

## APPENDIX-USEFUL TABLES AND FIGURES

**Table IV**

Velocity and acoustic impedance of pertinent materials and biological tissues at room temperature (20–25°C)

	Velocity (m/sec)	Impedance $\times 10^{-4}$ (kg/m <sup>2</sup> -sec) <sup>a</sup>
Water	1484	1.48
Aluminum	6420	17.00
Air	343	0.0004
Plexiglas	2670	3.20
Blood	1550	1.61
Myocardium (perpendicular to fibers)	1550	1.62
Fat	1450	1.38
Liver	1570	1.65
Kidney	1560	1.62
Skull bone	3360 (longitudinal)	6.00

<sup>a</sup>Rayl is a unit commonly used for acoustic impedance. One rayl = 1 kgm<sup>2</sup>-sec.

**Table V**

Attenuation coefficients of biological tissues and pertinent materials

Material	Attenuation coefficient (np/cm at 1 MHz at 20°C)
Air	1.38
Aluminum	0.0021
Plexiglas	0.23
Water	0.00025
Fat	0.06
Blood	0.02
Myocardium (perpendicular to fiber)	0.35
Liver	0.11
Kidney	0.09
Skull bone	1.30

**TABLE 9.3**

REFLECTIVITY OF NORMALLY INCIDENT WAVES

Materials at Interface	Reflectivity
Brain-skull bone	0.66
Fat-bone	0.69
Fat-blood	0.08
Fat-kidney	0.08
Fat-muscle	0.10
Fat-liver	0.09
Lens-aqueous humor	0.10
Lens-vitreous humor	0.09
Muscle-blood	0.03
Muscle-kidney	0.03
Muscle-liver	0.01
Soft tissue (mean value)-water	0.05
Soft tissue-air	0.9995
Soft tissue-PZT5 crystal	0.89

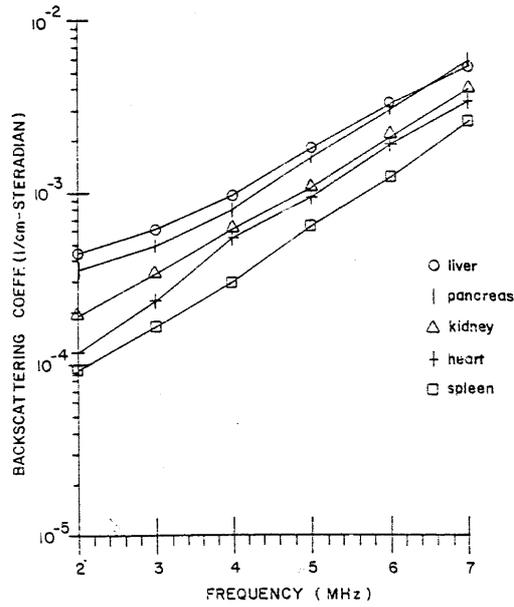


Figure 75 Backscattering coefficient of bovine tissues as a function of frequency.

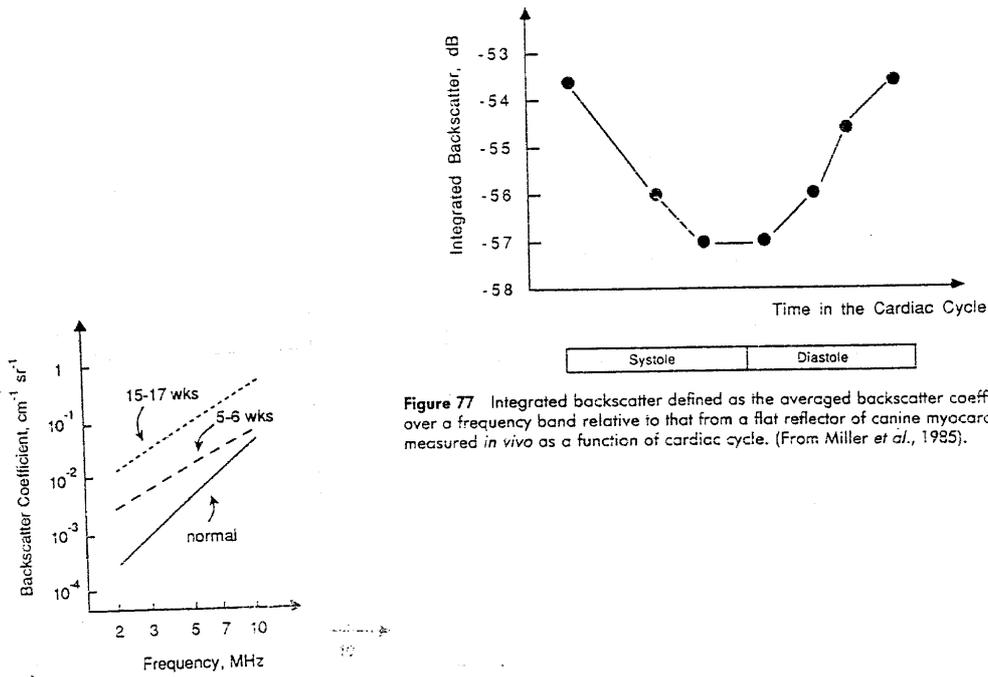


Figure 77 Integrated backscatter defined as the averaged backscatter coefficient over a frequency band relative to that from a flat reflector of canine myocardium measured *in vivo* as a function of cardiac cycle. (From Miller *et al.*, 1985).

