95% CONFIDENCE LIMITS
                             LOWER:   -0.96 DB
                             UPPER:   -0.01 DB
CORRELATION COEFFICIENT: 0.9926
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.39           1.85              0.10            3
  0.64           3.50              0.30            3
  0.96           5.02              0.09            3
  1.35           7.78              0.15            2

AT  9.820 MHZ
SLOPE:    6.17 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    5.50 DB/CM
                             UPPER:    6.84 DB/CM
INTERCEPT:   -0.23 DB       95% CONFIDENCE LIMITS
                             LOWER:   -0.80 DB
                             UPPER:    0.34 DB
CORRELATION COEFFICIENT: 0.9899
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.39           1.98              0.10            3
  0.64           4.06              0.35            3
  0.96           5.56              0.16            3
  1.35           8.09              0.03            2

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:    0.93
   95% CONFIDENCE LIMITS:   LOWER:    0.46


                            UPPER:    1.39
FREQUENCY MULTIPLIER:   -1.00
   95% CONFIDENCE LIMITS:   LOWER:   -1.34
                            UPPER:   -0.66
CORRELATION COEFFICIENT.   0.9866
FITTED ALPHA AT 1 MHZ:    0.10
   95% CONFIDENCE LIMITS:   LOWER:    0.05
                            UPPER:    0.22
FITTED ALPHA AT 10 MHZ:    0.84
```

COMP Output - Animal 10

```
AT  1.385 MHZ
SLOPE:    0.89 DB/CM        95% CONFIDENCE LIMITS
                             LOWER     0.80 DB/CM
                             UPPER:    0.98 DB/CM
INTERCEPT:    0.18 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.12 DB
                             UPPER:    0.25 DB
CORRELATION COEFFICIENT: 0.9938
THICKNESS  AVERAGE INSERTION      STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.38            0.51             0.04             3
  0.68            0.80             0.02             3
  1.08            1.14             0.01             3

AT  4.210 MHZ
SLOPE:    2.88 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    2.55 DB/CM
                             UPPER:    3.21 DB/CM
INTERCEPT   -0.19 DB        95% CONFIDENCE LIMITS
                             LOWER:   -0.44 DB
                             UPPER:    0.06 DB
CORRELATION COEFFICIENT: 0.9919
THICKNESS  AVERAGE INSERTION      STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.38            0.82             0.03             3
  0.68            1.71             0.05             3
  1.08            2.86             0.01             3

AT  7.015 MHZ
SLOPE:    5.17 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    4.70 DB/CM
                             UPPER:    5.65 DB/CM
INTERCEPT:   -0.24 DB       95% CONFIDENCE LIMITS
                             LOWER:   -0.61 DB
                             UPPER:    0.12 DB
CORRELATION COEFFICIENT: 0.9948
THICKNESS  AVERAGE INSERTION      STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.38            1.61             0.03             3
  0.68            3.47             0.08             3
  1.08            5.26             0.06             3

AT  9.820 MHZ
SLOPE:    6.33 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    5.66 DB/CM
                             UPPER:    7.00 DB/CM
INTERCEPT:   -0.02 DB       95% CONFIDENCE LIMITS
                             LOWER:   -0.53 DB
                             UPPER:    0.49 DB
CORRELATION COEFFICIENT: 0.9931
THICKNESS  AVERAGE INSERTION      STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.38            2.22             0.06             3
  0.68            4.58             0.04             3
  1.08            6.69             0.05             3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:        1.03
   95% CONFIDENCE LIMITS:  LOWER:     0.81
                           UPPER:     1.24
FREQUENCY MULTIPLIER:     -1.13
   95% CONFIDENCE LIMITS:  LOWER:    -1.28
                           UPPER:    -0.97


CORRELATION COEFFICIENT:    0.9976
FITTED ALPHA AT 1 MHZ:    0.07
   95% CONFIDENCE LIMITS:  LOWER:     0.05
                           UPPER:     0.11
FITTED ALPHA AT 10 MHZ:    0.80
```

COMP Output - Animal 11

```
AT   1.380 MHZ
SLOPE:    0.23 DB/CM         95% CONFIDENCE LIMITS
                                LOWER:    0.18 DB/CM
                                UPPER:    0.28 DB/CM
INTERCEPT:     0.90 DB       95% CONFIDENCE LIMITS
                                LOWER:    0.85 DB
                                UPPER:    0.95 DB
CORRELATION COEFFICIENT: 0.9519
THICKNESS   AVERAGE INSERTION      STANDARD              N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.34            0.96              0.01                3
   0.72            1.08              0.03                3
   1.08            1.16              0.02                3
   1.49            1.23              0.04                3

AT   4.210 MHZ
SLOPE:    0.55 DB/CM         95% CONFIDENCE LIMITS
                                LOWER:    0.40 DB/CM
                                UPPER:    0.70 DB/CM
INTERCEPT:     1.08 DB       95% CONFIDENCE LIMITS
                                LOWER:    0.93 DB
                                UPPER:    1.23 DB
CORRELATION COEFFICIENT: 0.9329
THICKNESS   AVERAGE INSERTION      STANDARD              N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.34            1.20              0.06                3
   0.72            1.58              0.08                3
   1.08            1.70              0.02                3
   1.49            1.86              0.08                3

AT   7.015 MHZ
SLOPE:    1.04 DB/CM         95% CONFIDENCE LIMITS
                                LOWER:    0.86 DB/CM
                                UPPER:    1.22 DB/CM
INTERCEPT:     1.67 DB       95% CONFIDENCE LIMITS
                                LOWER:    1.48 DB
                                UPPER:    1.85 DB
CORRELATION COEFFICIENT: 0.9708
THICKNESS   AVERAGE INSERTION      STANDARD              N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.34            1.93              0.02                3
   0.72            2.52              0.12                3
   1.08            2.82              0.04                3
   1.49            3.15              0.10                3

AT   9.820 MHZ
SLOPE:    1.26 DB/CM         95% CONFIDENCE LIMITS
                                LOWER:    1.04 DB/CM
                                UPPER:    1.49 DB/CM
INTERCEPT:     2.14 DB       95% CONFIDENCE LIMITS
                                LOWER:    1.92 DB
                                UPPER:    2.37 DB
CORRELATION COEFFICIENT: 0.9698
THICKNESS   AVERAGE INSERTION      STANDARD              N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.34            2.52              0.11                3
   0.72            3.10              0.11                3
   1.08            3.56              0.02                3
   1.49            3.97              0.19                3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:     0.89
   95% CONFIDENCE LIMITS:   LOWER:    0.63


                            UPPER:    1.15
FREQUENCY MULTIPLIER:   -1.71
   95% CONFIDENCE LIMITS:   LOWER:   -1.90
                            UPPER:   -1.52
CORRELATION COEFFICIENT:   0.9954
FITTED ALPHA AT 1 MHZ:    0.02
   95% CONFIDENCE LIMITS:   LOWER:    0.01
                            UPPER:    0.03
FITTED ALPHA AT 10 MHZ:    0.15
```

COMP Output - Animal 12

```
AT   1.385 MHZ
SLOPE:    1.00 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    0.81 DB/CM
                              UPPER:    1.19 DB/CM
INTERCEPT.    0.39 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.21 DB
                              UPPER:    0.57 DB
CORRELATION COEFFICIENT: 0.9659
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.30            0.50             0.03             3
   0.66            1.14             0.04             3
   1.04            1.54             0.03             3
   1.43            1.71             0.06             3

AT   4.210 MHZ
SLOPE:    3.54 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    3.15 DB/CM
                              UPPER:    3.93 DB/CM
INTERCEPT:    0.26 DB       95% CONFIDENCE LIMITS
                              LOWER:   -0.11 DB
                              UPPER:    0.64 DB
CORRELATION COEFFICIENT: 0.9878
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.30            1.10             0.07             3
   0.66            2.83             0.06             3
   1.04            4.15             0.08             3
   1.43            5.12             0.14             3

AT   7.015 MHZ
SLOPE:    6.15 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    5.43 DB/CM
                              UPPER:    6.88 DB/CM
INTERCEPT:    0.74 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.05 DB
                              UPPER:    1.44 DB
CORRELATION COEFFICIENT: 0.9862
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.30            2.13             0.09             3
   0.66            5.37             0.03             3
   1.04            7.36             0.19             3
   1.43            9.22             0.18             3

