DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2000/45

Special Core Analysis For the Rock Physics Project (EFP-98) ENS J.nr.: 1313/98-0007

Ultrasonic velocity measured on plugs from the wells: MFF-19P, MFB-7 and N-13 the Dan and Gorm Field

GEUS Core Laboratory
Christian Høier

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
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1. Introduction

By request of the Rock Physics Project (EFP-98), GEUS Core Laboratory has carried out special core analysis on plugs from the Dan and Gorm field which include the wells: MFF-19P, MFB-7 and N-13.

The analytical programme was specified by Peter Japsen and included the following services:

- Ultrasonic velocity, P and S wave at reservoir overburden pressure
- Pore volume reduction at reservoir overburden pressure

GEUS Core Laboratory received 18 plugs from MFF-19P, 7 plugs from MFB-7 and 2 plugs from N-13. Preliminary reports has been forwarded to the Rock Physics Project during year 2000.

2. Sampling and analytical procedure

The laboratory received a total of 27 1.5″ diameter plugs from Mærsk Olie og Gas A/S

2.1 Plug history

The plugs from MFF-19P have earlier been hot soxhlet cleaned, dried at 110 °C, and measured for conventional core analysis data by GEUS core laboratory.
The plugs from MFB-7 and N-13 were drilled for this project. The plugs have been hot soxhlet cleaned, dried at 110 °C, and measured for conventional core analysis data by GEUS core laboratory.

2.2 Conventional core analysis and trimming of plugs

The 1.5″ diameter plugs were trimmed to a length of 1.0″. The porosity, grain density and gas permeability was measured on the trimmed plugs. Conventional core analysis data can be seen in table 2.1.

2.3 Ultrasonic measurements

The transit time for the P- and S-wave was measured by a Tektronix Model TDS3012 2-channel digital phosphor oscilloscope, which was connected to a PAR spike-generator and a modified AutoLab 500 Ultrasonic core holder from New England Research. The P- and S-wave transducer has a centre frequency at 700 kHz.

P- and S-waves were measured on dried and full saturated plugs at 25, 50 and 75 bar hydrostatic confining pressure. The confining pressure was increased continually to the next pressure step during a time period of 30 minutes using a SP-5400 high pressure pump system from Quizix. The P- and S-waves measurements were saved digitally for later analysis. When unloading the core holder, the confining pressure was decreased continually from 75 to 0 bar during a time period of 1½ hour.

The system delay time was determined by measuring transit time without any plugs and on 3 aluminium plugs with different lengths. The system delay time was found to be $12.167*10^{-6}$ sec. for the P wave and $22.951*10^{-6}$ sec. for the S wave.

2.4 Saturation of plugs

After measuring P and S waves on the dried plugs, the plugs were saturated with tap water by vacuum saturation for one day and then high pressure saturation for 2 days (100 Bar).

2.5 Porosity reduction

The produced water from the fully saturated plugs were collected by a Mettler AE 163 high precision balance during the ultrasonic measurements. The balance was re-zeroed at 7 bar and the water production was monitored at 25, 50 and 75 bar. The water production from 0 –7 bar was estimated by extrapolating the water production curve to zero bar.

If the porosity reduction data is applied elsewhere it should be noted that the water production was recorded without waiting for a stable level to be reached on the balance, as the focus was to know the porosity of the samples during the sonic velocity measurements and not the final porosity reduction.

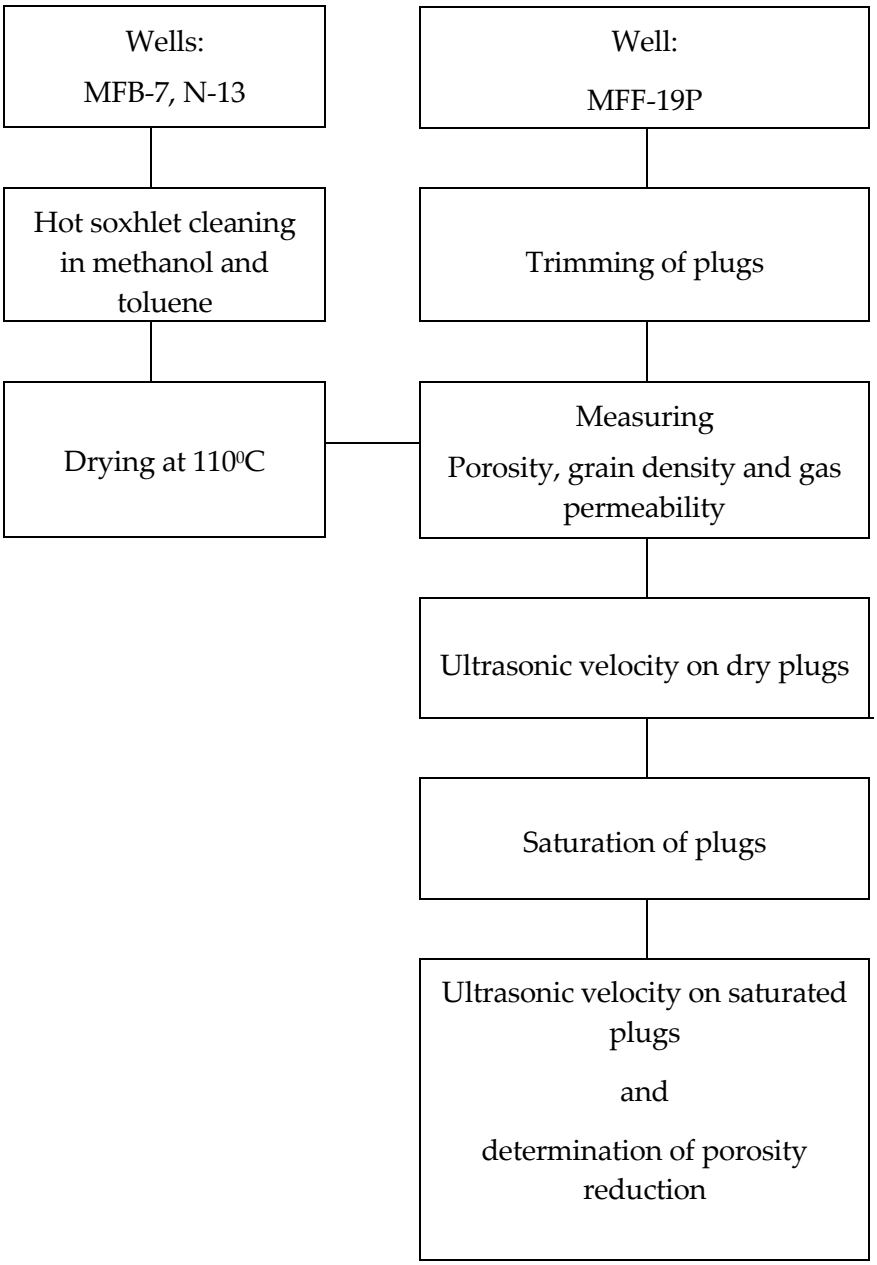
2.6 List of tables and figures

Table 2.1 Conventional core analysis data from the Dan and Gorm field.

WELL	PLUG NO.	LENGHT	DEPTH	POROSITY	GAS PERM.	GR.DENS.
		mm	feet	%	mD	g/cc
MFF-19P	1	24.26	8855.08	24.02	0.96	2.700
MFF-19P	2	25.63	8862.50	27.10	1.87	2.707
MFF-19P	3	26.71	8866.17	23.31	**0.52**	2.708
MFF-19P	4	21.74	8871.08	27.39	**0.55**	2.702
MFF-19P	5	25.76	8886.92	18.73	0.44	2.707
MFF-19P	6	26.93	8888.50	23.39	**0.66**	2.704
MFF-19P	8	25.80	8908.67	29.91	3.79	2.703
MFF-19P	14	25.14	8915.83	25.82	1.28	2.705
MFF-19P	15	24.93	8921.58	29.46	**2.69**	2.704
MFF-19P	17	26.24	8931.75	29.91	**1.83**	2.705
MFF-19P	20	20.33	8945.33	28.92	**1.60**	2.703
MFF-19P	21	21.54	8951.50	30.33	2.58	2.709
MFF-19P	22	25.25	8957.00	29.00	1.97	2.705
MFF-19P	30	25.93	9000.83	29.34	**1.28**	2.702
MFF-19P	31	19.96	9006.08	31.97	4.26	2.709
MFF-19P	32	19.30	9013.00	28.81	2.29	2.710
MFF-19P	35	24.02	9028.42	32.28	3.23	2.707
MFF-19P	37	26.15	9037.75	31.17	**2.32**	2.704
MFB-7	166	24.20	7904.50	26.72	1.91	2.710
MFB-7	167	22.58	7915.50	26.50	2.45	2.711
MFB-7	169	24.42	7928.75	25.55	5.31	2.708
MFB-7	170	24.65	7940.00	26.89	2.24	2.710
MFB-7	171	22.90	7948.50	25.77	1.66	2.711
MFB-7	172	23.73	7960.00	23.47	1.30	2.710
MFB-7	175	23.08	7994.00	22.21	0.94	2.710
N-13	176	21.23	9197.08	23.07	0.83	2.707
N-13	177	23.28	9277.67	20.84	34.03*	2.706

The bold permeabilities are from the CCAL report (GEUS report 1999/12).
*Fractured

3. Flow chart of the analytical procedure



4. Analytical methods

The following is a short description of the methods used by GEUS Core Laboratory. For a more detailed description of methods, instrumentation and principles of calculation the reader is referred to API recommended practice for core analysis procedure (API RP 40, 1998).

4.1 Ultrasonic measurements

The ultrasonic velocity is calculated from the following equation.

$$\text{Ultrasonic velocity}[\text{m/s}] = \frac{\text{Sample length}[\text{m}]}{\text{Transit time}[\text{s}] - \text{system delay}[\text{s}]}$$

The transit time of a plug is measured using an oscilloscope, which is connected to a spike-generator and an ultrasonic core holder. The system delay time is the transit time of the system without any plugs. It can be determined by measuring the transit time without any plugs or measuring the transit time for uniform plugs with known length and extrapolate to 0.

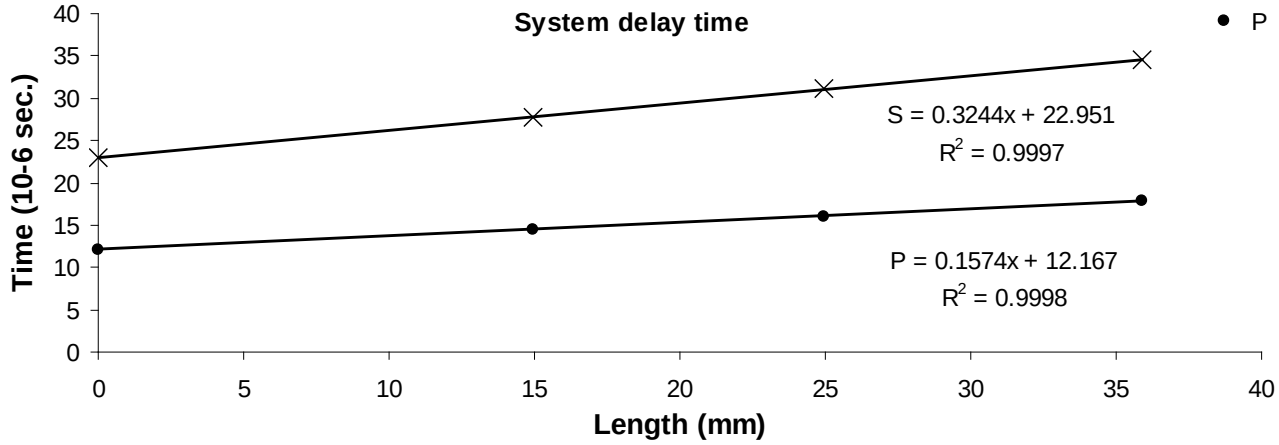


Figure 4.1 Determination of the system delay time.

The system is tested against 2 reference plugs giving the following result.

Aluminium 6061 plug:	P-velocity m/s	S1-velocity m/s	S2-velocity m/s
Measured	6393	3164	3132
Reference	6396	3125	3125
Difference (%)	-0.04	1.23	0.23

Acrylic plug:	P-velocity m/s	S1-velocity m/s	S2-velocity m/s
Measured	2740	1398	1386
Reference	2750	1392	1392

Difference (%)	-0.35	0.42	-0.40

4.2 Reduced porosity by overburden pressure.

The initial porosity is determined at room conditions. Archimedes test is applied to the fully saturated plug sample, and in combination with the sample grain density the porosity is calculated. During testing the sample pore volume decreases as overburden increases. This is observed as an amount of liquid expelled from the sample and constantly monitored using an electronic Mettler balance connected to a computer. The final reading is taken when a stable level has been reached on the balance. The porosity reduction is calculated as the relative decrease in the initial porosity:

$$\emptyset_i = \frac{V_{pi}}{V_{bi}}$$

$$\emptyset_{i+\Delta p} = \frac{V_{pi} - \Delta V_p}{V_{bi} - \Delta V_p}$$

The porosity reduction is then given as:

$$\frac{\emptyset_{i+\Delta p}}{\emptyset_i} \cdot 100\% = \frac{V_{pi} - \Delta V_p}{V_{bi} - \Delta V_p} \cdot \frac{V_{bi}}{V_{pi}} \cdot 100\%$$

Where $\emptyset_i$ = Initial porosity
V_{pi} = Initial pore volume
V_{bi} = Initial bulk volume
$\emptyset_{i+\Delta P}$ = New porosity induced by a certain change ΔP in overburden pressure
ΔV_p = Change in pore volume due to the change in overburden pressure

The initial change in the pore volume (PV_0) that occurs from room conditions to the lowest overburden pressure applied in the study, is extrapolated from a liquid production curve (produced liquid vs net overburden pressure).

4.3 Gas permeability

The plug is mounted in a Hassler core holder, and a confining pressure of 800 psi applied to the sleeve. The specific permeability to gas is measured by flowing nitrogen gas through a plug of known dimensions at differential pressures between 0 and 1 bar. No back pressure is applied. The readings of the digital gas permeameter are checked regularly by routine measurement of permeable steel reference plugs.

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4.4 He-porosity and grain density

The porosity is measured on cleaned and dried samples. The porosity is determined by subtraction of the measured grain volume and the measured bulk volume. The Helium technique, employing

Boyle's Law, is used for grain volume determination, applying a double chambered Helium porosimeter with digital readout, whereas bulk volume is measured by submersion of the plug in a mercury bath using Archimedes principle. Grain density is calculated from the grain volume measurement and the weight of the cleaned and dried sample.

4.5 Precision of analytical data

Conventional core analysis:

The table below gives the precision (= reproducibility) at the 68% level of confidence (+/- 1 standard deviation) for routine core analysis measurements performed at GEUS Core Laboratory.

Measurement	Range, mD	Precision
Grain density		0.003 g/cc
Porosity		0.1 porosity-%
Gas Permeability	0.001-0.01 0.01-0.1 > 0.1	25% 15% 4%

Ultrasonic data:

The largest errors are due to the difficulties of reading the transit time of the plug. If first break is clearly visible the reading is considered excellent and labelled a. If first break is more difficult to read the reading is considered normal and labelled b. If first break is not visible the reading is considered difficult and labelled c.

The table below gives the precision for sonic velocity measurements performed at GEUS Core Laboratory.

Measurement	Precision	The effect on the velocity for a typical chalk plug
Length	0.1 mm	15 m/s for P-waves and 10 m/s for S-waves
Time reading of a excellent signal (a)	$\pm 0.02*10^{-6}$ sec.	± 8 m/s for P-waves and 3 m/s for S-waves
Time reading of a normal signal (b)	$\pm 0.10*10^{-6}$ sec.	± 40 m/s for P-waves and 15 m/s for S-waves
Time reading of a difficult signal (c)	$\pm 0.30*10^{-6}$ sec.	± 120 m/s for P-waves and 45 m/s for S-waves

For every plug the transit time readings have been labelled in order to determine the uncertainty on the sonic velocity for each plug. Data are shown in the table on the next page.