Figure 76 Backscattering coefficient of canine myocardium as a function of frequency. Solid line, normal; dashed line, 5-6 weeks after coronary occlusion; dotted line, 15-17 weeks after coronary occlusion. (From O'Donnell *et al.*, 1981).

## I. PIEZOELECTRIC TRANSDUCERS

TABLE IV. Acoustic and Piezoelectric Parameters

Symbol	Definition
$d$	Transmission constant - (strain out/field in)
$g$	Receiving constant - (field out/stress in)
$\rho$	Density
$v^*$	Ultrasonic velocity in a particular direction $[(c^E/\rho)^{1/2}]$
$Z_0$	Characteristic acoustic impedance (lossless approximation) $(= \rho v)$
$\epsilon^T$	Free dielectric constant (unclamped)
$k_T$	Electromechanical coupling efficiency $(k_T^2 = e^2/\epsilon^S c^E)$
$Q_m$	Mechanical quality factor

TABLE V.\* Material Properties

	Longitudinal					
	Quartz (0° X-cut)	PZT-4 <sup>b</sup>	PZT-5 <sup>b</sup>	PZT-5H <sup>b</sup>	PbNb <sub>3</sub> O <sub>8</sub> <sup>b</sup>	BaTiO <sub>3</sub> <sup>b</sup>
$d$ ( $10^{-12}$ m/V)	2	289	374	593	75	149
$g$ ( $10^{-3}$ Vm/N)	50	26	25	20	35	14
$\rho$ (kg/m <sup>3</sup> )	2650	7600	7500	7500	5900	5700
$v^*$ (m/sec)	5650	3950	3870	4000	2700	4390
$Z_0$ ( $10^6$ kg/m <sup>2</sup> sec)	15	30	29	30	16	25
$\epsilon^T/\epsilon_0$	4.5	1300	1700	3400	240	1700
$k_T$ (%)	11	70	70	75	40	48
$Q_m$	>25000	<500	<75	<65	<5	<400

THE sinc FUNCTION

$z$ ( $\pi$ )	sinc $z$	sinc <sup>2</sup> $z$	$z$	sinc $z$	sinc <sup>2</sup> $z$
0.00	1.0	1.0	2.00	0	0
0.05	0.99589	0.99180	2.05	0.02429	0.00059
0.10	0.98363	0.96753	2.10	0.04684	0.00219
0.15	0.96340	0.92814	2.15	0.06721	0.00452
0.20	0.93549	0.87514	2.20	0.08504	0.00723
0.25	0.90032	0.81057	2.25	0.10003	0.01001
0.30	0.85839	0.73684	2.30	0.11196	0.01254
0.35	0.81033	0.65664	2.35	0.12069	0.01457
0.40	0.75683	0.57279	2.40	0.12614	0.01591
0.45	0.69865	0.48811	2.45	0.12832	0.01647
0.50	0.63662	0.40529	2.50	0.12732	0.01621
0.55	0.57162	0.32675	2.55	0.12329	0.01520
0.60	0.50455	0.25457	2.60	0.11644	0.01356
0.65	0.43633	0.19039	2.65	0.10703	0.01145
0.70	0.36788	0.13534	2.70	0.09538	0.00910
0.75	0.30011	0.09006	2.75	0.08185	0.00670
0.80	0.23387	0.05470	2.80	0.06682	0.00447
0.85	0.17001	0.02890	2.85	0.05071	0.00257
0.90	0.10929	0.01195	2.90	0.03392	0.00115
0.95	0.05242	0.00275	2.95	0.01688	0.00028
1.00	0	0	3.00	0	0
1.05	-0.04742	0.00225	3.05	-0.01633	0.00027
1.10	-0.08942	0.00800	3.10	-0.03173	0.00101
1.15	-0.12566	0.01579	3.15	-0.04588	0.00210
1.20	-0.15591	0.02431	3.20	-0.05847	0.00342
1.25	-0.18006	0.03242	3.25	-0.06925	0.00480
1.30	-0.19809	0.03924	3.30	-0.07804	0.00609
1.35	-0.21009	0.04414	3.35	-0.08466	0.00717
1.40	-0.21624	0.04676	3.40	-0.08904	0.00793
1.45	-0.21682	0.04701	3.45	-0.09113	0.00830
1.50	-0.21221	0.04503	3.50	-0.09095	0.00827
1.55	-0.20283	0.04114	3.55	-0.08856	0.00784
1.60	-0.18921	0.03580	3.60	-0.08409	0.00707
1.65	-0.17189	0.02955	3.65	-0.07770	0.00604
1.70	-0.15148	0.02295	3.70	-0.06960	0.00484
1.75	-0.12862	0.01654	3.75	-0.06002	0.00360
1.80	-0.10394	0.01080	3.80	-0.04924	0.00242
1.85	-0.07811	0.00610	3.85	-0.03754	0.00141
1.90	-0.05177	0.00268	3.90	-0.02522	0.00064
1.95	-0.02554	0.00065	3.95	-0.01261	0.00016
2.00	0	0	4.00	0	0