AT   9.820 MHZ
SLOPE:    7.32 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    6.37 DB/CM
                              UPPER:    8.27 DB/CM
INTERCEPT:    1.04 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.13 DB
                              UPPER:    1.95 DB
CORRELATION COEFFICIENT: 0.9834
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.30            2.63             0.05             3
   0.66            6.70             0.13             3
   1.04            8.79             0.03             3
   1.43           11.16             0.29             3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      1.05
   95% CONFIDENCE LIMITS:   LOWER:    0.75


                            UPPER:    1.35
FREQUENCY MULTIPLIER:  -1.07
   95% CONFIDENCE LIMITS:   LOWER:   -1.29
                            UPPER:   -0.85
CORRELATION COEFFICIENT:   0.9956
FITTED ALPHA AT 1 MHZ:    0.09
   95% CONFIDENCE LIMITS:   LOWER:    0.05
                            UPPER:    0.14
FITTED ALPHA AT 10 MHZ:    0.95
```

COMP Output - Animal 13

AT 1.385 MHZ
SLOPE: 0.60 DB/CM — 95% CONFIDENCE LIMITS
LOWER: 0.48 DB/CM
UPPER: 0.71 DB/CM
INTERCEPT: 0.54 DB — 95% CONFIDENCE LIMITS
LOWER: 0.44 DB
UPPER: 0.65 DB
CORRELATION COEFFICIENT: 0.9650

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.33	0.74	0.01	3
0.63	0.97	0.03	3
0.96	1.02	0.01	3
1.36	1.40	0.01	3

AT 4.210 MHZ
SLOPE: 1.80 DB/CM — 95% CONFIDENCE LIMITS
LOWER: 1.33 DB/CM
UPPER: 2.27 DB/CM
INTERCEPT: 1.04 DB — 95% CONFIDENCE LIMITS
LOWER: 0.61 DB
UPPER: 1.46 DB
CORRELATION COEFFICIENT: 0.9372

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.33	1.61	0.08	3
0.63	2.42	0.02	3
0.96	2.36	0.03	3
1.36	3.66	0.02	3

AT 7.015 MHZ
SLOPE: 3.20 DB/CM — 95% CONFIDENCE LIMITS
LOWER: 2.39 DB/CM
UPPER: 4.00 DB/CM
INTERCEPT: 1.88 DB — 95% CONFIDENCE LIMITS
LOWER: 1.15 DB
UPPER: 2.61 DB
CORRELATION COEFFICIENT: 0.9418

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.33	2.85	0.05	3
0.63	4.37	0.09	3
0.96	4.29	0.11	3
1.36	6.49	0.02	3

AT 9.820 MHZ
SLOPE: 3.76 DB/CM — 95% CONFIDENCE LIMITS
LOWER: 2.77 DB/CM
UPPER: 4.75 DB/CM
INTERCEPT: 2.61 DB — 95% CONFIDENCE LIMITS
LOWER: 1.72 DB
UPPER: 3.51 DB
CORRELATION COEFFICIENT: 0.9367

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
[illegible]	3.77	0.04	3
0.63	5.53	0.05	3
0.96	5.42	0.25	3
1.36	8.06	0.17	3

FREQUENCY [illegible] ATTENUATION COEFFICIENT
[illegible] COMPONENT: 0.97
[illegible] CONFIDENCE LIMITS: LOWER: 0.73

UPPER: 1.21
FREQUENCY MULTIPLIER: -1.29
95% CONFIDENCE LIMITS: LOWER: -1.47
UPPER: -1.12
[illegible] ICIENT: 0.9967
[illegible] ALPHA AT 1 MHZ: 0.05
95% CONFIDENCE LIMITS: LOWER: 0.03
UPPER: 0.08
FITTED ALPHA AT 10 MHZ: 0.48

COMP Output - Animal 14

```
AT  1.385 MHZ
SLOPE:    0.47 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    0.30 DB/CM
                               UPPER:    0.63 DB/CM
INTERCEPT     0.33 DB        95% CONFIDENCE LIMITS
                               LOWER:    0.20 DB
                               UPPER:    0.50 DB
CORRELATION COEFFICIENT: 0.9057
THICKNESS  AVERAGE INSERTION     STANDARD              N
  (CM)          LOSS (DB)       DEVIATION (DB)
   0.30           0.50              0.05               2
   0.63           0.58              0.02               3
   0.95           0.90              0.05               3
   1.31           0.92              0.02               3

AT  4.210 MHZ
SLOPE:    1.50 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    1.31 DB/CM
                               UPPER:    1.69 DB/CM
INTERCEPT:  -0.02 DB         95% CONFIDENCE LIMITS
                               LOWER:   -0.18 DB
                               UPPER:    0.15 DB
CORRELATION COEFFICIENT: 0.9843
THICKNESS  AVERAGE INSERTION     STANDARD              N
  (CM)          LOSS (DB)       DEVIATION (DB)
   0.30           0.36              0.03               3
   0.63           0.95              0.01               3
   0.95           1.55              0.01               3
   1.31           1.84              0.01               3

AT  [illegible]
SLOPE:   [illegible] DB/CM   95% CONFIDENCE LIMITS
                               LOWER:    2.61 DB/CM
                               UPPER:    3.35 DB/CM
INTERCEPT:  -0.21 DB         95% CONFIDENCE LIMITS
                               LOWER:   -0.53 DB
                               UPPER:    0.12 DB
CORRELATION COEFFICIENT: 0.9851
THICKNESS  AVERAGE INSERTION     STANDARD              N
  (CM)          LOSS (DB)       DEVIATION (DB)
   0.30           0.53              0.09               3
   0.63           1.77              0.04               3
   [illegible]    2.87              0.05               3
   1.31           3.50              0.08               3

AT  9.820 MHZ
SLOPE:    3.90 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    3.35 DB/CM
                               UPPER:    4.45 DB/CM
INTERCEPT.  -0.20 DB         95% CONFIDENCE LIMITS
                               LOWER:   -0.69 DB
                               UPPER:    0.28 DB
CORRELATION COEFFICIENT: 0.9805
THICKNESS  AVERAGE INSERTION     STANDARD              N
  (CM)          LOSS (DB)       DEVIATION (DB)
   0.30           0.81              0.06               3
   0.63           2.40              0.01               3
   0.95           3.68              0.01               3
   1.31           4.74              0.48               3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      1.10
   95% CONFIDENCE LIMITS:   LOWER:     0.91


                            UPPER:     1.30
FREQUENCY MULTIPLIER:   -1.43
   95% CONFIDENCE LIMITS:   LOWER:    -1.57
                            UPPER:    -1.29
CORRELATION COEFFICIENT:   0.9983
FITTED ALPHA AT 1 MHZ:    0.04
   95% CONFIDENCE LIMITS:   LOWER:     0.03
                            UPPER:     0.05
FITTED ALPHA AT 10 MHZ:    0.47
```

COMP Output - Animal 15

```
AT   1.305 MHZ
SLOPE:     0.44 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:     0.14 DB/CM
                               UPPER:     0.73 DB/CM
INTERCEPT:     0.31 DB        95% CONFIDENCE LIMITS
                               LOWER:     0.07 DB
                               UPPER:     0.55 DB
CORRELATION COEFFICIENT: 0.7244
THICKNESS  AVERAGE INSERTION     STANDARD           N
   (CM)          LOSS (DB)     DEVIATION (DB)
   0.29            0.37            0.07             3
   0.57            0.60            0.20             3
   0.92            0.82            0.10             3
   1.21            0.75            0.06             3

AT   4.210 MHZ
SLOPE:     1.73 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:     0.90 DB/CM
                               UPPER:     2.56 DB/CM
INTERCEPT:     0.23 DB        95% CONFIDENCE LIMITS
                               LOWER:    -0.49 DB
                               UPPER:     0.94 DB
CORRELATION COEFFICIENT: 0.8425
THICKNESS  AVERAGE INSERTION     STANDARD           N
   (CM)          LOSS (DB)     DEVIATION (DB)
   0.29            1.03            0.09             2
   0.57            0.72            0.15             3
   0.92            1.84            0.07             3
   1.21            2.40            0.56             3