Uncertainties of the signal reading				P-waves at:			S1-waves at:			S2-waves at:		
Well name	plug no.	depth feet	Condition	25 bar Reading	50 bar Reading	75 bar Reading	25 bar Reading	50 bar Reading	75 bar Reading	25 bar Reading	50 bar Reading	75 bar Reading
MFF-19P	1	8855.08	Dry	b	b	a	b	b	b	b	b	b
MFF-19P	1	8855.08	Saturated	a	a	a	c	c	c	c	b	b
MFF-19P	2	8862.50	Dry	b	b	a	c	b	b	-	-	c
MFF-19P	2	8862.50	Saturated	b	a	a	-	-	-	-	-	-
MFF-19P	3	8866.17	Dry	b	b	b	b	b	b	b	b	b
MFF-19P	3	8866.17	Saturated	b	a	a	c	b	b	c	b	b
MFF-19P	4	8871.08	Dry	b	a	a	c	c	c	c	c	c
MFF-19P	4	8871.08	Saturated	b	a	a	-	c	c	-	c	c
MFF-19P	5	8886.92	Dry	c	b	a	c	b	a	b	a	a
MFF-19P	5	8886.92	Saturated	a	a	a	-	c	c	c	c	c
MFF-19P	6	8888.50	Dry	b	a	a	c	c	c	c	c	c
MFF-19P	6	8888.50	Saturated	a	a	a	b	b	a	b	b	b
MFF-19P	8	8908.67	Dry	-	b	a	c	b	b	b	a	a
MFF-19P	8	8908.67	Saturated	a	a	a	b	b	a	b	a	a
MFF-19P	14	8915.83	Dry	-	b	b	-	a	a	-	c	c
MFF-19P	14	8915.83	Saturated	a	a	a	-	c	c	-	c	c
MFF-19P	15	8921.58	Dry	b	b	b	-	b	b	b	b	b
MFF-19P	15	8921.58	Saturated	a	a	a	-	b	a	-	b	b
MFF-19P	17	8931.75	Dry	b	b	b	a	a	a	a	a	a
MFF-19P	17	8931.75	Saturated	a	a	a	b	b	b	c	a	a
MFF-19P	20	8945.33	Dry	a	a	a	b	b	b	b	a	a
MFF-19P	20	8945.33	Saturated	a	a	a	b	a	a	c	a	a
MFF-19P	21	8951.50	Dry	b	a	a	b	a	a	b	a	a
MFF-19P	21	8951.50	Saturated	a	a	a	c	b	b	c	b	b
MFF-19P	22	8957.00	Dry	b	a	a	c	b	b	b	b	b
MFF-19P	22	8957.00	Saturated	a	a	a	c	b	b	c	a	a
MFF-19P	30	9000.83	Dry	a	a	a	b	b	b	b	a	a
MFF-19P	30	9000.83	Saturated	a	a	a	b	c	c	c	b	c
MFF-19P	31	9006.08	Dry	a	a	a	b	b	b	b	b	b
MFF-19P	31	9006.08	Saturated	b	a	a	c	c	c	c	c	c
MFF-19P	32	9013.00	Dry	a	a	a	b	b	b	b	b	b
MFF-19P	32	9013.00	Saturated	b	a	a	c	c	c	c	c	c
MFF-19P	35	9028.42	Dry	a	a	a	b	b	b	b	b	b
MFF-19P	35	9028.42	Saturated	a	a	a	c	a	a	c	a	a
MFF-19P	37	9037.75	Dry	b	a	a	b	b	b	c	a	a
MFF-19P	37	9037.75	Saturated	a	a	a	b	a	a	b	a	a
MFB-7	166	7904.50	Dry	-	b	b	-	c	c	-	c	c
MFB-7	167	7915.50	Dry	a	a	a	b	b	a	c	c	c
MFB-7	169	7928.75	Dry	b	a	a	c	c	c	c	c	c
MFB-7	170	7940.00	Dry	b	a	a	b	b	a	b	b	b
MFB-7	171	7948.50	Dry	-	a	a	-	b	b	-	b	b
MFB-7	172	7960.00	Dry	b	a	a	c	b	b	c	b	b
MFB-7	175	7994.00	Dry	b	b	b	-	b	b	-	c	b
N-13	176	9197.08	Dry	a	a	a	b	b	b	c	c	c
N-13	177	9277.67	Dry	a	a	a	b	b	b	b	b	b

5. Results of special core analysis

The results of the special core analysis are shown in the following tables and figures:

The dry ultrasonic velocities are presented in table 5.1, measured at 25, 50 and 75 bar hydrostatic confining pressure.

The saturated ultrasonic velocities and the porosity reduction are presented in table 5.2, measured at 25, 50 and 75 bar hydrostatic confining pressure.

The reduced porosity at 25, 50 and 75 bar hydrostatic confining pressure is listed in table 5.3

The ultrasonic velocity have been plotted as follows:

- Porosity vs. P,S1,S2-wave velocity
- P-wave velocity vs. S-wave velocity
- P-wave / S2-wave vs. porosity
- P-wave / S2-wave vs. P-wave
- P and S-waves measured dry vs. saturated measurements

5.1 Data tabulation.

Table 5.1: Ultrasonic velocities measured on dried plugs from the Dan and Gorm field.

Dry measurements on Dan and Gorm					P-waves at:			S1-waves at:			S2-waves at:			Vp/Vs
					25 bar	50 bar	75 bar	25 bar	50 bar	75 bar	25 bar	50 bar	75 bar	75 bar
Well	plug	depth	Porosity	Gr. Dens.	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
name	no.	feet	%	g/cc	m/s	m/s	m/s	m/s	m/s	m/s	m/s	m/s	m/s	
MFF-19P	1	8855.08	24.02	2.700	3220	3264	3354	2047	2065	2101	2047	2083	2119	1.59
MFF-19P	2	8862.50	27.10	2.707	3495	3543	3543	2127	2163	2181	-	-	2145	1.64
MFF-19P	3	8866.17	23.31	2.708	3325	3367	3410	2095	2112	2112	2047	2079	2095	1.62
MFF-19P	4	8871.08	27.39	2.702	2886	2925	3006	1850	1899	1933	1866	1899	1933	1.56
MFF-19P	5	8886.92	18.73	2.707	3513	3611	3716	2230	2290	2331	2230	2290	2311	1.60
MFF-19P	6	8888.50	23.39	2.704	3812	3868	3868	2329	2414	2414	2329	2371	2392	1.61
MFF-19P	8	8908.67	29.91	2.703	-	2989	3024	1836	1890	1918	1850	1877	1890	1.59
MFF-19P	14	8915.83	25.82	2.705	-	3294	3337	-	2003	2036	-	2003	2052	1.63
MFF-19P	15	8921.58	29.46	2.704	3143	3183	3224	-	1987	2003	1925	1955	1987	1.62
MFF-19P	17	8931.75	29.91	2.705	3075	3149	3187	1922	1937	1951	1909	1922	1922	1.65
MFF-19P	20	8945.33	28.92	2.703	3065	3112	3160	1964	1984	2003	1946	1984	1984	1.59
MFF-19P	21	8951.50	30.33	2.709	3107	3152	3199	1932	1949	1967	1915	1949	1967	1.63
MFF-19P	22	8957.00	29.00	2.705	2959	2994	3030	1850	1920	1935	1877	1906	1920	1.57
MFF-19P	30	9000.83	29.34	2.702	3112	3150	3150	1928	1957	1987	1957	1972	1987	1.58
MFF-19P	31	9006.08	31.97	2.709	2838	2879	2921	1840	1857	1874	1823	1840	1857	1.57
MFF-19P	32	9013.00	28.81	2.710	3199	3253	3309	1980	2000	2000	1960	1980	2000	1.65
MFF-19P	35	9028.42	32.28	2.707	2782	2815	2848	1786	1799	1813	1786	1799	1799	1.58
MFF-19P	37	9037.75	31.17	2.704	2895	2994	3029	1810	1848	1875	1797	1848	1875	1.62
MFB-7	166	7904.50	26.72	2.710	-	3013	3051	-	1928	1944	-	1928	1944	1.57
MFB-7	167	7915.50	26.50	2.711	3257	3305	3354	2044	2062	2081	2044	2062	2081	1.61
MFB-7	169	7928.75	25.55	2.708	3199	3242	3285	1962	1994	2010	1962	1994	2010	1.63
MFB-7	170	7940.00	26.89	2.710	2994	3069	3147	1918	1949	1964	1933	1949	1964	1.60
MFB-7	171	7948.50	25.77	2.711	-	3256	3303	-	2073	2092	-	2073	2092	1.58
MFB-7	172	7960.00	23.47	2.710	3423	3473	3524	2148	2187	2228	2148	2187	2208	1.59
MFB-7	175	7994.00	22.21	2.710	3588	3644	3703	-	2230	2252	-	2209	2252	1.64
N-13	176	9197.08	23.07	2.707	3908	3981	3981	2346	2372	2399	2320	2372	2399	1.66
N-13	177	9277.67	20.84	2.706	4061	4133	4207	2413	2438	2464	2413	2438	2464	1.71

Table 5.2: Ultrasonic velocities measured on saturated plugs from the Dan field.

Sat. measurements on Dan					P-waves at:			S1-waves at:			S2-waves at:			Vp/Vs2
					25 bar	50 bar	75 bar	25 bar	50 bar	75 bar	25 bar	50 bar	75 bar	75 bar
Well	plug	depth	Porosity	Gr. Dens.	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	Velocity	
name	no.	feet	%	g/cc	m/s	m/s	m/s	m/s	m/s	m/s	m/s	m/s	m/s	
MFF-19P	1	8855.08	24.02	2.7	3264	3354	3401	1764	1817	1859	1739	1752	1791	1.86
MFF-19P	2	8862.50	27.10	2.707	3543	3543	3593	-	-	-	-	-	-	-
MFF-19P	3	8866.17	23.31	2.708	3410	3499	3546	1836	1875	1901	1811	1875	1915	1.86
MFF-19P	4	8871.08	27.39	2.702	3048	3136	3182	-	1605	1641	-	1641	1653	1.93
MFF-19P	5	8886.92	18.73	2.707	3663	3716	3770	-	2037	2053	2005	2037	2053	1.84
MFF-19P	6	8888.50	23.39	2.704	3925	3925	3925	2123	2158	2175	2073	2089	2106	1.83
MFF-19P	8	8908.67	29.91	2.703	3059	3172	3212	1638	1692	1726	1628	1681	1714	1.87
MFF-19P	14	8915.83	25.82	2.705	3169	3251	3337	-	1740	1777	-	1728	1764	1.88
MFF-19P	15	8921.58	29.46	2.704	3266	3309	3354	-	1775	1800	-	1827	1827	1.85
MFF-19P	17	8931.75	29.91	2.705	3187	3226	3267	1688	1744	1767	1677	1710	1732	1.87
MFF-19P	20	8945.33	28.92	2.703	3210	3262	3315	1730	1760	1776	1730	1760	1776	1.87
MFF-19P	21	8951.50	30.33	2.709	3152	3199	3247	1663	1703	1730	1676	1703	1730	1.88
MFF-19P	22	8957.00	29.00	2.705	3067	3105	3143	1634	1667	1700	1624	1656	1689	1.85
MFF-19P	30	9000.83	29.34	2.702	3150	3188	3228	1689	1723	1746	1678	1735	1758	1.84
MFF-19P	31	9006.08	31.97	2.709	2921	2965	3009	1591	1603	1616	1578	1603	1616	1.86
MFF-19P	32	9013.00	28.81	2.71	3199	3253	3309	1716	1779	1812	1779	1796	1830	1.82
MFF-19P	35	9028.42	32.28	2.707	2883	2918	2953	1525	1555	1575	1525	1545	1565	1.88
MFF-19P	37	9037.75	31.17	2.704	3065	3101	3138	1619	1650	1660	1609	1650	1671	1.88

Table 5.3: Reduced porosity by overburden pressure.

Well	Plug no.	Depth	Porosity At 0 bar	Porosity At 25 bar	Porosity At 50 bar	Porosity At 75 bar	Reduced At 75 bar
		feet	%	%	%	%	%
MFF-19P	1	8855.08	24.02	23.76	23.68	23.70	1.34
MFF-19P	2	8862.50	27.10	27.01	26.99	26.97	0.49
MFF-19P	3	8866.17	23.31	23.14	23.04	22.98	1.43
MFF-19P	4	8871.08	27.39	27.30	27.19	27.13	0.97
MFF-19P	5	8886.92	18.73	18.56	18.49	18.44	1.55
MFF-19P	6	8888.50	23.39	-	-	-	-
MFF-19P	8	8908.67	29.91	29.80	29.76	29.72	0.63
MFF-19P	14	8915.83	25.82	25.67	25.61	25.56	1.00
MFF-19P	15	8921.58	29.46	29.31	29.23	29.18	0.95
MFF-19P	17	8931.75	29.91	29.81	29.75	29.70	0.70
MFF-19P	20	8945.33	28.92	28.84	28.79	28.75	0.57
MFF-19P	21	8951.50	30.33	29.87	29.66	29.49	2.77
MFF-19P	22	8957.00	29.00	28.99	28.92	28.87	0.44
MFF-19P	30	9000.83	29.34	29.26	29.21	29.16	0.60
MFF-19P	31	9006.08	31.97	31.53	31.45	31.39	1.82
MFF-19P	32	9013.00	28.81	28.62	28.56	28.52	1.00
MFF-19P	35	9028.42	32.28	32.17	32.11	32.06	0.68
MFF-19P	37	9037.75	31.17	-	-	-	-

5.2 Diagrams.

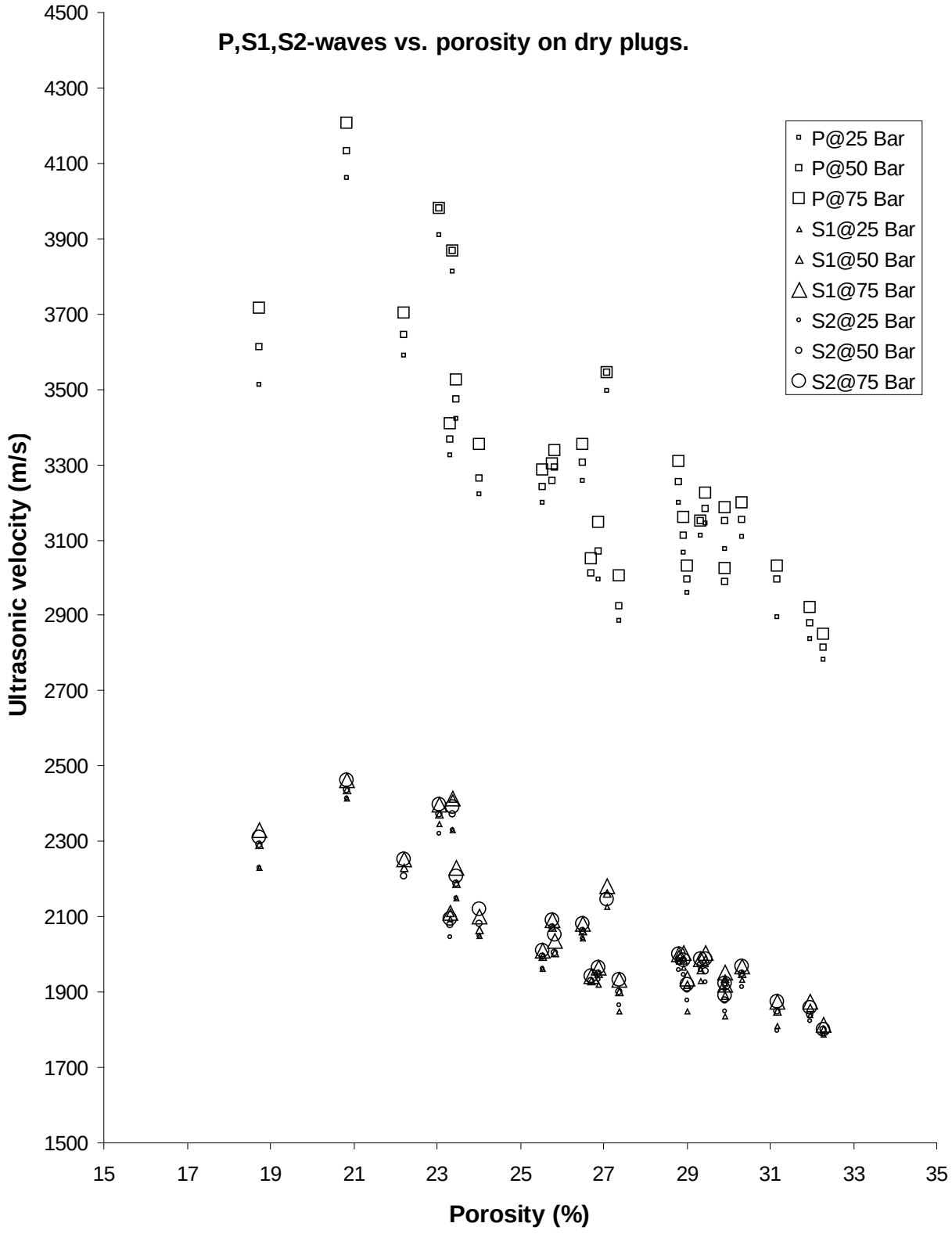


Figure 5.1: P,S1,S2 waves vs. porosity on dry plugs measured at 25, 50 and 75 bar hydrostatic confining pressure

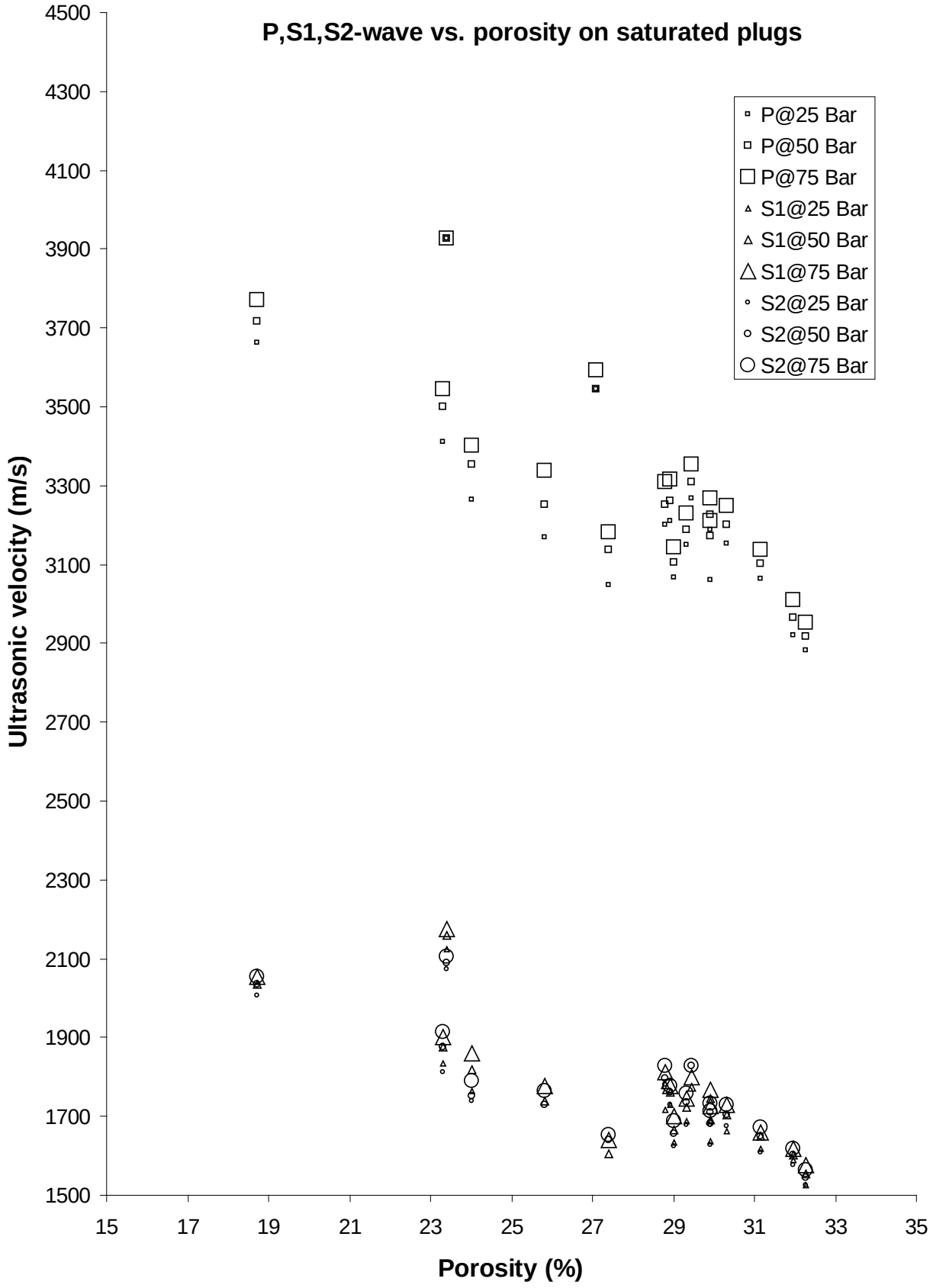


Figure 5.2: P,S1,S2 waves vs. porosity on fully saturated plugs measured at 25, 50 and 75 bar hydrostatic confining pressure