AT   7.015 MHZ
SLOPE:     2.35 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:     1.60 DB/CM
                               UPPER:     3.11 DB/CM
INTERCEPT:     0.60 DB        95% CONFIDENCE LIMITS
                               LOWER:    -0.02 DB
                               UPPER:     1.22 DB
CORRELATION COEFFICIENT: 0.9099
THICKNESS  AVERAGE INSERTION     STANDARD           N
   (CM)          LOSS (DB)     DEVIATION (DB)
   0.29            1.37            0.03             3
   0.57            1.57            0.29             3
   0.92            3.27            0.16             3
   1.21            3.21            0.05             3

AT   9.820 MHZ
SLOPE:     3.14 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:     2.15 DB/CM
                               UPPER:     4.13 DB/CM
INTERCEPT:     0.30 DB        95% CONFIDENCE LIMITS
                               LOWER:    -0.52 DB
                               UPPER:     1.12 DB
CORRELATION COEFFICIENT: 0.9124
THICKNESS  AVERAGE INSERTION     STANDARD           N
   (CM)          LOSS (DB)     DEVIATION (DB)
   0.29            1.56            0.24             3
   0.57            1.49            0.27             3
   0.92            3.44            0.31             3
   1.21            4.12            0.43             3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT.      1.01
   95% CONFIDENCE LIMITS:   LOWER:     0.58


                            UPPER:     1.44
FREQUENCY MULTIPLIER.   -1.41
   95% CONFIDENCE LIMITS:   LOWER:    -1.72
                            UPPER.    -1.09
CORRELATION COEFFICIENT:   0.9702
FITTED ALPHA AT 1 MHZ.     0.04
   95% CONFIDENCE LIMITS:   LOWER:     0.02
                            UPPER      0.08
FITTED ALPHA AT 10 MHZ     0.40
```

COMP Output - Animal 16

```
AT   1.385 MHZ
SLOPE:    0.79 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    0.68 DB/CM
                              UPPER:    0.90 DB/CM
INTERCEPT:    0.37 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.26 DB
                              UPPER:    0.49 DB
CORRELATION COEFFICIENT: 0.9799
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.35            0.59             0.01            3
  0.75            1.07             0.01            3
  1.12            1.22             0.01            3
  1.48            1.52             0.04            3

AT   4.210 MHZ
SLOPE:    2.75 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    2.36 DB/CM
                              UPPER:    3.14 DB/CM
INTERCEPT:    0.52 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.13 DB
                              UPPER:    0.92 DB
CORRELATION COEFFICIENT: 0.9804
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.35            1.45             0.00            3
  0.75            2.81             0.04            3
  1.12            3.25             0.04            3
  1.48            4.75             0.09            3

AT   7.015 MHZ
SLOPE:    4.34 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    3.20 DB/CM
                              UPPER:    5.49 DB/CM
INTERCEPT:    1.46 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.30 DB
                              UPPER:    2.62 DB
CORRELATION COEFFICIENT: 0.9368
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.35            3.39             0.25            3
  0.75            4.31             1.00            3
  1.12            5.89             0.17            3
  1.48            8.33             0.21            3

AT   9.820 MHZ
SLOPE:    5.75 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    5.08 DB/CM
                              UPPER:    6.41 DB/CM
INTERCEPT:    1.66 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.98 DB
                              UPPER:    2.33 DB
CORRELATION COEFFICIENT: 0.9868
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.35            3.51             0.07            3
  0.75            6.42             0.14            3
  1.12            7.68             0.29            3
  1.48           10.29             0.33            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      1.02
   95% CONFIDENCE LIMITS:   LOWER:     0.82
                .

                            UPPER:     1.23
FREQUENCY MULTIPLIER:   -1.17
   95% CONFIDENCE LIMITS:   LOWER:    -1.32
                            UPPER:    -1.02
CORRELATION COEFFICIENT:    0.9978
FITTED ALPHA AT 1 MHZ:     0.07
   95% CONFIDENCE LIMITS:   LOWER:     0.05
                            UPPER:     0.09
FITTED ALPHA AT 10 MHZ:     0.71
```

COMP Output - Animal 17

```
AT   1.385 MHZ
SLOPE:     0.78 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     0.59 DB/CM
                                 UPPER:     0.97 DB/CM
INTERCEPT:     0.25 DB         95% CONFIDENCE LIMITS
                                 LOWER:     0.11 DB
                                 UPPER:     0.38 DB
CORRELATION COEFFICIENT: 0.9654
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)       DEVIATION (DB)
   0.35             0.51              0.03            3
   0.69             0.81              0.07            3
   0.93             0.95              0.03            3

AT   4.210 MHZ
SLOPE:     1.50 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     1.25 DB/CM
                                 UPPER:     1.75 DB/CM
INTERCEPT:     0.29 DB         95% CONFIDENCE LIMITS
                                 LOWER:     0.11 DB
                                 UPPER:     0.46 DB
CORRELATION COEFFICIENT: 0.9827
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)       DEVIATION (DB)
   0.35             0.81              0.07            3
   0.69             1.32              0.08            3
   0.93             1.68              0.04            3

AT   7.015 MHZ
SLOPE:     2.33 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     0.75 DB/CM
                                 UPPER:     3.91 DB/CM
INTERCEPT:     0.79 DB         95% CONFIDENCE LIMITS
                                 LOWER:    -0.31 DB
                                 UPPER:     1.90 DB
CORRELATION COEFFICIENT: 0.7963
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)       DEVIATION (DB)
   0.35             1.71              0.09            3
   0.69             2.14              0.63            3
   0.93             3.11              0.14            3

AT   9.820 MHZ
SLOPE:     3.34 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     1.25 DB/CM
                                 UPPER:     5.42 DB/CM
INTERCEPT:     0.67 DB         95% CONFIDENCE LIMITS
                                 LOWER:    -0.78 DB
                                 UPPER:     2.13 DB
CORRELATION COEFFICIENT: 0.8198
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)       DEVIATION (DB)
   0.35             1.92              0.04            3
   0.69             2.78              0.93            3
   0.93             3.89              0.07            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      0.73
   95% CONFIDENCE LIMITS:    LOWER:     0.43
                             UPPER:     1.02
FREQUENCY MULTIPLIER:   -1.17
   95% CONFIDENCE LIMITS:    LOWER:    -1.39
                             UPPER:    -0.96


CORRELATION COEFFICIENT:    0.9912
FITTED ALPHA AT 1 MHZ:     0.07
   95% CONFIDENCE LIMITS:    LOWER:     0.04
                             UPPER:     0.11
FITTED ALPHA AT 10 MHZ:     0.36
```

COMP Output - Animal 17R

```
AT  1.385 MHZ
SLOPE:    0.62 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    0.57 DB/CM
                             UPPER:    0.68 DB/CM
INTERCEPT:    0.26 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.22 DB
                             UPPER:    0.30 DB
CORRELATION COEFFICIENT: 0.9951
THICKNESS  AVERAGE INSERTION      STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.37            0.50             0.00             3
  0.71            0.68             0.01             3
  0.96            0.87             0.01             3

AT  4.210 MHZ
SLOPE:    1.49 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    1.22 DB/CM
                             UPPER:    1.77 DB/CM
INTERCEPT:    0.46 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.27 DB
                             UPPER:    0.66 DB
CORRELATION COEFFICIENT: 0.9798
THICKNESS  AVERAGE INSERTION      STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.37            1.03             0.01             3
  0.71            1.49             0.09             3
  0.96            1.92             0.08             3

AT  7.015 MHZ
SLOPE:    2.84 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    2.63 DB/CM
                             UPPER:    3.06 DB/CM
INTERCEPT:    0.84 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.69 DB
                             UPPER:    1.00 DB
CORRELATION COEFFICIENT: 0.9964
THICKNESS  AVERAGE INSERTION      STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.37            1.88             0.03             3
  0.71            2.90             0.08             3
  0.96            3.55             0.01             3

AT  9.820 MHZ
SLOPE:    3.60 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    3.29 DB/CM
                             UPPER:    3.92 DB/CM
INTERCEPT:    1.15 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.92 DB
                             UPPER:    1.37 DB
CORRELATION COEFFICIENT: 0.9954
THICKNESS  AVERAGE INSERTION      STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.37            2.48             0.03             3
  0.71            3.71             0.14             3
  0.96            4.61             0.04             3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      0.91
   95% CONFIDENCE LIMITS:  LOWER:    0.64
                           UPPER:    1.18
FREQUENCY MULTIPLIER:   -1.29
   95% CONFIDENCE LIMITS:  LOWER:   -1.48
                           UPPER:   -1.09


CORRELATION COEFFICIENT:   0.9953
FITTED ALPHA AT 1 MHZ:    0.05
   95% CONFIDENCE LIMITS:  LOWER:    0.03
                           UPPER:    0.08
FITTED ALPHA AT 10 MHZ:   0.42
```

COMP Output - Animal 18

```
AT   1.385 MHZ
SLOPE:     0.51 DB/CM           95% CONFIDENCE LIMITS
                                  LOWER:     0.13 DB/CM
                                  UPPER:     0.89 DB/CM
INTERCEPT:     0.42 DB          95% CONFIDENCE LIMITS
                                  LOWER:     0.06 DB
                                  UPPER:     0.78 DB
CORRELATION COEFFICIENT: 0.6837
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.35          0.61              0.06            3
   0.69          0.66              0.04            3
   1.07          1.17              0.30            3
   1.35          0.99              0.09            3

AT   4.210 MHZ
SLOPE:     1.16 DB/CM           95% CONFIDENCE LIMITS
                                  LOWER:     0.51 DB/CM
                                  UPPER:     1.81 DB/CM
INTERCEPT:     0.56 DB          95% CONFIDENCE LIMITS
                                  LOWER:    -0.05 DB
                                  UPPER:     1.18 DB
CORRELATION COEFFICIENT: 0.7828
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.35          0.80              0.22            3
   0.69          1.48              0.33            3
   1.07          1.86              0.10            3
   1.35          2.05              0.53            3

AT   7.015 MHZ
SLOPE:     2.51 DB/CM           95% CONFIDENCE LIMITS
                                  LOWER:     1.93 DB/CM
                                  UPPER:     3.09 DB/CM
INTERCEPT:     0.93 DB          95% CONFIDENCE LIMITS
                                  LOWER:     0.41 DB
                                  UPPER:     1.45 DB
CORRELATION COEFFICIENT: 0.9563
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.35          1.76              0.19            3
   0.69          2.65              0.18            3
   1.07          3.86              0.25            3
   1.35          4.08              0.28            2

AT   9.820 MHZ
SLOPE:     3.08 DB/CM           95% CONFIDENCE LIMITS
                                  LOWER:     2.19 DB/CM
                                  UPPER:     3.96 DB/CM
INTERCEPT:     1.12 DB          95% CONFIDENCE LIMITS
                                  LOWER:     0.28 DB
                                  UPPER:     1.95 DB
CORRELATION COEFFICIENT: 0.9262
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.35          2.12              0.08            3
   0.69          3.19              0.28            3
   1.07          4.78              0.42            3
   1.35          5.02              0.65            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      0.95
   95% CONFIDENCE LIMITS:   LOWER:     0.50


                            UPPER:     1.39
FREQUENCY MULTIPLIER:   -1.39
   95% CONFIDENCE LIMITS:   LOWER:    -1.71
                            UPPER:    -1.07
CORRELATION COEFFICIENT:    0.9882
FITTED ALPHA AT 1 MHZ:    0.04
   95% CONFIDENCE LIMITS:   LOWER:     0.02
                            UPPER:     0.09
FITTED ALPHA AT 10 MHZ:    0.36
```

COMP Output - Animal 19

```
AT   1.385 MHZ
SLOPE:     0.64 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:     0.52 DB/CM
                              UPPER:     0.76 DB/CM
INTERCEPT:     0.43 DB       95% CONFIDENCE LIMITS
                              LOWER:     0.33 DB
                              UPPER:     0.54 DB
CORRELATION COEFFICIENT: 0.9687
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)     DEVIATION (DB)
   0.33            0.71             0.04           3
   0.64            0.80             0.04           3
   0.96            0.97             0.02           3
   1.44            1.41             0.01           3

AT   4.210 MHZ
SLOPE:     1.23 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:     0.83 DB/CM
                              UPPER:     1.62 DB/CM
INTERCEPT:     0.35 DB       95% CONFIDENCE LIMITS
                              LOWER:    -0.02 DB
                              UPPER:     0.72 DB
CORRELATION COEFFICIENT: 0.9092
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)     DEVIATION (DB)
   0.33            0.91             0.02           3
   0.64            1.13             0.11           3
   0.96            1.18             0.11           3
   1.44            2.31             0.07           3

AT   7.015 MHZ
SLOPE:     2.33 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:     1.56 DB/CM
                              UPPER:     3.10 DB/CM
INTERCEPT:     0.15 DB       95% CONFIDENCE LIMITS
                              LOWER:    -0.57 DB
                              UPPER:     0.87 DB
CORRELATION COEFFICIENT: 0.9061
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)     DEVIATION (DB)
   0.33            1.35             0.14           3
   0.64            1.41             0.07           3
   0.96            1.79             0.06           3
   1.44            3.92             0.06           3

AT   9.820 MHZ
SLOPE:     3.27 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:     2.38 DB/CM
                              UPPER:     4.16 DB/CM
INTERCEPT:    -0.08 DB       95% CONFIDENCE LIMITS
                              LOWER:    -0.92 DB
                              UPPER:     0.76 DB
CORRELATION COEFFICIENT: 0.9325
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)          LOSS (DB)     DEVIATION (DB)
   0.33            1.52             0.11           3
   0.64            1.70             0.10           3
   0.96            2.39             0.16           3
   1.44            5.10             0.06           3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:     0.83
   95% CONFIDENCE LIMITS:   LOWER:    0.36


                            UPPER:    1.30
FREQUENCY MULTIPLIER:   -1.28
   95% CONFIDENCE LIMITS:   LOWER:   -1.62
                            UPPER:   -0.95
CORRELATION COEFFICIENT:   0.9833
FITTED ALPHA AT 1 MHZ:   0.05
   95% CONFIDENCE LIMITS:   LOWER:    0.02
                            UPPER:    0.11
FITTED ALPHA AT 10 MHZ:   0.35
```

COMP Output - Animal 20

```
AT   1.385 MHZ
SLOPE:    0.24 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:   -0.14 DB/CM
                              UPPER:    0.61 DB/CM
INTERCEPT:    0.51 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.13 DB
                              UPPER:    0.89 DB
CORRELATION COEFFICIENT: 0.4074
```

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.38	0.59	0.03	3
0.74	0.72	0.01	3
1.14	0.72	0.35	3
1.43	0.88	0.22	3

```
AT   4.210 MHZ
SLOPE:    1.14 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    0.70 DB/CM
                              UPPER:    1.57 DB/CM
INTERCEPT:    0.41 DB       95% CONFIDENCE LIMITS
                              LOWER:   -0.02 DB
                              UPPER:    0.85 DB
CORRELATION COEFFICIENT: 0.8792
```

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.38	0.94	0.01	3
0.74	1.11	0.33	3
1.14	1.70	0.24	3
1.43	2.10	0.20	3

```
AT   7.015 MHZ
SLOPE:    2.46 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    1.67 DB/CM
                              UPPER:    3.24 DB/CM
INTERCEPT:    0.81 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.02 DB
                              UPPER:    1.61 DB
CORRELATION COEFFICIENT: 0.9101
```

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.38	1.76	0.21	3
0.74	2.40	0.24	3
1.14	4.14	0.49	3
1.43	4.03	0.17	3

```
AT   9.820 MHZ
SLOPE:    3.65 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    3.14 DB/CM
                              UPPER:    4.16 DB/CM
INTERCEPT:    0.56 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.05 DB
                              UPPER:    1.07 DB
CORRELATION COEFFICIENT: 0.9809
```

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.38	1.97	0.11	3
0.74	3.06	0.05	3
1.14	5.12	0.20	3
1.43	5.56	0.17	3