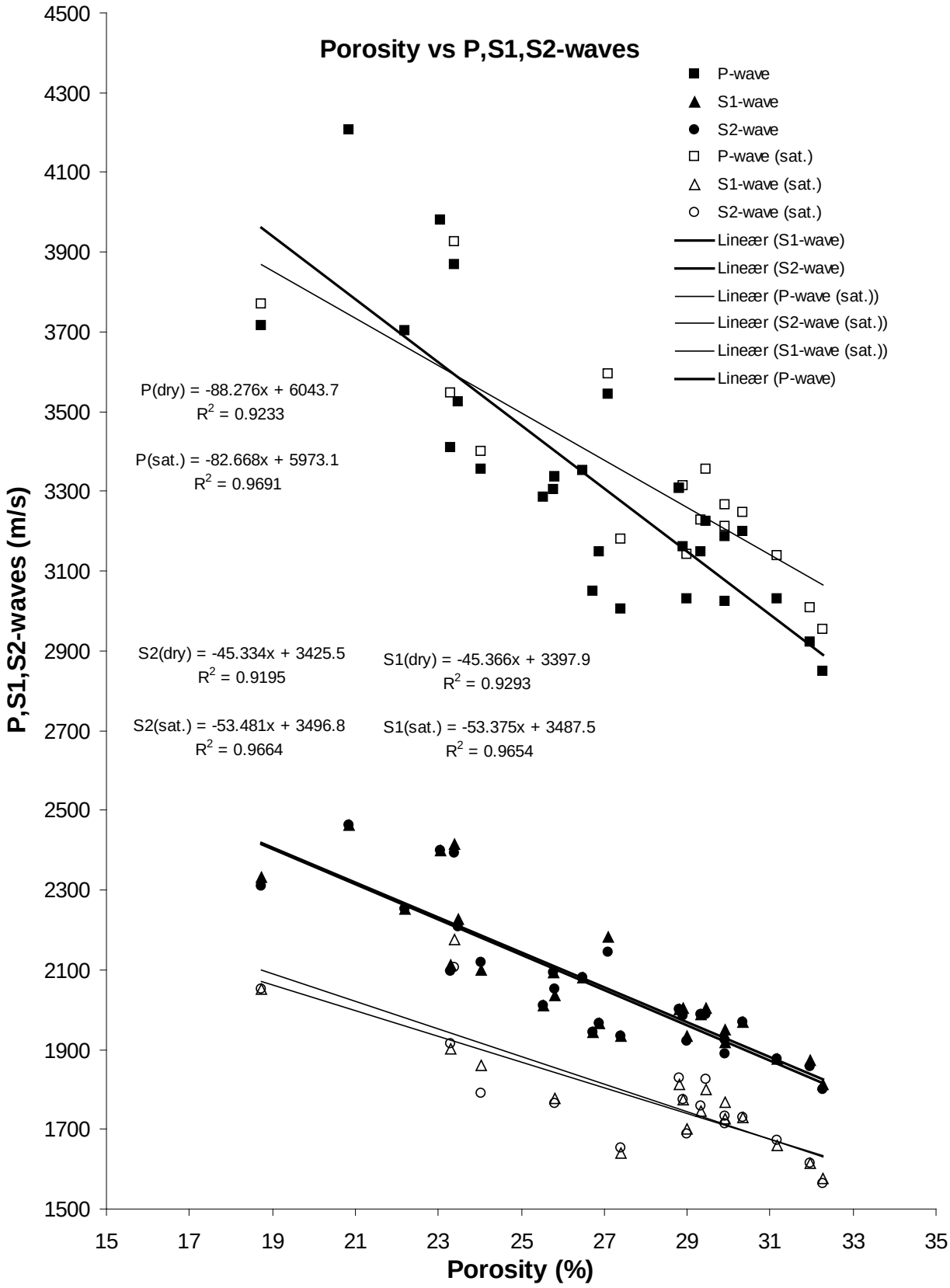


Figure 5.3: Porosity plotted against P,S1,S2-waves measured at 75 bar on dry and saturated plugs.

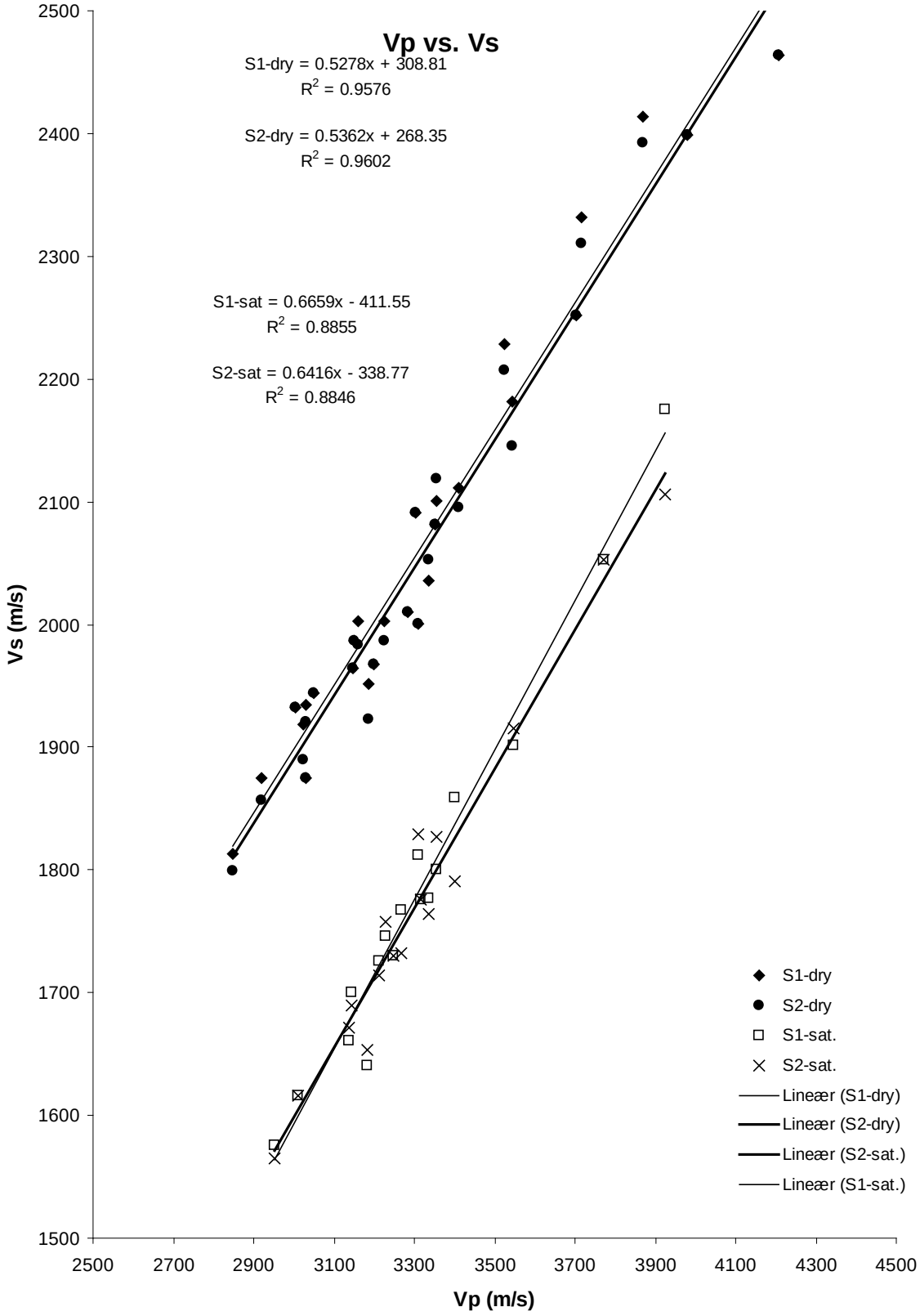


Figure 5.4: P-wave plotted against S1 and S2 wave measured at 75 bar on dry and saturated plugs..

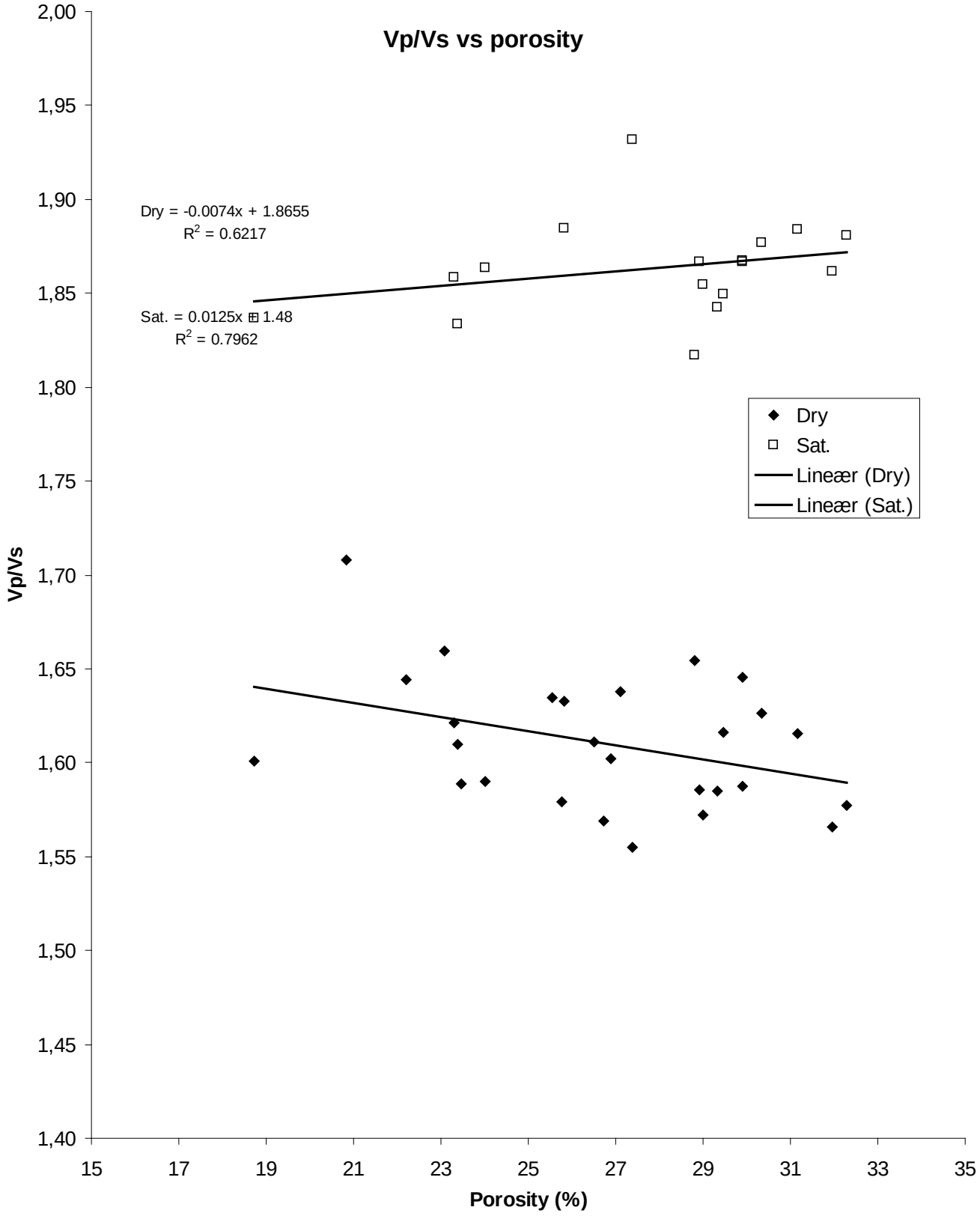


Figure 5.5: P-wave/S2-wave plotted against porosity measured at 75 bar on dry and saturated plugs.

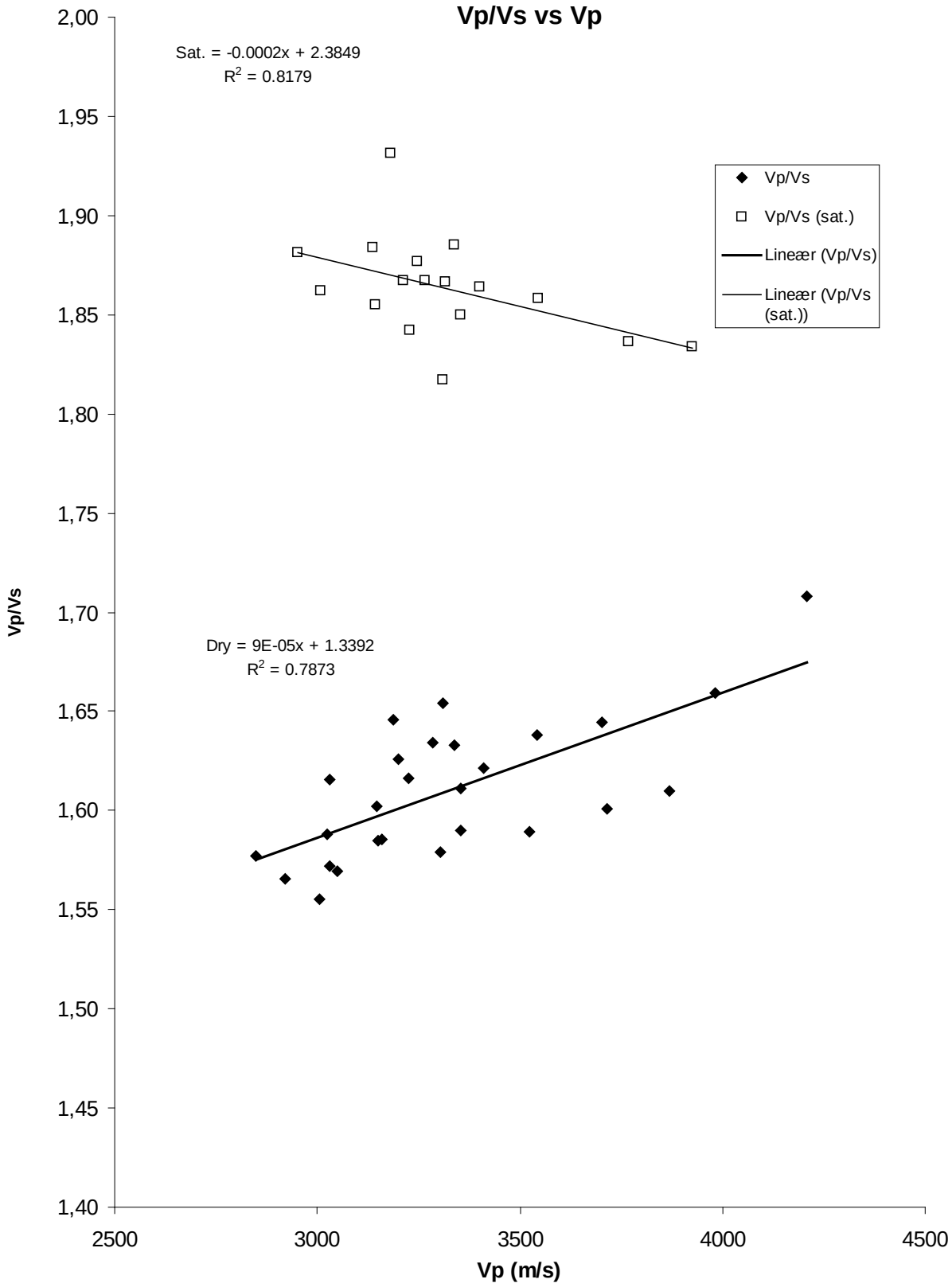


Figure 5.6: P-wave/S2-wave plotted against P-wave measured at 75 bar on dry and saturated plugs.