```
FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      1.41
   95% CONFIDENCE LIMITS:   LOWER:    1.29


                            UPPER:    1.52
FREQUENCY MULTIPLIER:   -1.76
   95% CONFIDENCE LIMITS:   LOWER:   -1.84
                            UPPER:   -1.68
CORRELATION COEFFICIENT:   0.9996
FITTED ALPHA AT 1 MHZ:   0.02
   95% CONFIDENCE LIMITS:   LOWER:    0.01
                            UPPER:    0.02
FITTED ALPHA AT 10 MHZ:    0.45
```

COMP Output - Animal 21

```
AT   1.385 MHZ
SLOPE:     0.68 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     0.55 DB/CM
                                 UPPER:     0.81 DB/CM
INTERCEPT:     0.11 DB         95% CONFIDENCE LIMITS
                                 LOWER:     0.01 DB
                                 UPPER:     0.22 DB
CORRELATION COEFFICIENT: 0.9641
THICKNESS  AVERAGE INSERTION     STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.28            0.26             0.03            3
   0.60            0.55             0.08            3
   0.82            0.72             0.02            3
   1.21            0.89             0.02            3

AT   4.210 MHZ
SLOPE:     1.80 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     1.33 DB/CM
                                 UPPER:     2.27 DB/CM
INTERCEPT:   -0.01 DB          95% CONFIDENCE LIMITS
                                 LOWER:    -0.38 DB
                                 UPPER:     0.36 DB
CORRELATION COEFFICIENT: 0.9385
THICKNESS  AVERAGE INSERTION     STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.28            0.36             0.05            3
   0.60            1.05             0.03            3
   0.82            1.81             0.04            3
   1.21            1.97             0.14            3

AT   7.015 MHZ
SLOPE:     3.48 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     2.80 DB/CM
                                 UPPER:     4.16 DB/CM
INTERCEPT:     0.01 DB         95% CONFIDENCE LIMITS
                                 LOWER:    -0.53 DB
                                 UPPER:     0.56 DB
CORRELATION COEFFICIENT: 0.9636
THICKNESS  AVERAGE INSERTION     STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.28            0.83             0.07            3
   0.60            2.01             0.02            3
   0.82            3.38             0.04            3
   1.21            3.96             0.23            3

AT   9.820 MHZ
SLOPE:     4.70 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     3.95 DB/CM
                                 UPPER:     5.45 DB/CM
INTERCEPT:     0.10 DB         95% CONFIDENCE LIMITS
                                 LOWER:    -0.50 DB
                                 UPPER:     0.71 DB
CORRELATION COEFFICIENT: 0.9752
THICKNESS  AVERAGE INSERTION     STANDARD           N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.28            1.21             0.09            3
   0.60            2.87             0.11            3
   0.82            4.53             0.03            3
   1.21            5.48             0.16            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:       1.00
   95% CONFIDENCE LIMITS:   LOWER:     0.76



                            UPPER:     1.24
FREQUENCY MULTIPLIER:  -1.26
   95% CONFIDENCE LIMITS:   LOWER:    -1.44
                            UPPER:    -1.09
CORRELATION COEFFICIENT:   0.9969
FITTED ALPHA AT 1 MHZ:    0.05
   95% CONFIDENCE LIMITS:   LOWER:     0.04
                            UPPER:     0.08
FITTED ALPHA AT 10 MHZ:    0.54
```

COMP Output - Animal 22

```
AT  1.385 MHZ
SLOPE:    0.39 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    0.19 DB/CM
                              UPPER:    0.59 DB/CM
INTERCEPT:    0.47 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.31 DB
                              UPPER:    0.63 DB
CORRELATION COEFFICIENT: 0.8077
THICKNESS  AVERAGE INSERTION     STANDARD           N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.29           0.57            0.13              3
   0.57           0.66            0.01              3
   0.83           0.88            0.09              3
   1.21           0.90            0.04              3

AT  4.210 MHZ
SLOPE:    0.92 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    0.21 DB/CM
                              UPPER:    1.62 DB/CM
INTERCEPT:    0.70 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.14 DB
                              UPPER:    1.26 DB
CORRELATION COEFFICIENT: 0.6766
THICKNESS  AVERAGE INSERTION     STANDARD           N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.29           0.76            0.24              3
   0.57           1.27            0.05              3
   0.83           1.90            0.10              3
   1.21           1.54            0.27              3

AT  7.015 MHZ
SLOPE:    2.16 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    1.29 DB/CM
                              UPPER:    3.02 DB/CM
INTERCEPT:    1.19 DB       95% CONFIDENCE LIMITS
                              LOWER:    0.49 DB
                              UPPER:    1.88 DB
CORRELATION COEFFICIENT: 0.8685
THICKNESS  AVERAGE INSERTION     STANDARD           N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.29           1.60            0.26              3
   0.57           2.36            0.15              3
   0.83           3.59            0.19              3
   1.21           3.45            0.18              3

AT  9.820 MHZ
SLOPE:    3.05 DB/CM        95% CONFIDENCE LIMITS
                              LOWER:    1.63 DB/CM
                              UPPER:    4.47 DB/CM
INTERCEPT:    1.13 DB       95% CONFIDENCE LIMITS
                              LOWER:   -0.01 DB
                              UPPER:    2.27 DB
CORRELATION COEFFICIENT: 0.8341
THICKNESS  AVERAGE INSERTION     STANDARD           N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.29           1.78            0.12              3
   0.57           2.69            0.18              3
   0.83           4.56            0.65              3
   1.21           4.36            0.55              3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:       1.06
   95% CONFIDENCE LIMITS:  LOWER:    0.51


                           UPPER:    1.62
FREQUENCY MULTIPLIER:   -1.54
   95% CONFIDENCE LIMITS:  LOWER:   -1.94
                           UPPER:   -1.13
CORRELATION COEFFICIENT:   0.9855
FITTED ALPHA AT 1 MHZ:    0.03
   95% CONFIDENCE LIMITS:  LOWER:    0.01
                           UPPER:    0.07
FITTED ALPHA AT 10 MHZ:    0.33
```

COMP Output - Animal 22R

```
AT   1.385 MHZ
SLOPE:     0.35 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:     0.27 DB/CM
                               UPPER:     0.43 DB/CM
INTERCEPT:     0.39 DB        95% CONFIDENCE LIMITS
                               LOWER:     0.32 DB
                               UPPER:     0.46 DB
CORRELATION COEFFICIENT: 0.9514
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.29             0.48            0.02             3
   0.60             0.63            0.02             3
   0.89             0.69            0.07             3
   1.27             0.84            0.01             3

AT   4.210 MHZ
SLOPE:     1.23 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:     1.00 DB/CM
                               UPPER:     1.47 DB/CM
INTERCEPT:     0.33 DB        95% CONFIDENCE LIMITS
                               LOWER:     0.13 DB
                               UPPER:     0.53 DB
CORRELATION COEFFICIENT: 0.9651
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.29             0.65            0.18             3
   0.60             1.18            0.01             3
   0.89             1.33            0.02             3
   1.27             1.92            0.04             3

AT   7.015 MHZ
SLOPE:     2.65 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:     2.28 DB/CM
                               UPPER:     3.02 DB/CM
INTERCEPT:     0.32 DB        95% CONFIDENCE LIMITS
                               LOWER:     0.00 DB
                               UPPER:     0.63 DB
CORRELATION COEFFICIENT: 0.9809
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.29             0.92            0.18             3
   0.60             2.15            0.04             3
   0.89             2.67            0.13             3
   1.27             3.61            0.05             3

AT   9.820 MHZ
SLOPE:     2.82 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:     2.22 DB/CM
                               UPPER:     3.42 DB/CM
INTERCEPT:     1.22 DB        95% CONFIDENCE LIMITS
                               LOWER:     0.71 DB
                               UPPER:     1.73 DB
CORRELATION COEFFICIENT: 0.9573
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.29             1.78            0.34             3
   0.60             3.33            0.08             3
   0.89             3.65            0.05             3
   1.27             4.72            0.05             3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      1.12
   95% CONFIDENCE LIMITS:   LOWER:     0.66