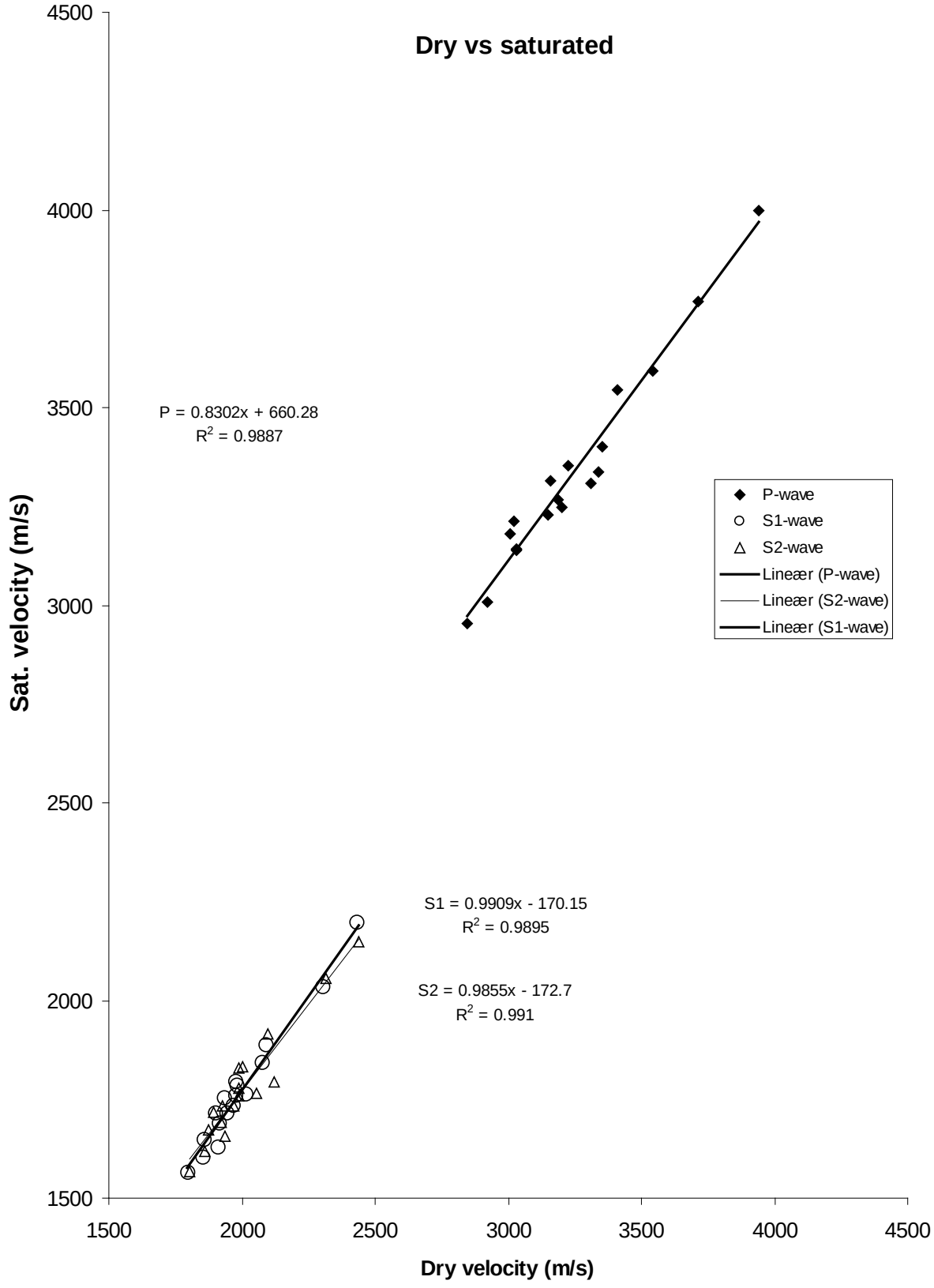


Figure 5.7: Dry measured P and S-waves plotted against saturated measured P and S-waves.

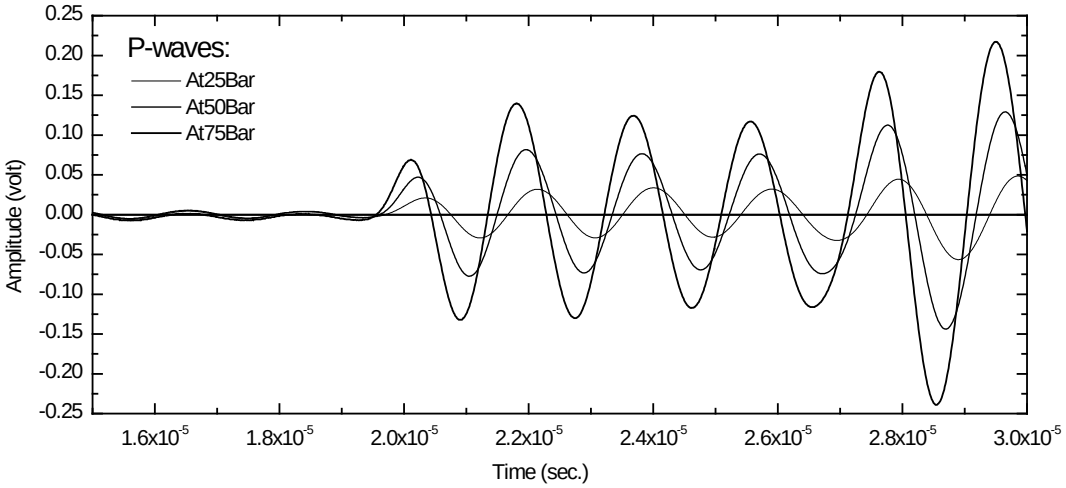
6. Documentation of data.

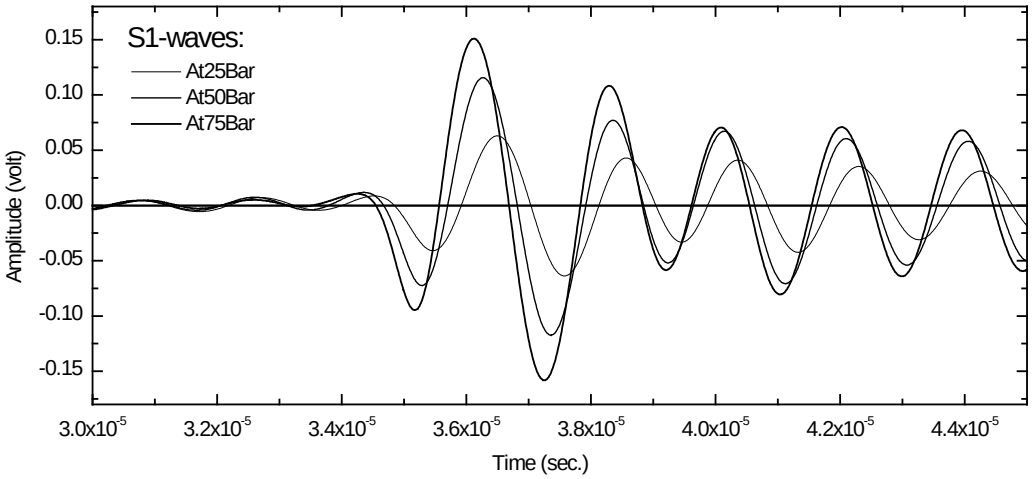
The recorded ultrasonic profiles are plotted and the registered transit time is listed. The data for each sample are presented in the following way.

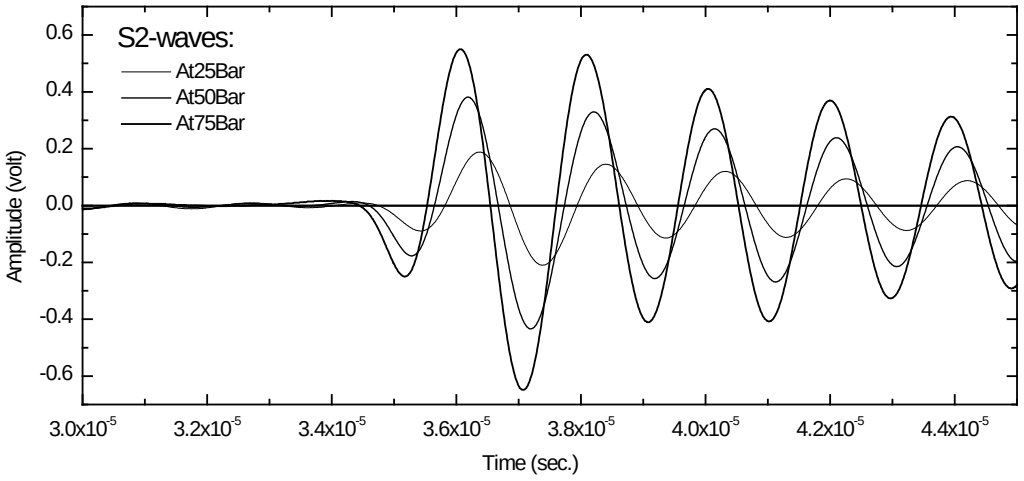
- The registered transit time is listed on top of the page
- The P-wave profile measured at 25, 50 and 75 bar are plotted in the first diagram
- The S1-wave profile measured at 25, 50 and 75 bar are plotted in the second diagram
- The S2-wave profile measured at 25, 50 and 75 bar are plotted in the third diagram

The profiles used for estimation of the porosity reduction are shown at the end of the present report.

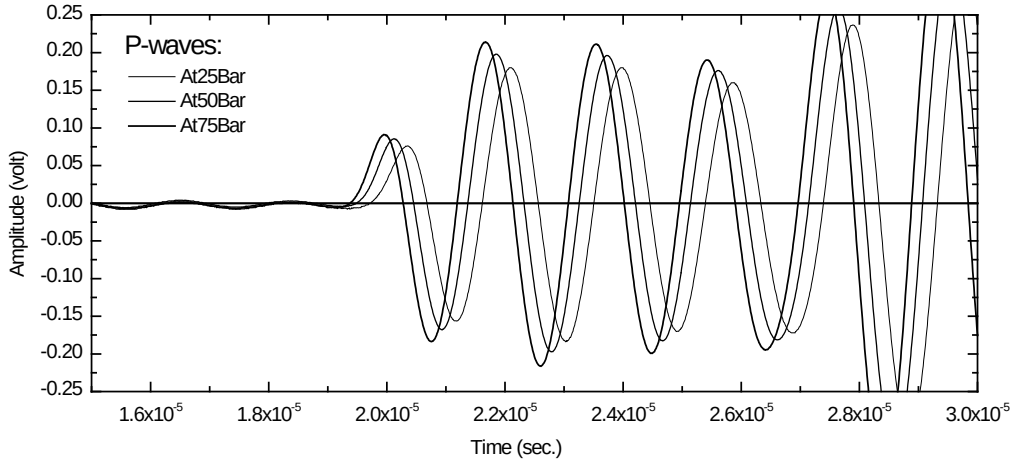
MFF-19P	P@25 Bar: $19.7*10^{-6}$ sec.	S1@25 Bar: $34.8*10^{-6}$ sec.	S2@25 Bar: $34.8*10^{-6}$ sec.
Plug no. 1	P@50 Bar: $19.6*10^{-6}$ sec.	S1@50 Bar: $34.7*10^{-6}$ sec.	S2@50 Bar: $34.6*10^{-6}$ sec.
Dry	P@75 Bar: $19.4*10^{-6}$ sec.	S1@75 Bar: $34.5*10^{-6}$ sec.	S2@75 Bar: $34.4*10^{-6}$ sec.

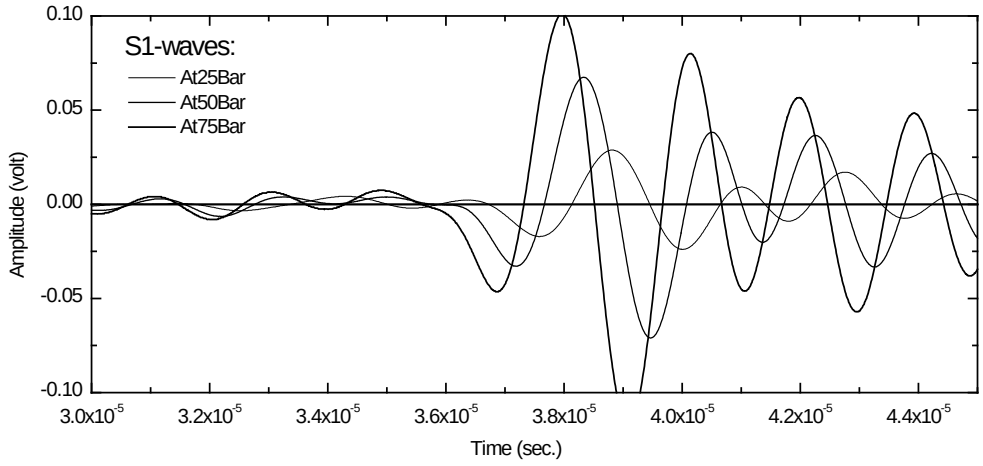


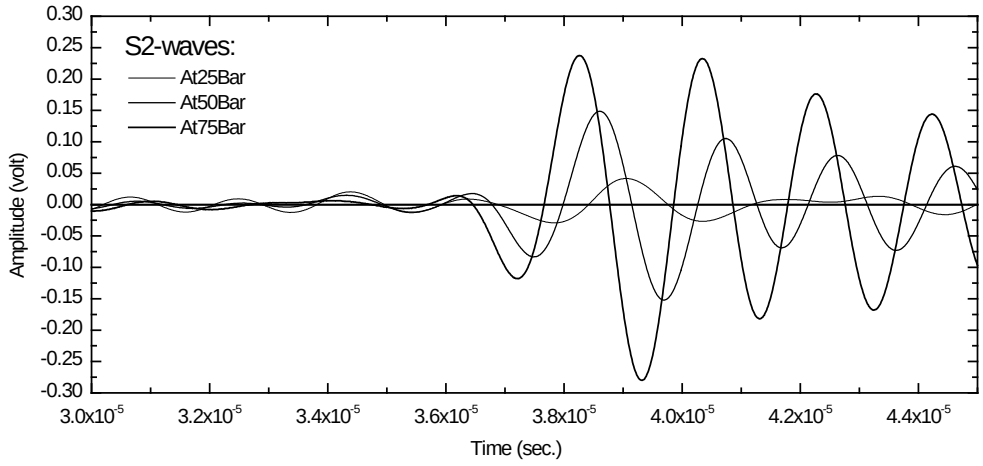




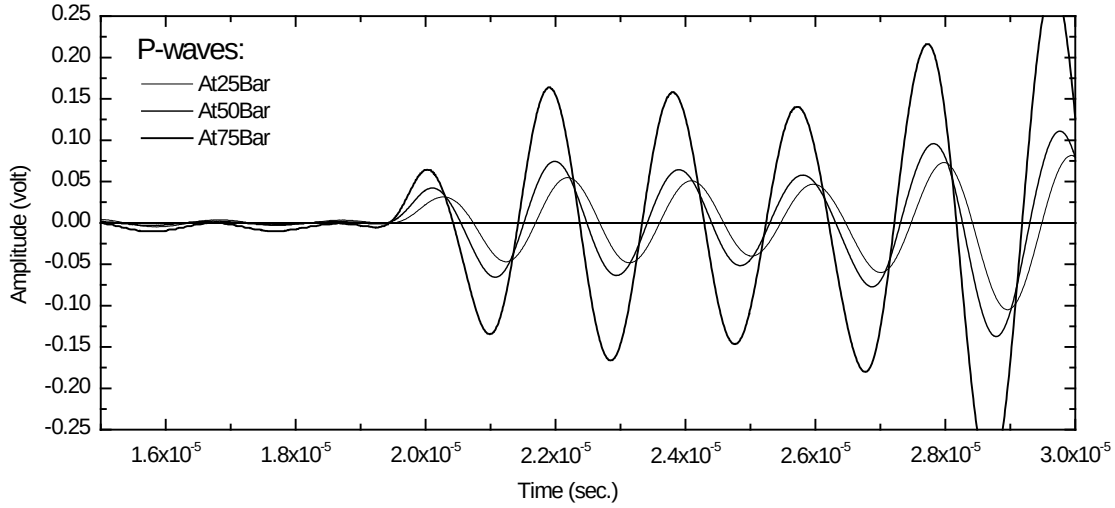
MFF-19P	P@25 Bar: $19.6*10^{-6}$ sec.	S1@25 Bar: $36.7*10^{-6}$ sec.	S2@25 Bar: $36.9*10^{-6}$ sec.
Plug no. 1	P@50 Bar: $19.4*10^{-6}$ sec.	S1@50 Bar: $36.3*10^{-6}$ sec.	S2@50 Bar: $36.8*10^{-6}$ sec.
Sat.	P@75 Bar: $19.3*10^{-6}$ sec.	S1@75 Bar: $36.0*10^{-6}$ sec.	S2@75 Bar: $36.5*10^{-6}$ sec.