                            UPPER:     1.58
FREQUENCY MULTIPLIER:   -1.54
   95% CONFIDENCE LIMITS:   LOWER:    -1.88
                            UPPER:    -1.20
CORRELATION COEFFICIENT:    0.9909
FITTED ALPHA AT 1 MHZ:    0.03
   95% CONFIDENCE LIMITS:   LOWER:     0.01
                            UPPER:     0.06
FITTED ALPHA AT 10 MHZ:    0.38
```

COMP Output - Animal 23

```
AT  1.385 MHZ
SLOPE:    0.39 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    0.14 DB/CM
                             UPPER:    0.65 DB/CM
INTERCEPT:    0.32 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.06 DB
                             UPPER:    0.57 DB
CORRELATION COEFFICIENT: 0.7380
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.36            0.45             0.02            3
  0.72            0.63             0.02            3
  1.07            0.71             0.26            3
  1.50            0.92             0.15            3

AT  4.210 MHZ
SLOPE:    1.27 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    0.89 DB/CM
                             UPPER:    1.65 DB/CM
INTERCEPT:    0.46 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.08 DB
                             UPPER:    0.84 DB
CORRELATION COEFFICIENT: 0.9220
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.36            0.80             0.08            3
  0.72            1.39             0.03            3
  1.07            2.11             0.08            3
  1.50            2.18             0.24            3

AT  7.015 MHZ
SLOPE:    2.56 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    1.69 DB/CM
                             UPPER:    3.43 DB/CM
INTERCEPT:    0.19 DB       95% CONFIDENCE LIMITS
                             LOWER:   -0.68 DB
                             UPPER:    1.07 DB
CORRELATION COEFFICIENT: 0.9007
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.36            0.70             0.04            3
  0.72            2.25             0.05            3
  1.07            3.62             0.09            3
  1.50            3.53             0.35            3

AT  9.820 MHZ
SLOPE:    2.52 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    1.66 DB/CM
                             UPPER:    3.39 DB/CM
INTERCEPT:    0.73 DB       95% CONFIDENCE LIMITS
                             LOWER:   -0.14 DB
                             UPPER:    1.60 DB
CORRELATION COEFFICIENT: 0.8993
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
  0.36            1.31             0.07            3
  0.72            2.63             0.26            3
  1.07            4.16             0.06            3
  1.50            4.04             0.36            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      1.01
   95% CONFIDENCE LIMITS:   LOWER:    0.49


                            UPPER:    1.53
FREQUENCY MULTIPLIER:   -1.47
   95% CONFIDENCE LIMITS:   LOWER:   -1.85
                            UPPER:   -1.09
CORRELATION COEFFICIENT:   0.9860
FITTED ALPHA AT 1 MHZ:    0.03
   95% CONFIDENCE LIMITS:   LOWER:    0.01
                            UPPER:    0.08
FITTED ALPHA AT 10 MHZ:    0.35
```

COMP Output - Animal 24

```
AT   1.385 MHZ
SLOPE:    0.48 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    0.35 DB/CM
                               UPPER:    0.61 DB/CM
INTERCEPT:    0.74 DB        95% CONFIDENCE LIMITS
                               LOWER:    0.64 DB
                               UPPER:    0.84 DB
CORRELATION COEFFICIENT: 0.9329
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.25           0.79             0.03            3
   0.52           1.08             0.01            3
   0.80           1.15             0.02            3
   1.21           1.29             0.03            3

AT   4.210 MHZ
SLOPE:    0.85 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    0.43 DB/CM
                               UPPER:    1.28 DB/CM
INTERCEPT:    0.87 DB        95% CONFIDENCE LIMITS
                               LOWER:    0.54 DB
                               UPPER:    1.20 DB
CORRELATION COEFFICIENT: 0.8190
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.25           0.87             0.07            3
   0.52           1.66             0.07            3
   0.80           1.47             0.01            3
   1.21           1.86             0.02            3

AT   7.015 MHZ
SLOPE:    1.78 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    1.36 DB/CM
                               UPPER:    2.21 DB/CM
INTERCEPT:    1.14 DB        95% CONFIDENCE LIMITS
                               LOWER:    0.81 DB
                               UPPER:    1.48 DB
CORRELATION COEFFICIENT: 0.9469
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.25           1.37             0.04            3
   0.52           2.41             0.07            3
   0.80           2.52             0.07            3
   1.21           3.23             0.07            3

AT   9.820 MHZ
SLOPE:    3.06 DB/CM         95% CONFIDENCE LIMITS
                               LOWER:    2.28 DB/CM
                               UPPER:    3.85 DB/CM
INTERCEPT:    1.00 DB        95% CONFIDENCE LIMITS
                               LOWER:    0.39 DB
                               UPPER:    1.61 DB
CORRELATION COEFFICIENT: 0.9404
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)      DEVIATION (DB)
   0.25           1.33             0.08            3
   0.52           3.20             0.13            3
   0.80           3.47             0.03            3
   1.21           4.53             0.06            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      0.91
   95% CONFIDENCE LIMITS:   LOWER:    0.11


                            UPPER:    1.71
FREQUENCY MULTIPLIER:   -1.44
   95% CONFIDENCE LIMITS:   LOWER:   -2.03
                            UPPER:   -0.86
CORRELATION COEFFICIENT:    0.9606
FITTED ALPHA AT 1 MHZ:    0.04
   95% CONFIDENCE LIMITS:   LOWER:    0.01
                            UPPER:    0.14
FITTED ALPHA AT 10 MHZ:     0.29
```

COMP Output - Animal 25

```
AT   1.385 MHZ
SLOPE:     0.44 DB/CM           95% CONFIDENCE LIMITS
                                  LOWER:     0.35 DB/CM
                                  UPPER:     0.53 DB/CM
INTERCEPT:     0.39 DB          95% CONFIDENCE LIMITS
                                  LOWER:     0.31 DB
                                  UPPER:     0.47 DB
CORRELATION COEFFICIENT: 0.9597
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.30           0.48             0.03              3
   0.60           0.71             0.05              3
   0.96           0.80             0.01              3
   1.33           0.96             0.03              3

AT   4.210 MHZ
SLOPE:     1.10 DB/CM           95% CONFIDENCE LIMITS
                                  LOWER:     0.80 DB/CM
                                  UPPER:     1.41 DB/CM
INTERCEPT:     0.38 DB          95% CONFIDENCE LIMITS
                                  LOWER:     0.11 DB
                                  UPPER:     0.65 DB
CORRELATION COEFFICIENT: 0.9317
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.30           0.81             0.10              3
   0.60           1.02             0.07              3
   0.96           1.20             0.02              3
   1.33           2.00             0.07              3

AT   7.015 MHZ
SLOPE:     2.38 DB/CM           95% CONFIDENCE LIMITS
                                  LOWER:     1.80 DB/CM
                                  UPPER:     2.95 DB/CM
INTERCEPT:     0.16 DB          95% CONFIDENCE LIMITS
                                  LOWER:    -0.35 DB
                                  UPPER:     0.67 DB
CORRELATION COEFFICIENT: 0.9458
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.30           1.11             0.04              3
   0.60           1.44             0.14              3
   0.96           2.08             0.22              3
   1.33           3.60             0.20              3

AT   9.820 MHZ
SLOPE:     2.77 DB/CM           95% CONFIDENCE LIMITS
                                  LOWER:     1.88 DB/CM
                                  UPPER:     3.65 DB/CM
INTERCEPT:     0.07 DB          95% CONFIDENCE LIMITS
                                  LOWER:    -0.71 DB
                                  UPPER:     0.86 DB
CORRELATION COEFFICIENT: 0.9107
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.30           1.22             0.21              3
   0.60           1.59             0.17              3
   0.96           2.13             0.18              3
   1.33           4.18             0.41              3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      0.98
   95% CONFIDENCE LIMITS:   LOWER:     0.57


                            UPPER:     1.38
FREQUENCY MULTIPLIER:   -1.45
   95% CONFIDENCE LIMITS:   LOWER:    -1.74
                            UPPER:    -1.16
CORRELATION COEFFICIENT:    0.9909
FITTED ALPHA AT 1 MHZ:    0.04
   95% CONFIDENCE LIMITS:   LOWER:     0.02
                            UPPER:     0.07
FITTED ALPHA AT 10 MHZ:    0.34
```

COMP Output - Animal 26

```
AT   1.385 MHZ
SLOPE.    0.74 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    0.50 DB/CM
                                UPPER:    0.99 DB/CM
INTERCEPT:   -0.16 DB         95% CONFIDENCE LIMITS
                                LOWER:   -0.38 DB
                                UPPER:    0.05 DB
CORRELATION COEFFICIENT: 0.9157
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)       DEVIATION (DB)
   0.34           0.13             0.12            3
   0.61           0.20             0.05            2
   0.93           0.53             0.07            3
   1.24           0.77             0.14            3

AT   4.210 MHZ
SLOPE:    2.19 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    1.58 DB/CM
                                UPPER:    2.80 DB/CM
INTERCEPT:   -0.43 DB         95% CONFIDENCE LIMITS
                                LOWER:   -0.95 DB
                                UPPER:    0.09 DB
CORRELATION COEFFICIENT: 0.9290
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)       DEVIATION (DB)
   0.34           0.52             0.20            3
   0.61           0.53             0.13            3
   0.93           1.77             0.28            3
   1.24           2.29             0.05            3

AT   7.015 MHZ
SLOPE:    3.86 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    3.18 DB/CM
                                UPPER:    4.55 DB/CM
INTERCEPT:   -0.43 DB         95% CONFIDENCE LIMITS
                                LOWER:   -1.01 DB
                                UPPER:    0.15 DB
CORRELATION COEFFICIENT: 0.9698
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)       DEVIATION (DB)
   0.34           1.18             0.27            3
   0.61           1.44             0.05            3
   0.93           3.28             0.08            3
   1.24           4.43             0.10            3

AT   9.820 MHZ
SLOPE:    3.53 DB/CM          95% CONFIDENCE LIMITS
                                LOWER:    2.55 DB/CM
                                UPPER:    4.52 DB/CM
INTERCEPT:    0.09 DB         95% CONFIDENCE LIMITS
                                LOWER:   -0.74 DB
                                UPPER:    0.93 DB
CORRELATION COEFFICIENT: 0.9297
THICKNESS  AVERAGE INSERTION     STANDARD          N
   (CM)         LOSS (DB)       DEVIATION (DB)
   0.34           1.64             0.24            3
   0.61           1.65             0.27            3
   0.93           3.62             0.44            3
   1.24           4.50             0.19            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      0.86
   95% CONFIDENCE LIMITS:   LOWER:     0.29


                            UPPER:     1.44
FREQUENCY MULTIPLIER:   -1.16
   95% CONFIDENCE LIMITS:   LOWER:    -1.58
                            UPPER:    -0.75
CORRELATION COEFFICIENT:   0.9767
FITTED ALPHA AT 1 MHZ:    0.07
   95% CONFIDENCE LIMITS:   LOWER:     0.03
                            UPPER:     0.18
FITTED ALPHA AT 10 MHZ:    0.50
```

COMP Output - Animal 27

```
AT   1.385 MHZ
SLOPE:     0.44 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     0.27 DB/CM
                                 UPPER:     0.62 DB/CM
INTERCEPT:     0.33 DB         95% CONFIDENCE LIMITS
                                 LOWER:     0.16 DB
                                 UPPER:     0.51 DB
CORRELATION COEFFICIENT: 0.8892
THICKNESS  AVERAGE INSERTION      STANDARD            N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.26            0.38              0.01             2
   0.68            0.66              0.06             3
   1.08            0.92              0.05             3
   1.44            0.89              0.07             3

AT   4.210 MHZ
SLOPE:     1.29 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     0.66 DB/CM
                                 UPPER:     1.93 DB/CM
INTERCEPT:     0.57 DB         95% CONFIDENCE LIMITS
                                 LOWER:    -0.05 DB
                                 UPPER:     1.18 DB
CORRELATION COEFFICIENT: 0.8205
THICKNESS  AVERAGE INSERTION      STANDARD            N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.26            0.73              0.16             3
   0.68            1.47              0.25             3
   1.08            2.47              0.21             3
   1.44            2.07              0.20             3

AT   7.015 MHZ
SLOPE:     2.07 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     1.34 DB/CM
                                 UPPER:     2.80 DB/CM
INTERCEPT:     1.16 DB         95% CONFIDENCE LIMITS
                                 LOWER:     0.45 DB
                                 UPPER:     1.87 DB
CORRELATION COEFFICIENT: 0.8935
THICKNESS  AVERAGE INSERTION      STANDARD            N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.26            1.63              0.18             3
   0.68            2.43              0.03             3
   1.08            3.91              0.29             3
   1.44            3.83              0.58             3

AT   9.820 MHZ
SLOPE:     2.44 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:     1.63 DB/CM
                                 UPPER      3.24 DB/CM
INTERCEPT:     1.26 DB         95% CONFIDENCE LIMITS
                                 LOWER:     0.47 DB
                                 UPPER:     2.04 DB
CORRELATION COEFFICIENT: 0.9051
THICKNESS  AVERAGE INSERTION      STANDARD            N
   (CM)          LOSS (DB)      DEVIATION (DB)
   0.26            1.61              0.08             3
   0.68            3.09              0.29             3
   1.08            4.41              0.19             3
   1.44            4.33              0.57             3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:        0.89
   95% CONFIDENCE LIMITS:   LOWER:     0.66


                            UPPER:     1.12
FREQUENCY MULTIPLIER:    -1.40
   95% CONFIDENCE LIMITS:   LOWER.    -1.57
                            UPPER:    -1.24
CORRELATION COEFFICIENT:   0.9964
FITTED ALPHA AT 1 MHZ:     0.04
   95% CONFIDENCE LIMITS:   LOWER:     0.03
                            UPPER:     0.06
FITTED ALPHA AT 10 MHZ:    0.31
```

COMP Output - Animal 27R

```
AT  1.385 MHZ
SLOPE:    0.30 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    0.24 DB/CM
                             UPPER:    0.36 DB/CM
INTERCEPT:    0.43 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.38 DB
                             UPPER:    0.48 DB
CORRELATION COEFFICIENT: 0.9666
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.24           0.50             0.02            3
   0.59           0.62             0.03            3
   0.93           0.67             0.05            3
   1.29           0.83             0.01            3

AT  4.210 MHZ
SLOPE:    1.15 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    1.00 DB/CM
                             UPPER:    1.30 DB/CM
INTERCEPT:    0.33 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.19 DB
                             UPPER:    0.46 DB
CORRELATION COEFFICIENT: 0.9826
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.24           0.65             0.10            3
   0.59           0.92             0.01            3
   0.93           1.43             0.05            3
   1.29           1.81             0.08            3

AT  7.015 MHZ
SLOPE:    2.31 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    2.07 DB/CM
                             UPPER:    2.55 DB/CM
INTERCEPT:    0.55 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.34 DB
                             UPPER:    0.75 DB
CORRELATION COEFFICIENT: 0.9893
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.24           1.21             0.10            3
   0.59           1.72             0.07            3
   0.93           2.75             0.06            3
   1.29           3.56             0.01            3

AT  9.820 MHZ
SLOPE:    2.94 DB/CM        95% CONFIDENCE LIMITS
                             LOWER:    2.70 DB/CM
                             UPPER:    3.18 DB/CM
INTERCEPT:    0.90 DB       95% CONFIDENCE LIMITS
                             LOWER:    0.69 DB
                             UPPER:    1.10 DB
CORRELATION COEFFICIENT: 0.9933
THICKNESS  AVERAGE INSERTION     STANDARD          N
  (CM)          LOSS (DB)      DEVIATION (DB)
   0.24           1.71             0.05            3
   0.59           2.44             0.11            3
   0.93           3.67             0.04            3
   1.29           4.72             0.07            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      1.19
   95% CONFIDENCE LIMITS:  LOWER:     0.95