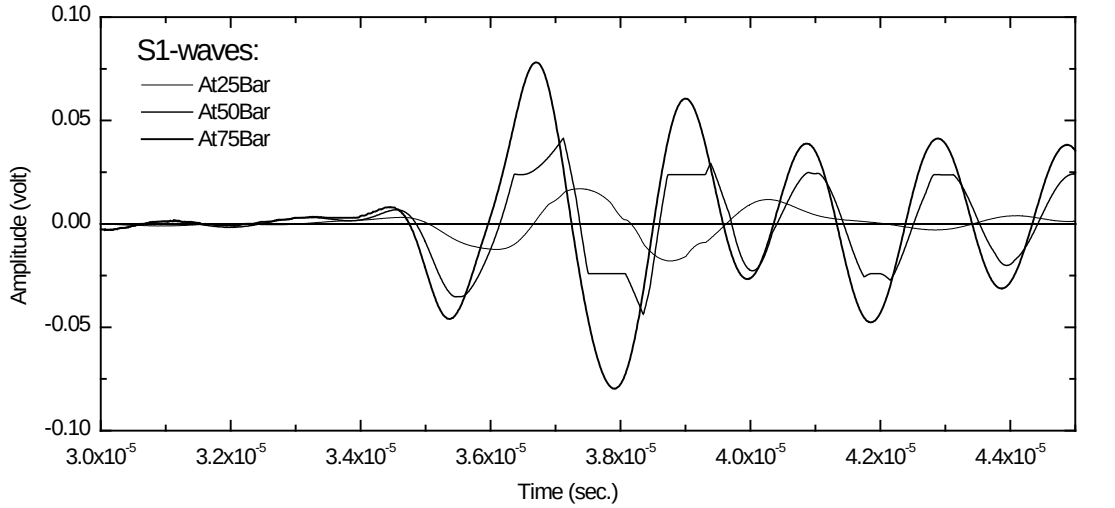


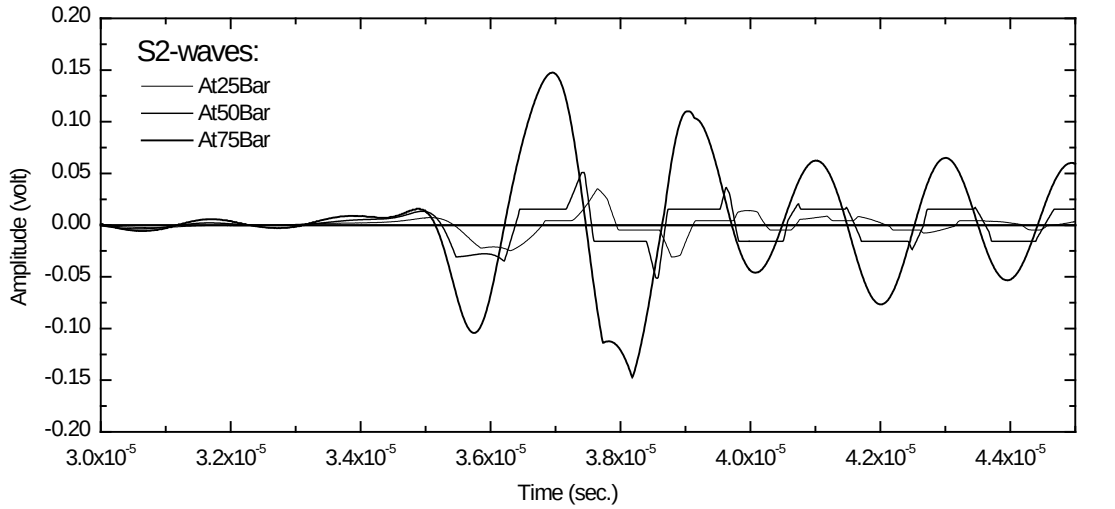




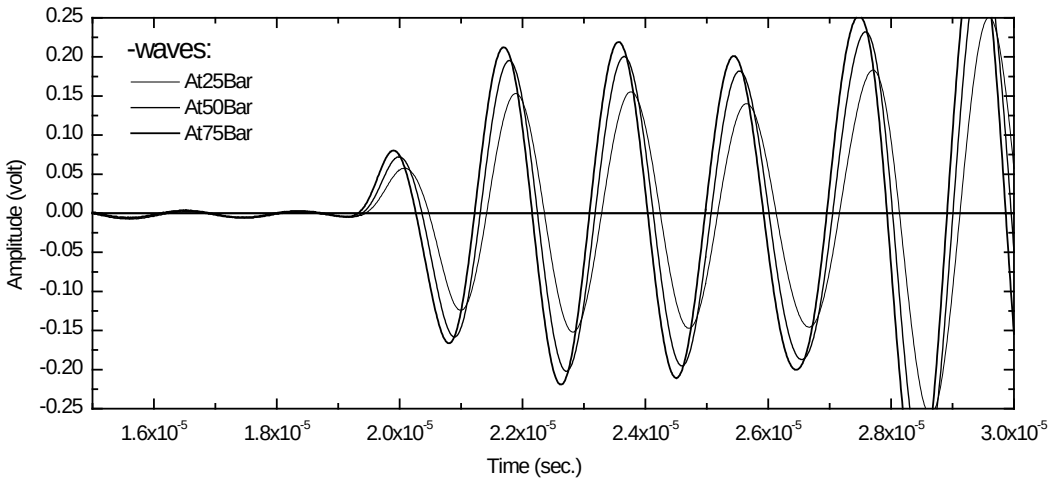
MFF-19P	P@25 Bar: 19.5*10^{-6} sec.	S1@25 Bar: 35.0*10^{-6} sec.	S2@25 Bar: ? *10^{-6} sec.
Plug no. 2	P@50 Bar: 19.4*10^{-6} sec.	S1@50 Bar: 34.8*10^{-6} sec.	S2@50 Bar: ? *10^{-6} sec.
Dry	P@75 Bar: 19.4*10^{-6} sec.	S1@75 Bar: 34.7*10^{-6} sec.	S2@75 Bar: 34.9*10^{-6} sec.

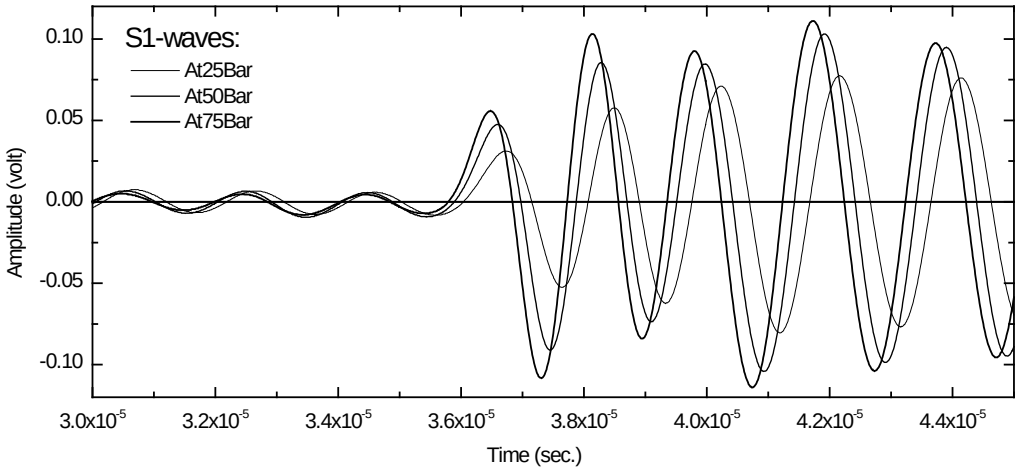


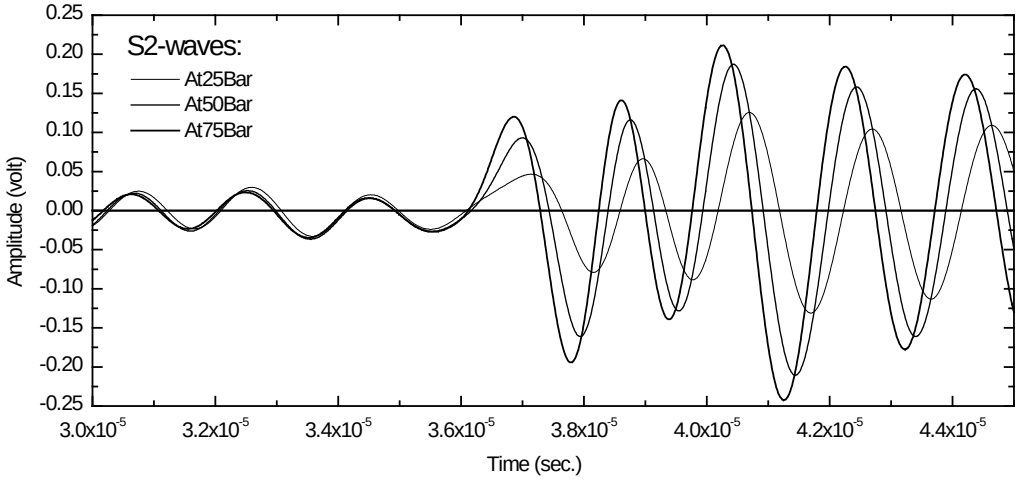




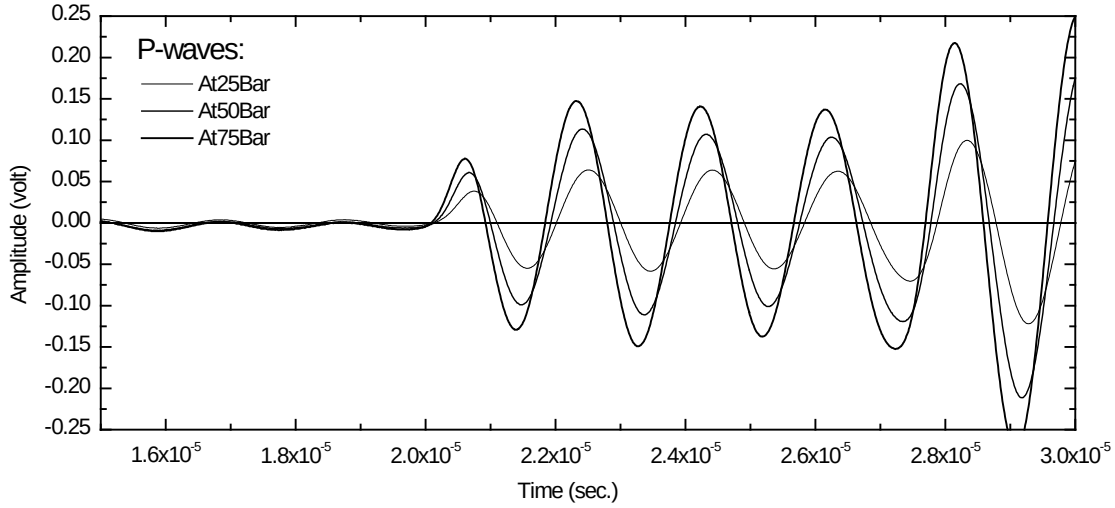
MFF-19P	P@25 Bar: 19.4*10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: ? *10^{-6} sec.
Plug no. 2	P@50 Bar: 19,4*10^{-6} sec.	S1@50 Bar: ? *10^{-6} sec.	S2@50 Bar: ? *10^{-6} sec.
Sat.	P@75 Bar: 19.3*10^{-6} sec.	S1@75 Bar: ? *10^{-6} sec.	S2@75 Bar: ? *10^{-6} sec.

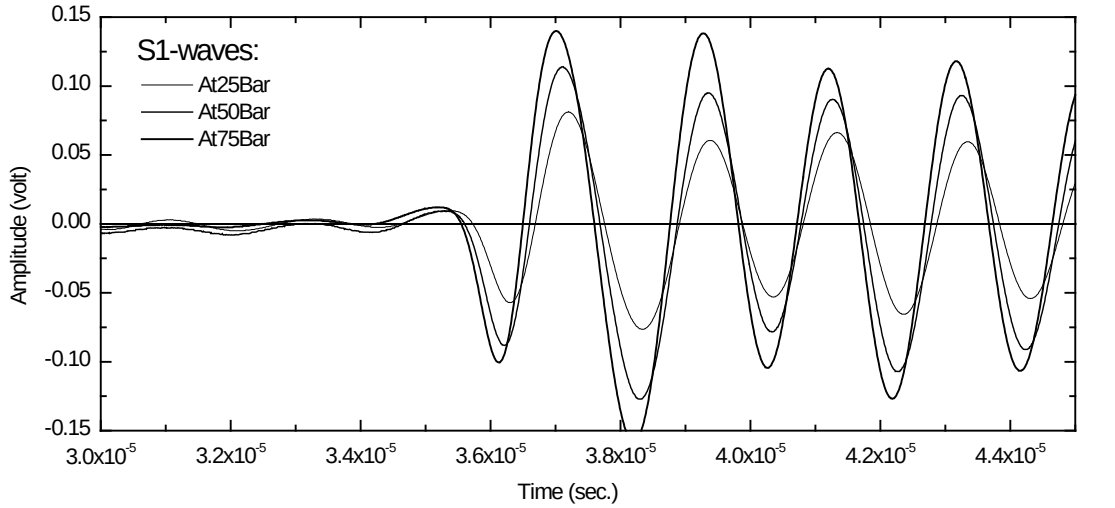


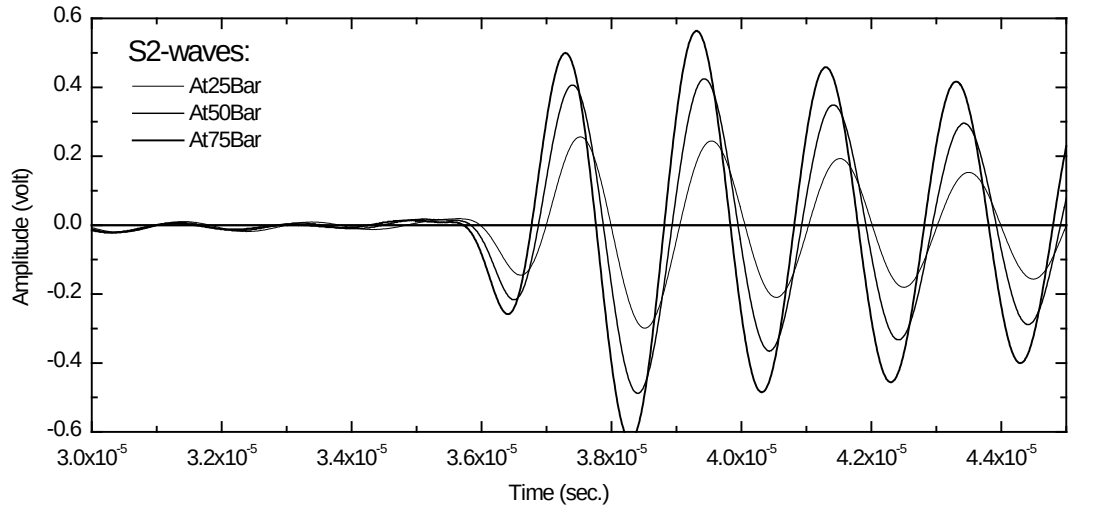




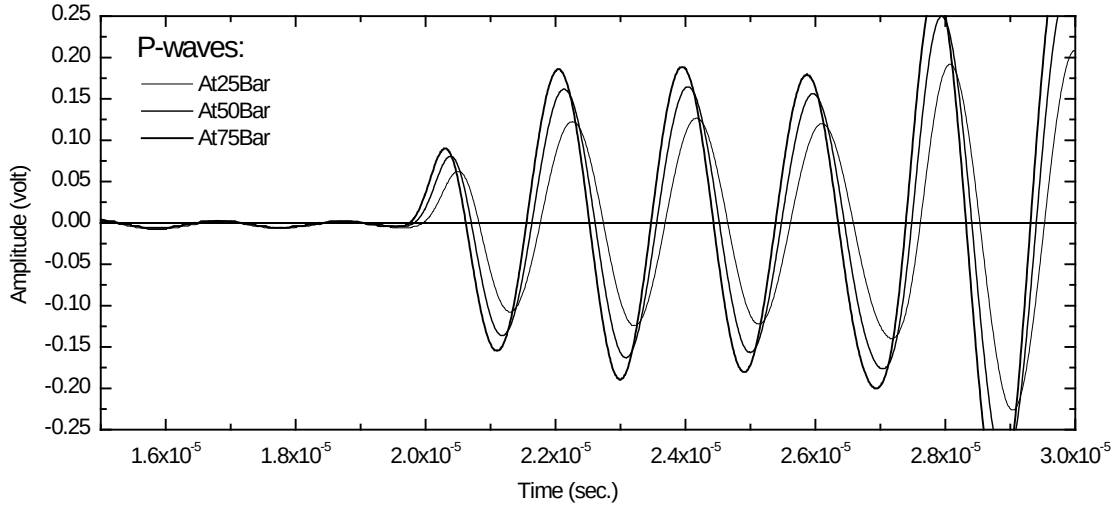
MFF-19P	P@25 Bar: $20.2*10^{-6}$ sec.	S1@25 Bar: $35.7*10^{-6}$ sec.	S2@25 Bar: $36.0*10^{-6}$ sec.
Plug no. 3	P@50 Bar: $20.1*10^{-6}$ sec.	S1@50 Bar: $35.6*10^{-6}$ sec.	S2@50 Bar: $35.8*10^{-6}$ sec.
Dry	P@75 Bar: $20.0*10^{-6}$ sec.	S1@75 Bar: $35.6*10^{-6}$ sec.	S2@75 Bar: $35.7*10^{-6}$ sec.

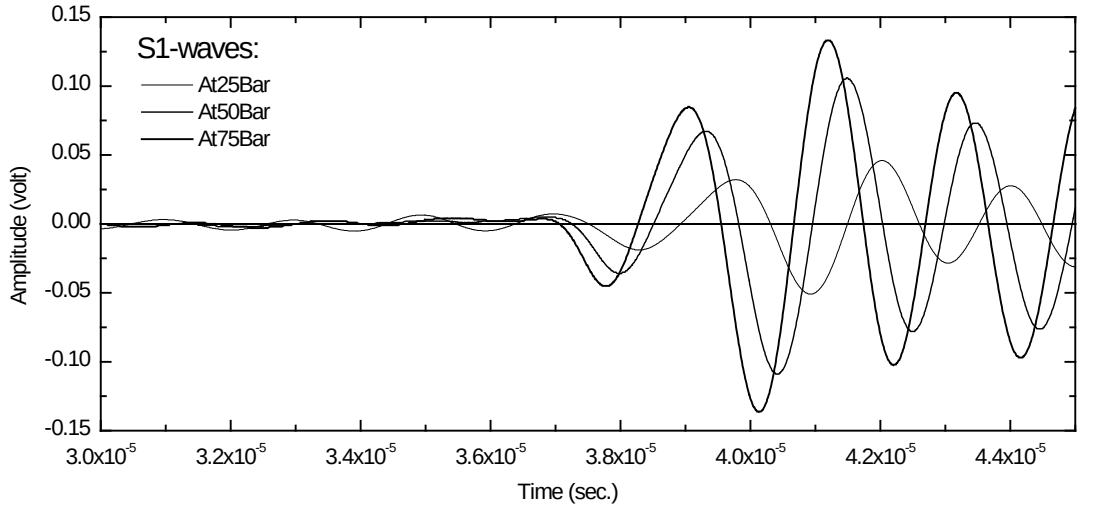


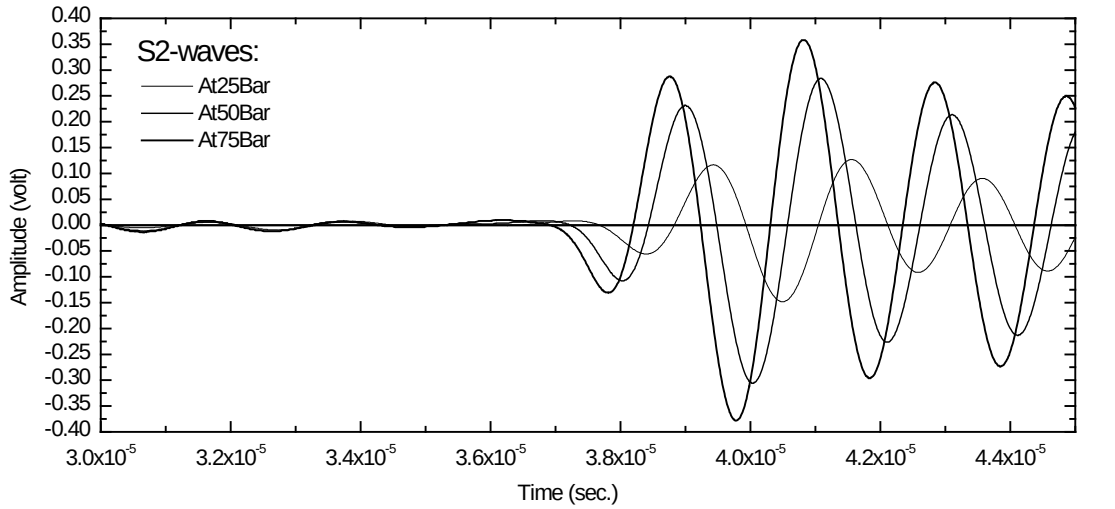




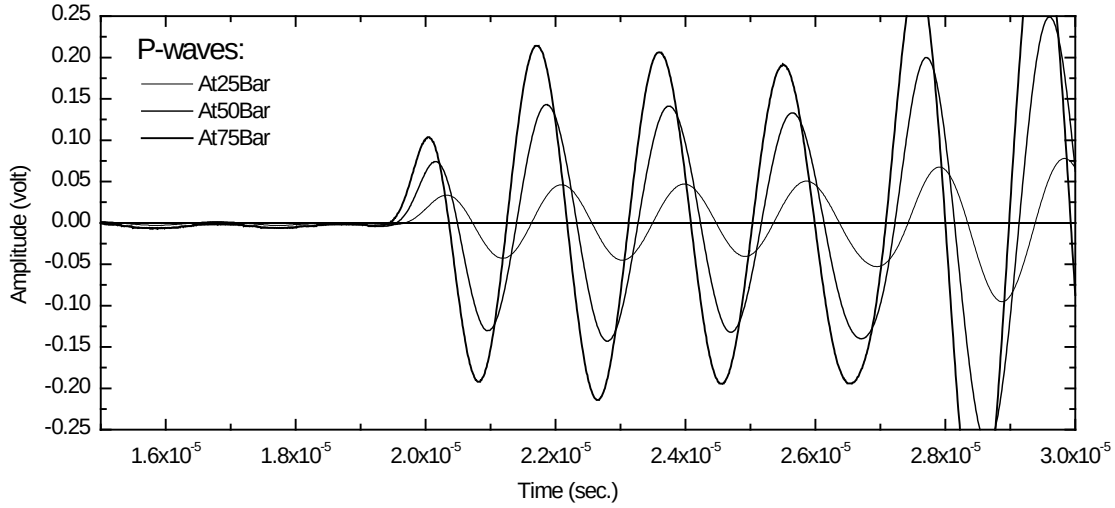
MFF-19P	P@25 Bar: $20.0*10^{-6}$ sec.	S1@25 Bar: $37.5*10^{-6}$ sec.	S2@25 Bar: $37.7*10^{-6}$ sec.
Plug no. 3	P@50 Bar: $19.8*10^{-6}$ sec.	S1@50 Bar: $37.2*10^{-6}$ sec.	S2@50 Bar: $37.2*10^{-6}$ sec.
Sat.	P@75 Bar: $19.7*10^{-6}$ sec.	S1@75 Bar: $37.0*10^{-6}$ sec.	S2@75 Bar: $36.9*10^{-6}$ sec.

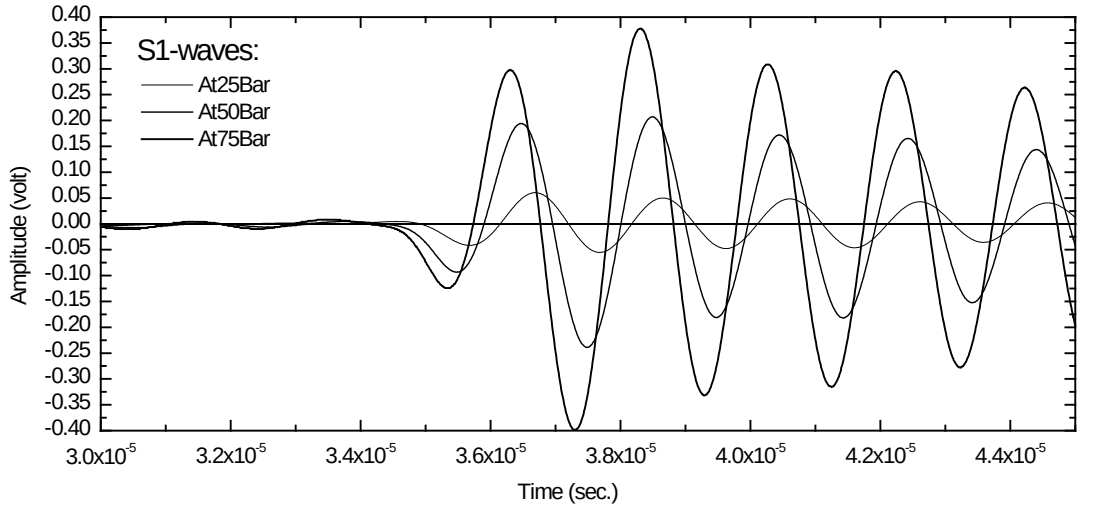


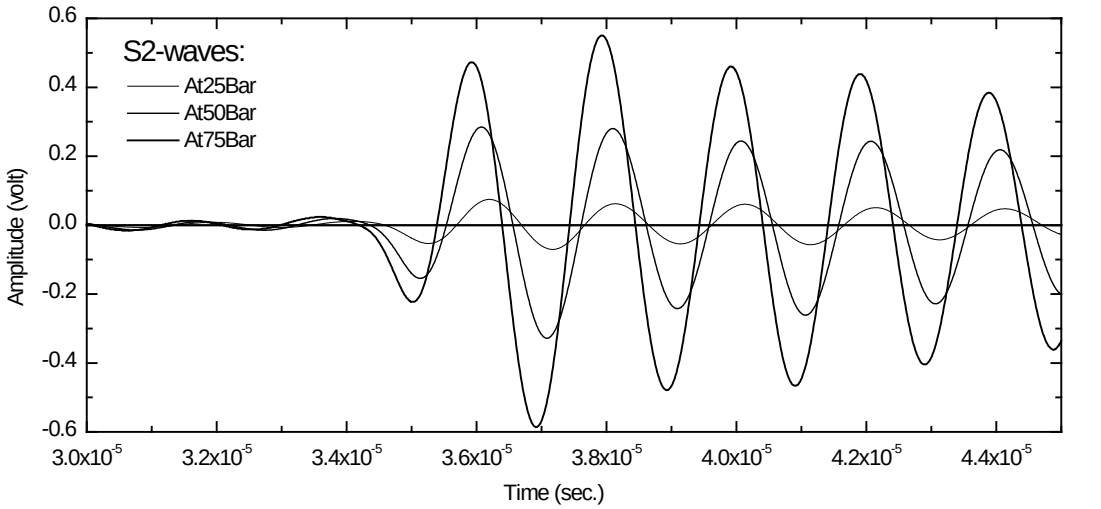




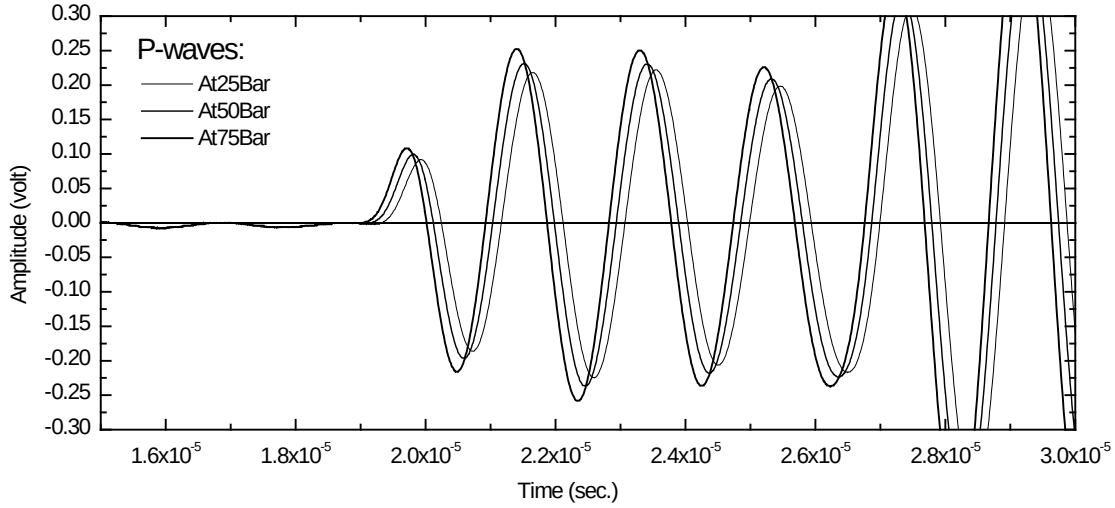
MFF-19P	P@25 Bar: $19.7*10^{-6}$ sec.	S1@25 Bar: $34.7*10^{-6}$ sec.	S2@25 Bar: $34.6*10^{-6}$ sec.
Plug no. 4	P@50 Bar: $19.6*10^{-6}$ sec.	S1@50 Bar: $34.4*10^{-6}$ sec.	S2@50 Bar: $34.4*10^{-6}$ sec.
Dry	P@75 Bar: $19.4*10^{-6}$ sec.	S1@75 Bar: $34.2*10^{-6}$ sec.	S2@75 Bar: $34.2*10^{-6}$ sec.

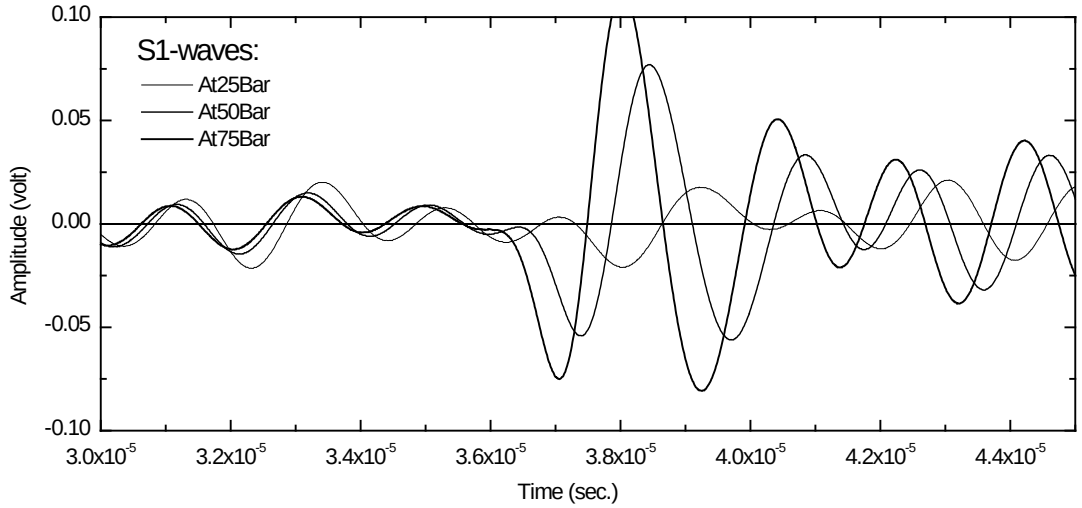


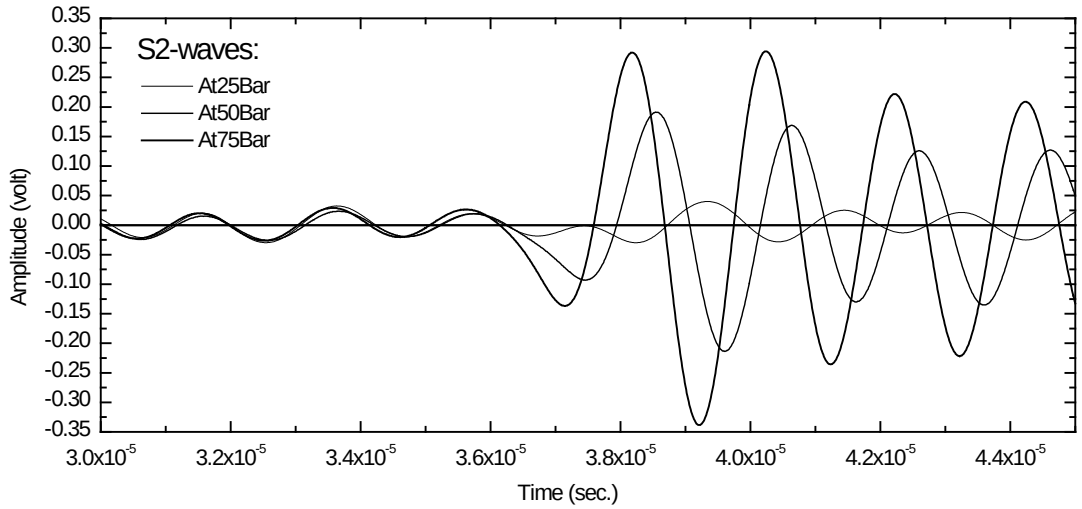




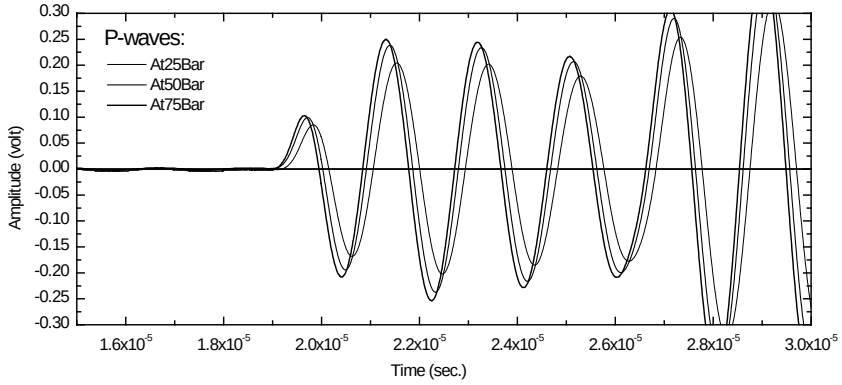
MFF-19P	P@25 Bar: 19.3*10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: ? *10^{-6} sec.
Plug no. 4	P@50 Bar: 19.1*10^{-6} sec.	S1@50 Bar: 36.5*10^{-6} sec.	S2@50 Bar: 36.2*10^{-6} sec.
Sat.	P@75 Bar: 19.0*10^{-6} sec.	S1@75 Bar: 36.2*10^{-6} sec.	S2@75 Bar: 36.1*10^{-6} sec.

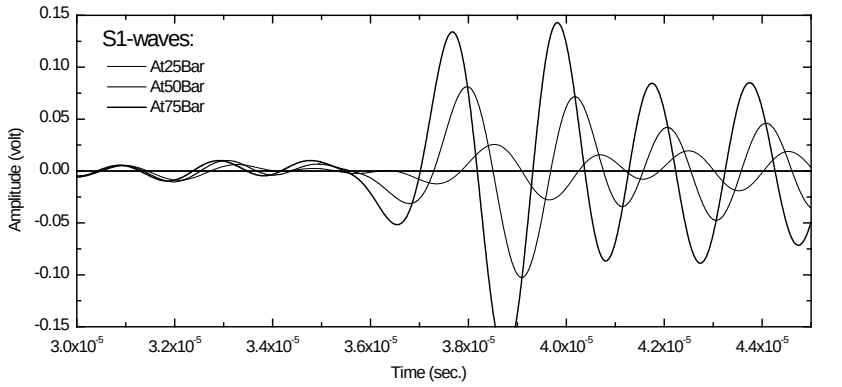


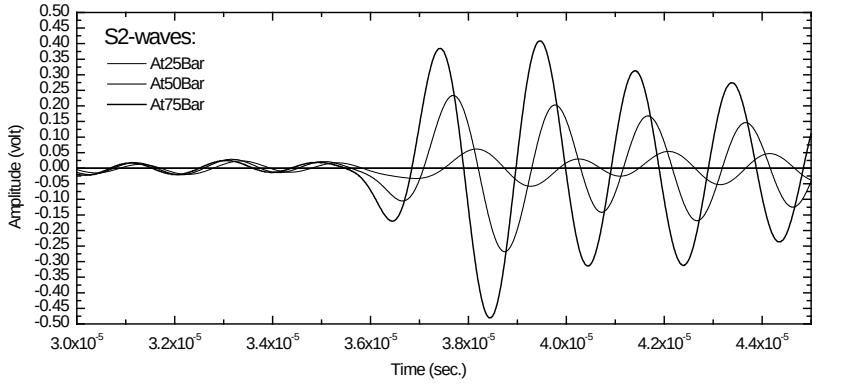




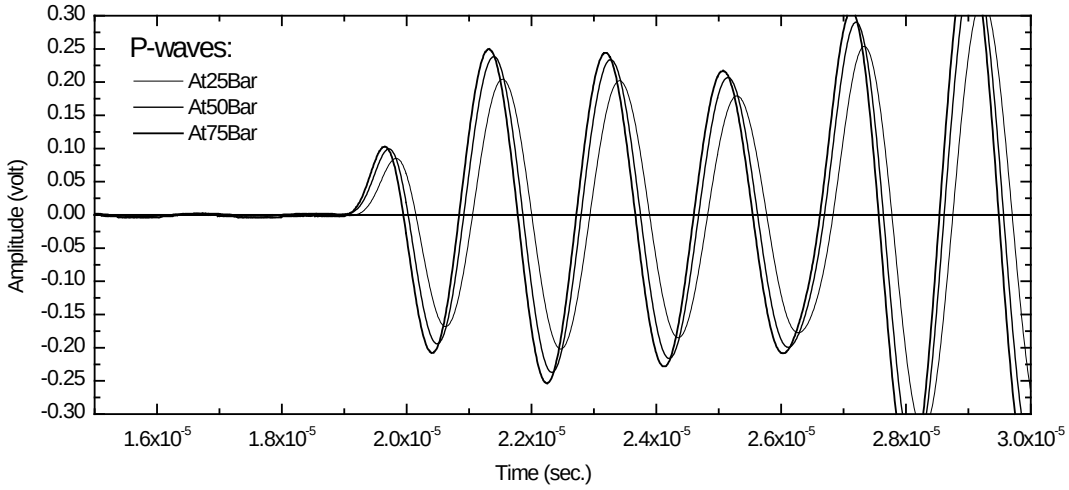
MFF-19P	P@25 Bar: $19.5*10^{-6}$ sec.	S1@25 Bar: $34.5*10^{-6}$ sec.	S2@25 Bar: $34.5*10^{-6}$ sec.
Plug no. 5	P@50 Bar: $19.3*10^{-6}$ sec.	S1@50 Bar: $34.2*10^{-6}$ sec.	S2@50 Bar: $34.2*10^{-6}$ sec.
Dry	P@75 Bar: $19.1*10^{-6}$ sec.	S1@75 Bar: $34.0*10^{-6}$ sec.	S2@75 Bar: $34.1*10^{-6}$ sec.