                           UPPER:     1.43
FREQUENCY MULTIPLIER:   -1.62
   95% CONFIDENCE LIMITS:  LOWER:    -1.80
                           UPPER:    -1.45
CORRELATION COEFFICIENT:   0.9978
FITTED ALPHA AT 1 MHZ:   0.02
   95% CONFIDENCE LIMITS:  LOWER:     0.02
                           UPPER:     0.04
FITTED ALPHA AT 10 MHZ:    0.37
```

COMP Output - Animal 28

AT 1.385 MHZ
SLOPE: 0.32 DB/CM — 95% CONFIDENCE LIMITS
LOWER: --0.06 DB/CM
UPPER: 0.71 DB/CM
INTERCEPT: 0.25 DB — 95% CONFIDENCE LIMITS
LOWER: -0.05 DB
UPPER: 0.56 DB
CORRELATION COEFFICIENT: 0.5151

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.28	0.45	0.07	3
0.57	0.37	0.07	3
0.81	0.37	0.29	3
1.21	0.74	0.03	3

AT 4.210 MHZ
SLOPE: 1.06 DB/CM — 95% CONFIDENCE LIMITS
LOWER: 0.47 DB/CM
UPPER: 1.66 DB/CM
INTERCEPT: 0.32 DB — 95% CONFIDENCE LIMITS
LOWER: --0.15 DB
UPPER: 0.79 DB
CORRELATION COEFFICIENT: 0.7821

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.28	0.80	0.10	3
0.57	0.85	0.19	3
0.81	0.88	0.35	3
1.21	1.80	0.02	3

AT 7.015 MHZ
SLOPE: 2.09 DB/CM — 95% CONFIDENCE LIMITS
LOWER: 1.30 DB/CM
UPPER: 2.89 DB/CM
INTERCEPT: 0.54 DB — 95% CONFIDENCE LIMITS
LOWER: -0.09 DB
UPPER: 1.17 DB
CORRELATION COEFFICIENT: 0.8806

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.28	1.44	0.07	3
0.57	1.52	0.25	3
0.81	1.86	0.37	3
1.21	3.36	0.13	3

AT 9.820 MHZ
SLOPE: 2.76 DB/CM — 95% CONFIDENCE LIMITS
LOWER: 2.28 DB/CM
UPPER: 3.24 DB/CM
INTERCEPT: 1.04 DB — 95% CONFIDENCE LIMITS
LOWER: 0.66 DB
UPPER: 1.42 DB
CORRELATION COEFFICIENT: 0.9707

THICKNESS (CM)	AVERAGE INSERTION LOSS (DB)	STANDARD DEVIATION (DB)	N
0.28	2.03	0.15	3
0.57	2.43	0.19	3
0.81	3.07	0.09	3
1.21	4.55	0.04	3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT: 1.11
95% CONFIDENCE LIMITS: LOWER: 0.94
UPPER: 1.29
FREQUENCY MULTIPLIER: -1.59
95% CONFIDENCE LIMITS: LOWER: -1.72
UPPER: -1.46
CORRELATION COEFFICIENT: 0.9986
FITTED ALPHA AT 1 MHZ: 0.03
95% CONFIDENCE LIMITS: LOWER: 0.02
UPPER: 0.03
FITTED ALPHA AT 10 MHZ: 0.33

COMP Output - Animal 30R

```
AT   1.385 MHZ
SLOPE:     0.40 DB/CM        95% CONFIDENCE LIMITS
                               LOWER:     0.35 DB/CM
                               UPPER:     0.46 DB/CM
INTERCEPT:     0.33 DB       95% CONFIDENCE LIMITS
                               LOWER:     0.28 DB
                               UPPER:     0.38 DB
CORRELATION COEFFICIENT: 0.9840
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)       DEVIATION (DB)
   0.34            0.46              0.02            3
   0.68            0.61              0.00            3
   1.00            0.77              0.01            3
   1.38            0.87              0.02            3

AT   4.210 MHZ
SLOPE:     1.23 DB/CM        95% CONFIDENCE LIMITS
                               LOWER:     1.03 DB/CM
                               UPPER:     1.44 DB/CM
INTERCEPT:     0.23 DB       95% CONFIDENCE LIMITS
                               LOWER:     0.04 DB
                               UPPER:     0.42 DB
CORRELATION COEFFICIENT: 0.9744
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)       DEVIATION (DB)
   0.34            0.61              0.10            3
   0.68            1.05              0.06            3
   1.00            1.61              0.08            3
   1.38            1.85              0.03            3

AT   7.015 MHZ
SLOPE:     2.66 DB/CM        95% CONFIDENCE LIMITS
                               LOWER:     2.36 DB/CM
                               UPPER:     2.97 DB/CM
INTERCEPT:     0.20 DB       95% CONFIDENCE LIMITS
                               LOWER:    -0.09 DB
                               UPPER:     0.49 DB
CORRELATION COEFFICIENT: 0.9869
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)       DEVIATION (DB)
   0.34            1.14              0.15            3
   0.68            1.84              0.02            3
   1.00            3.09              0.04            3
   1.38            3.79              0.04            3

AT   9.820 MHZ
SLOPE:     3.35 DB/CM        95% CONFIDENCE LIMITS
                               LOWER:     3.03 DB/CM
                               UPPER:     3.67 DB/CM
INTERCEPT:     0.44 DB       95% CONFIDENCE LIMITS
                               LOWER:     0.14 DB
                               UPPER:     0.74 DB
CORRELATION COEFFICIENT: 0.9910
THICKNESS   AVERAGE INSERTION      STANDARD          N
   (CM)          LOSS (DB)       DEVIATION (DB)
   0.34            1.62              0.09            3
   0.68            2.53              0.06            3
   1.00            4.02              0.11            3
   1.38            4.98              0.05            3

FREQUENCY VS ATTENUATION COEFFICIENT
FREQUENCY COMPONENT:      1.11
   95% CONFIDENCE LIMITS:   LOWER:     0.80


                            UPPER:     1.42
FREQUENCY MULTIPLIER:    -1.50
   95% CONFIDENCE LIMITS:   LOWER:    -1.72
                            UPPER:    -1.28
CORRELATION COEFFICIENT:   0.9959
FITTED ALPHA AT 1 MHZ:    0.03
   95% CONFIDENCE LIMITS:   LOWER:     0.02
                            UPPER:     0.05
FITTED ALPHA AT 10 MHZ:    0.41
```

COMP Output - No Sample

```
AT   1.385 MHZ
SLOPE     -3.33 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:  -17.61 DB/CM
                                 UPPER:   10.94 DB/CM
INTERCEPT.     0.11 DB         95% CONFIDENCE LIMITS
                                 LOWER:   -0.12 DB
                                 UPPER:    0.33 DB
CORRELATION COEFFICIENT:  -.3083
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)         LOSS (DB)        DEVIATION (DB)
   0.01           0.07              0.07              3
   0.02           0.04              0.02              3

AT   4.210 MHZ
SLOPE.    17.33 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:  -51.22 DB/CM
                                 UPPER:   85.88 DB/CM
INTERCEPT:    -0.07 DB         95% CONFIDENCE LIMITS
                                 LOWER:   -1.16 DB
                                 UPPER:    1.01 DB
CORRELATION COEFFICIENT:  0.3312
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)         LOSS (DB)        DEVIATION (DB)
   0.01           0.10              0.16              3
   0.02           0.27              0.31              3

AT   7.015 MHZ
SLOPE:    33.33 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:  -29.69 DB/CM
                                 UPPER:   96.36 DB/CM
INTERCEPT:    -0.30 DB         95% CONFIDENCE LIMITS
                                 LOWER:   -1.29 DB
                                 UPPER:    0.70 DB
CORRELATION COEFFICIENT:  0.5918
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)         LOSS (DB)        DEVIATION (DB)
   0.01           0.04              0.04              3
   0.02           0.37              0.32              3

AT   9.820 MHZ
SLOPE     -7.67 DB/CM          95% CONFIDENCE LIMITS
                                 LOWER:  -17.10 DB/CM
                                 UPPER:    1.77 DB/CM
INTERCEPT:     0.31 DB         95% CONFIDENCE LIMITS
                                 LOWER:    0.16 DB
                                 UPPER:    0.46 DB
CORRELATION COEFFICIENT:  -.7482
THICKNESS   AVERAGE INSERTION      STANDARD           N
   (CM)         LOSS (DB)        DEVIATION (DB)
   0.01           0.23              0.02              3
   0.02           0.16              0.04              3
```

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