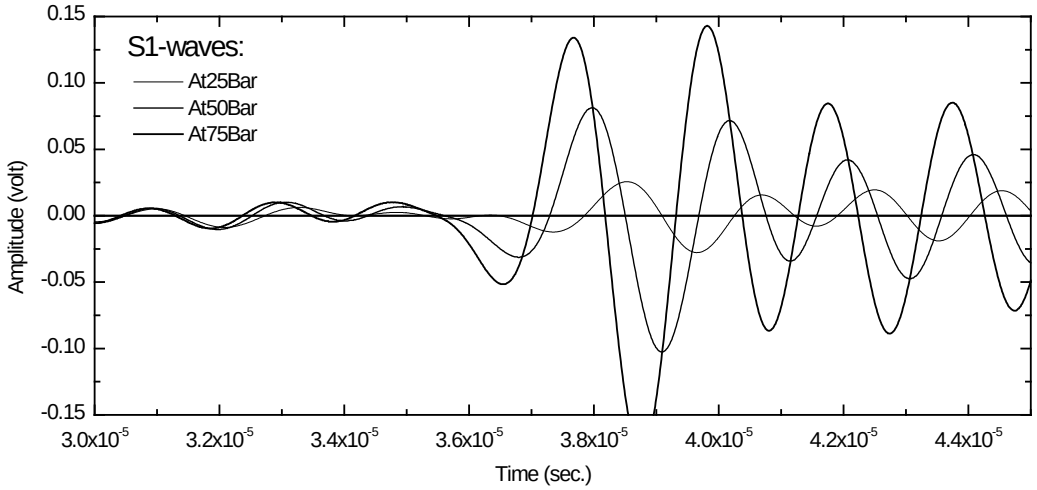


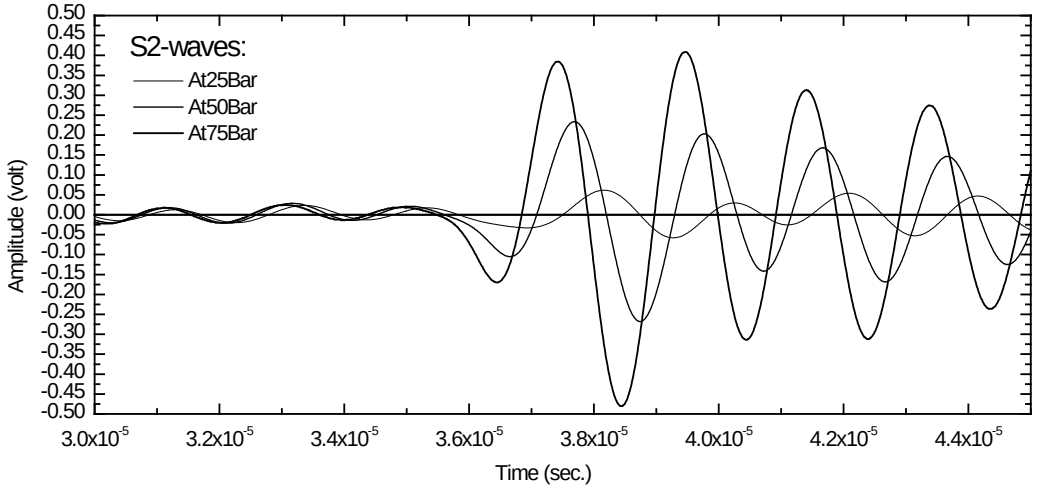




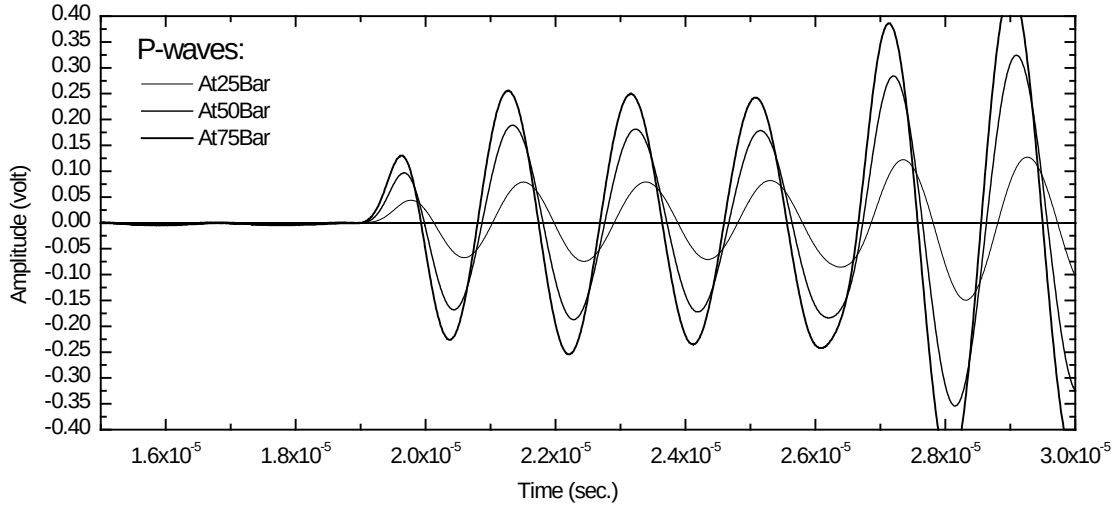
MFF-19P	P@25 Bar: 19.2*10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: 35.8*10^{-6} sec.
Plug no. 5	P@50 Bar: 19.1*10^{-6} sec.	S1@50 Bar: 35.6*10^{-6} sec.	S2@50 Bar: 35.6*10^{-6} sec.
Sat.	P@75 Bar: 19.0*10^{-6} sec.	S1@75 Bar: 35.5*10^{-6} sec.	S2@75 Bar: 35.5*10^{-6} sec.

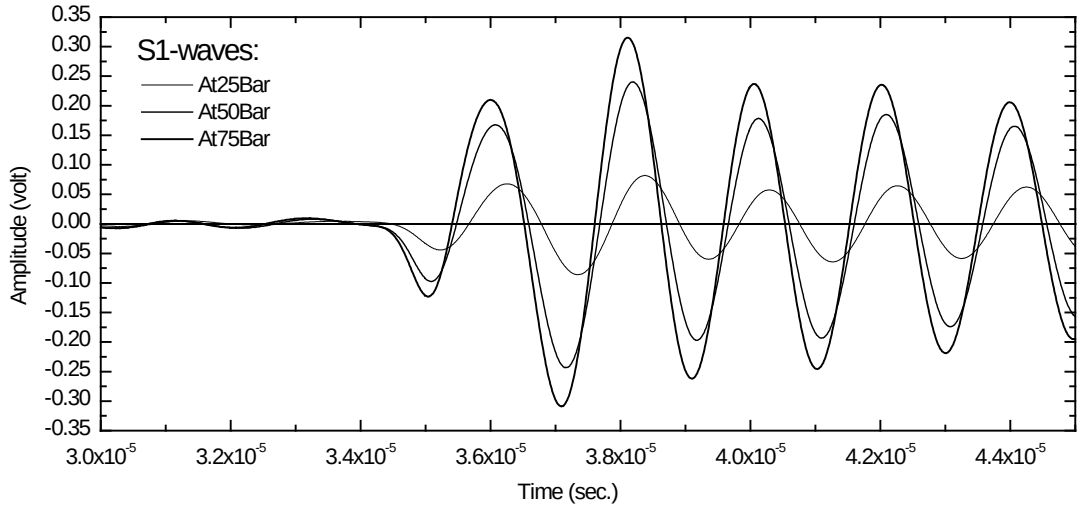


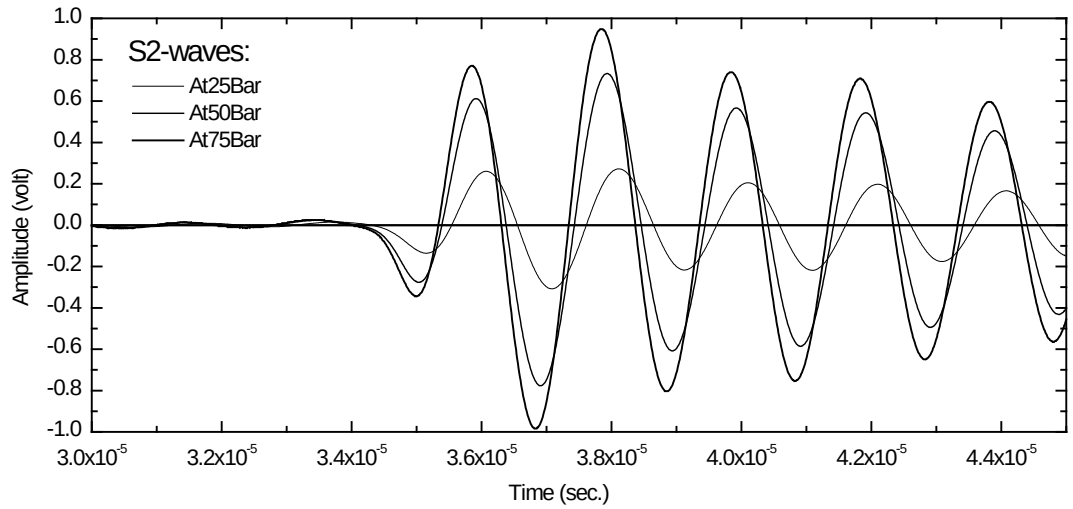




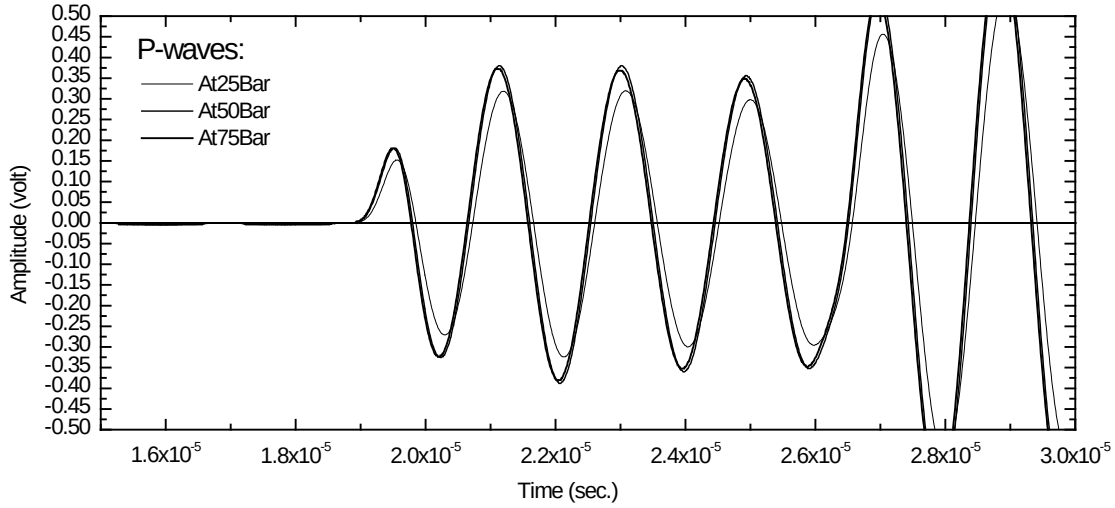
MFF-19P	P@25 Bar: $19.1*10^{-6}$ sec.	S1@25 Bar: $34.3*10^{-6}$ sec.	S2@25 Bar: $34.3*10^{-6}$ sec.
Plug no. 6	P@50 Bar: $19.0*10^{-6}$ sec.	S1@50 Bar: $33.9*10^{-6}$ sec.	S2@50 Bar: $34.1*10^{-6}$ sec.
Dry	P@75 Bar: $19.0*10^{-6}$ sec.	S1@75 Bar: $33.9*10^{-6}$ sec.	S2@75 Bar: $34.0*10^{-6}$ sec.

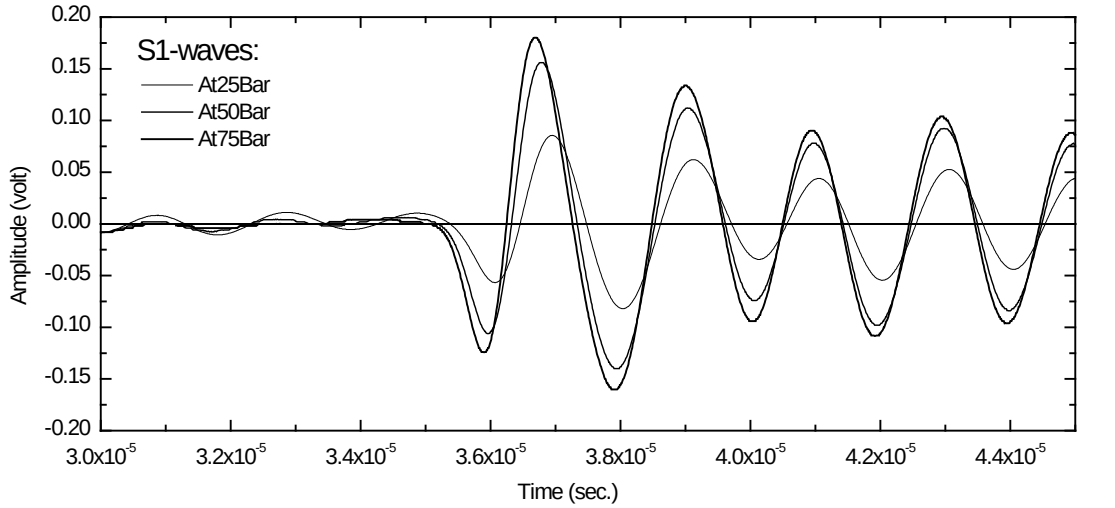


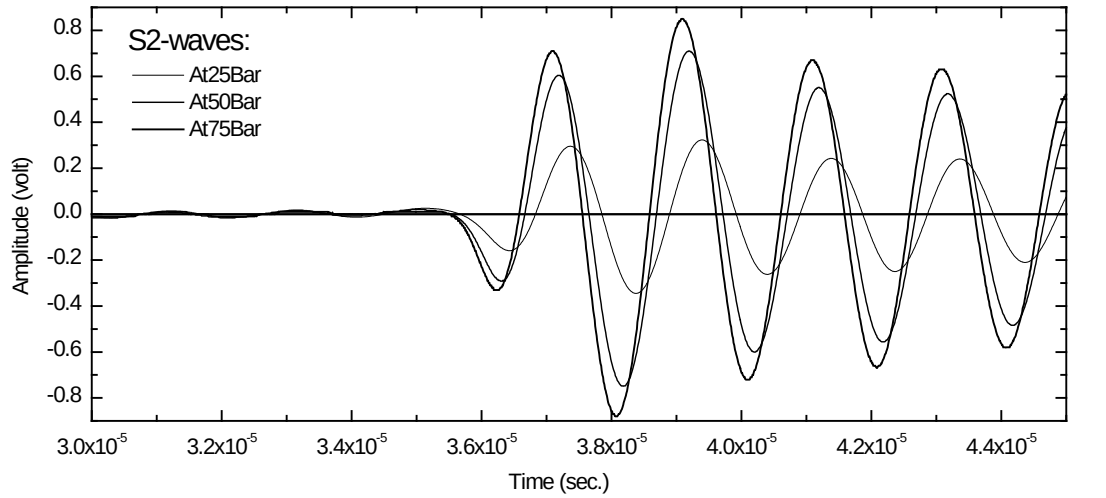




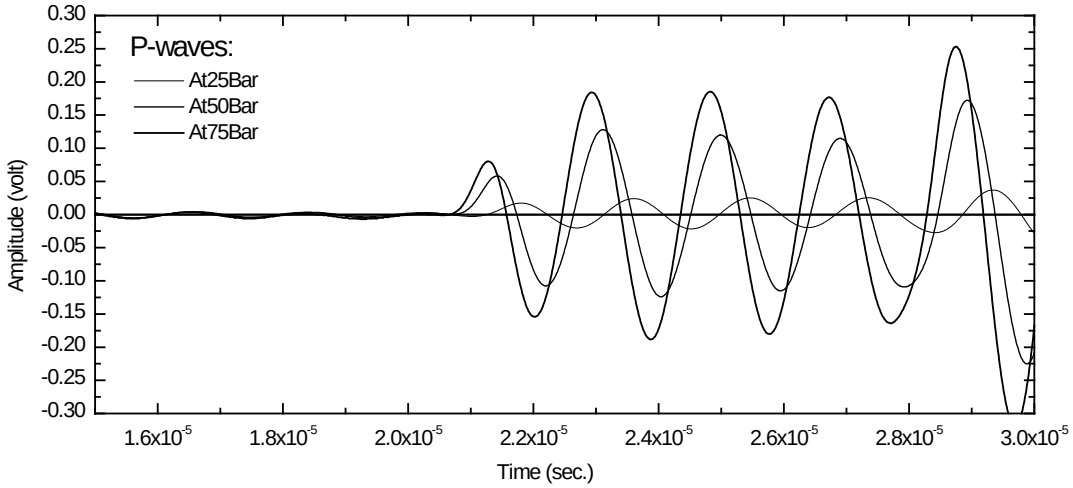
MFF-19P	P@25 Bar: $18.9*10^{-6}$ sec.	S1@25 Bar: $35.4*10^{-6}$ sec.	S2@25 Bar: $35.7*10^{-6}$ sec.
Plug no. 6	P@50 Bar: $18.9*10^{-6}$ sec.	S1@50 Bar: $35.2*10^{-6}$ sec.	S2@50 Bar: $35.6*10^{-6}$ sec.
Sat.	P@75 Bar: $18.9*10^{-6}$ sec.	S1@75 Bar: $35.1*10^{-6}$ sec.	S2@75 Bar: $35.5*10^{-6}$ sec.

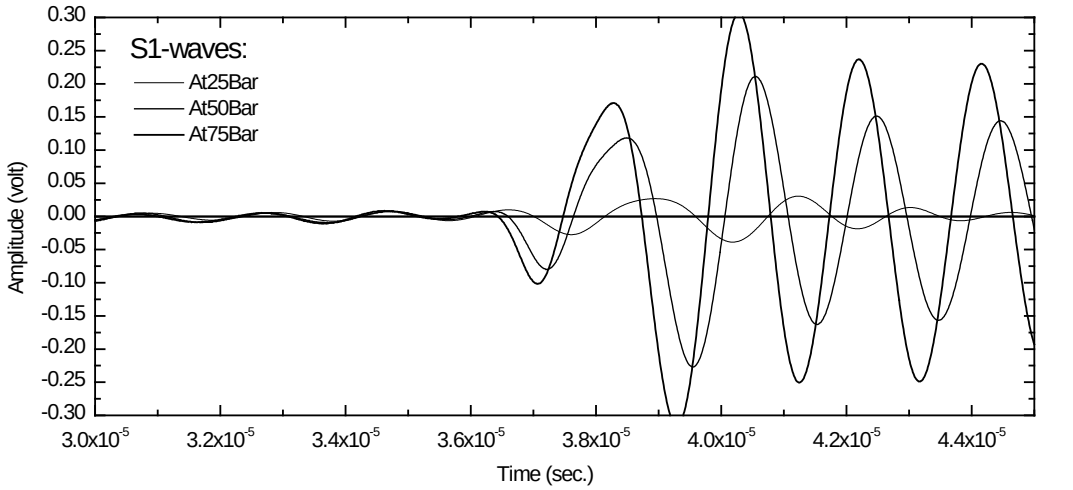


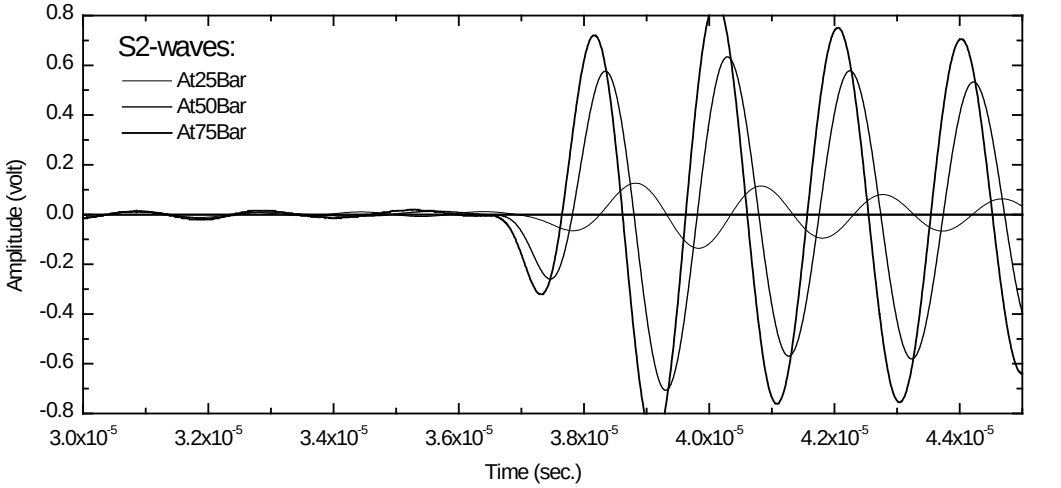




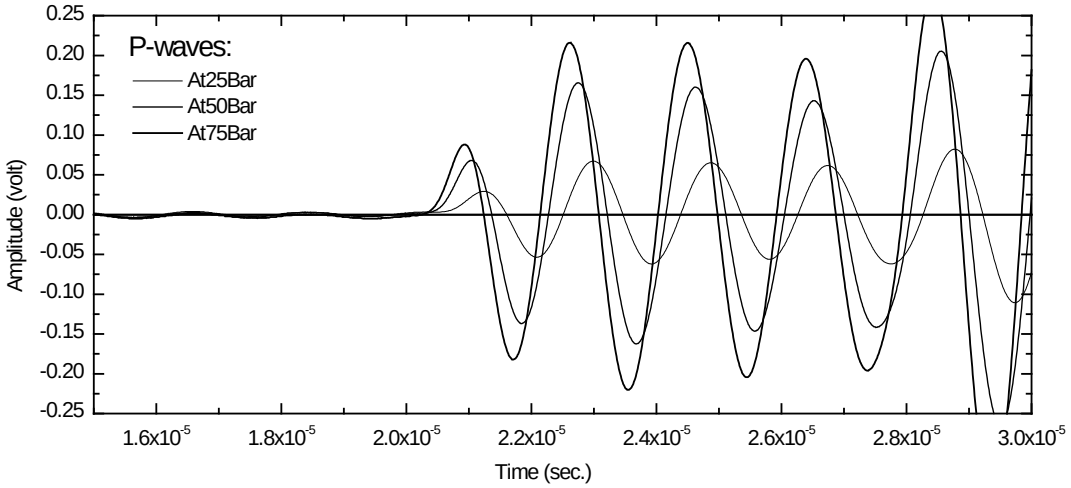
MFF-19P	P@25 Bar: ? $*10^{-6}$ sec.	S1@25 Bar: 37.0$*10^{-6}$ sec.	S2@25 Bar: 36.9$*10^{-6}$ sec.
Plug no. 8	P@50 Bar: 20.8$*10^{-6}$ sec.	S1@50 Bar: 36.6$*10^{-6}$ sec.	S2@50 Bar: 36.7$*10^{-6}$ sec.
Dry.	P@75 Bar: 20.7$*10^{-6}$ sec.	S1@75 Bar: 36.4$*10^{-6}$ sec.	S2@75 Bar: 36.6$*10^{-6}$ sec.

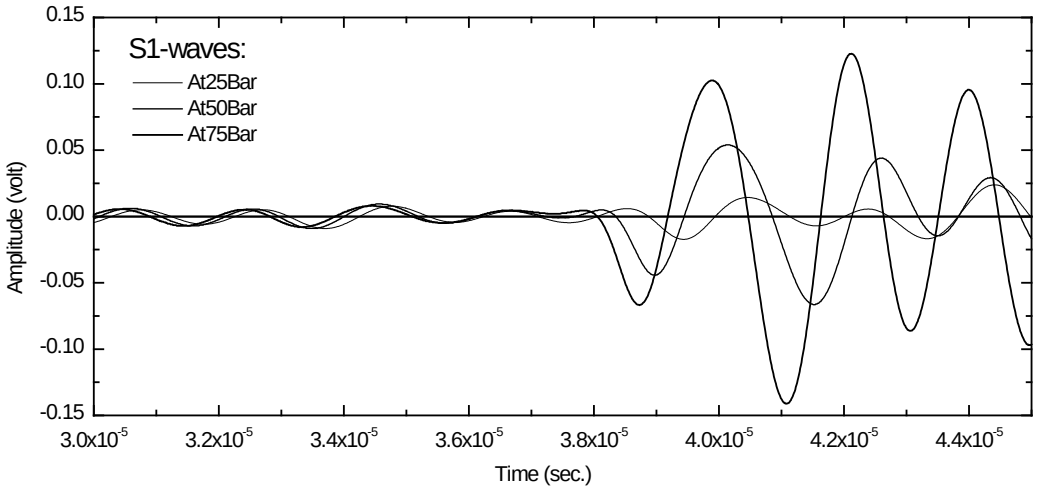


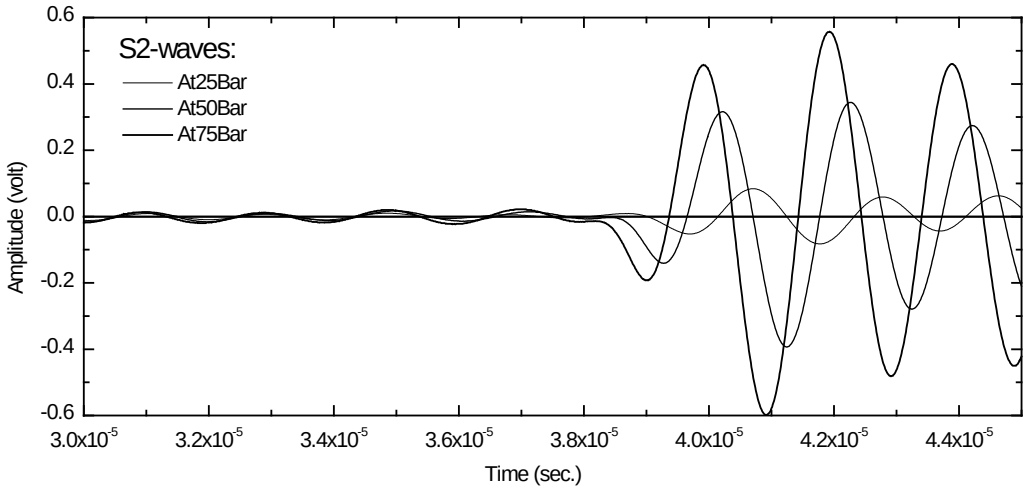




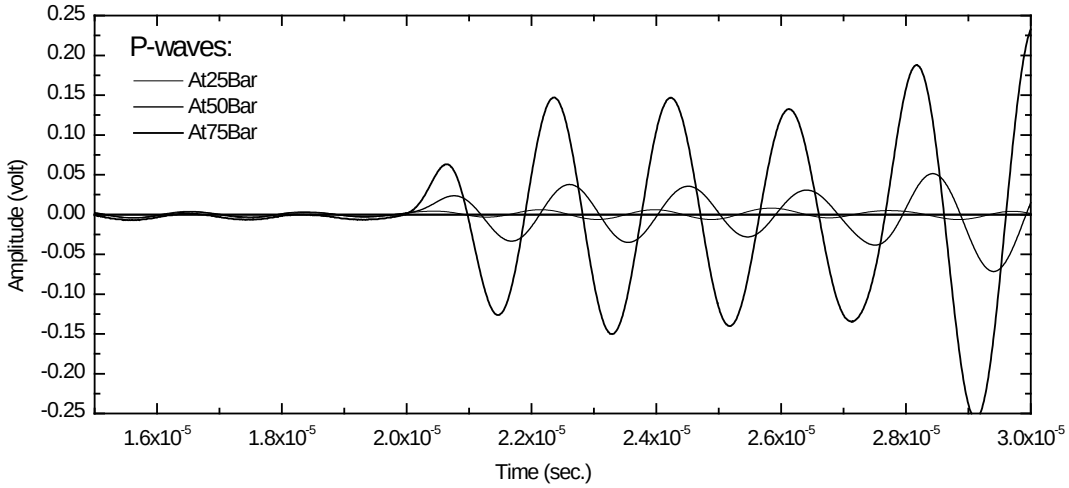
MFF-19P	P@25 Bar: $20.6*10^{-6}$ sec.	S1@25 Bar: $38.7*10^{-6}$ sec.	S2@25 Bar: $38.8*10^{-6}$ sec.
Plug no. 8	P@50 Bar: $20.3*10^{-6}$ sec.	S1@50 Bar: $38.2*10^{-6}$ sec.	S2@50 Bar: $38.3*10^{-6}$ sec.
Sat.	P@75 Bar: $20.2*10^{-6}$ sec.	S1@75 Bar: $37.9*10^{-6}$ sec.	S2@75 Bar: $38.0*10^{-6}$ sec.

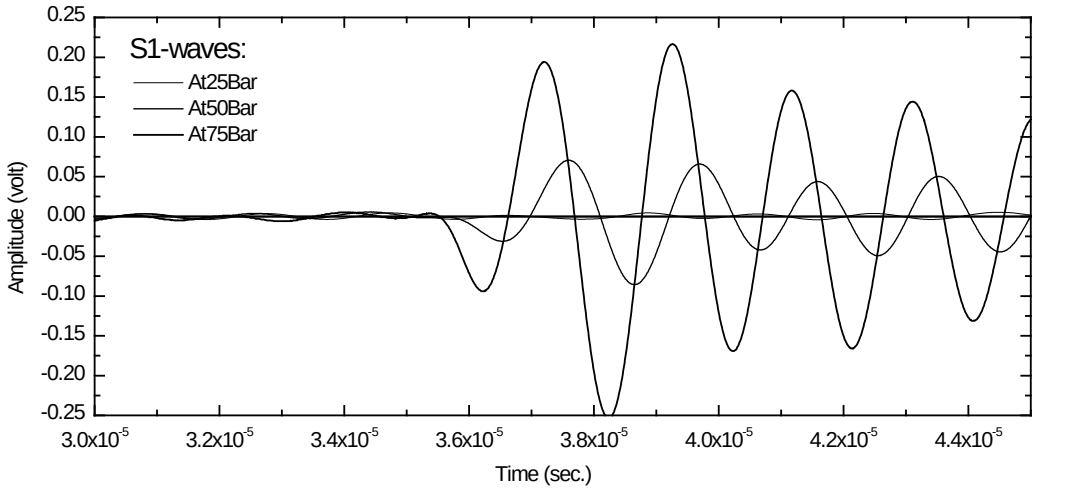


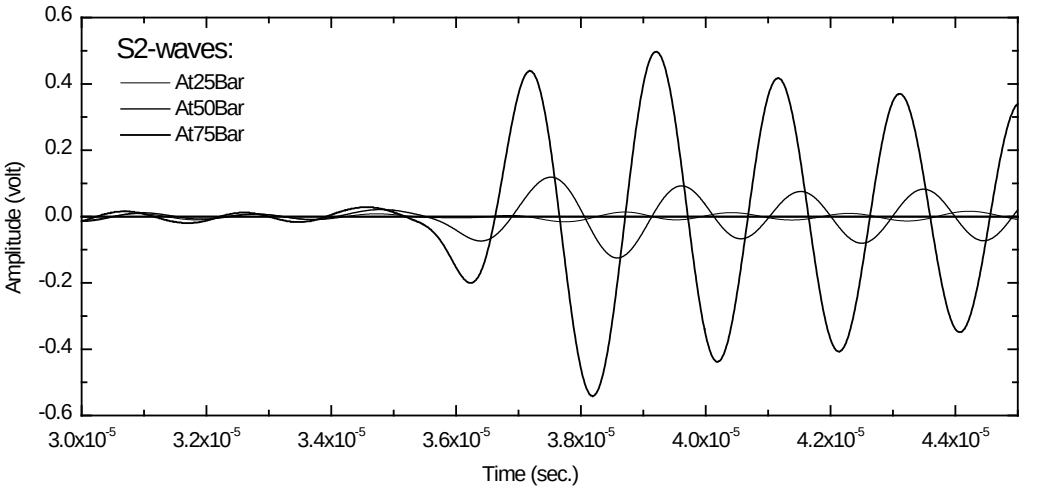




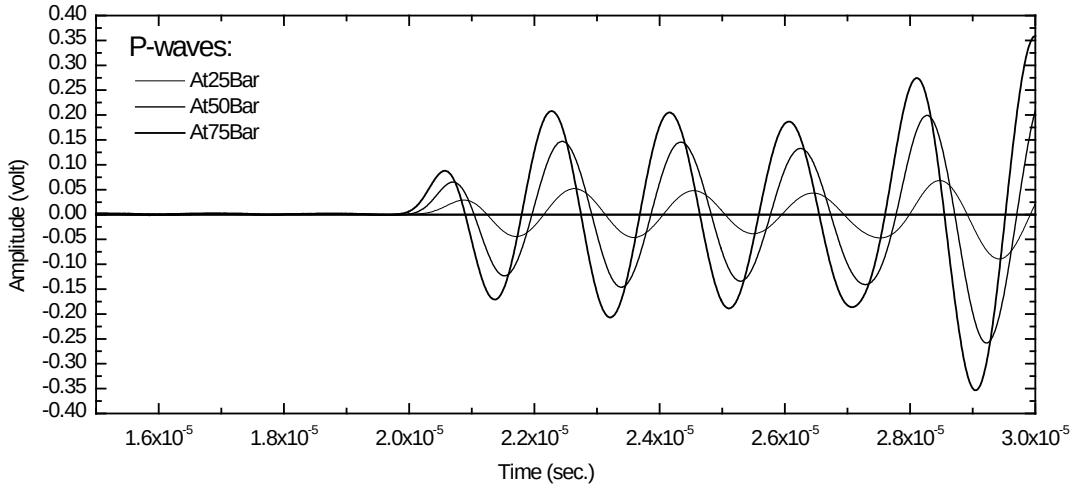
MFF-19P	P@25 Bar: ? *10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: ? *10^{-6} sec.
Plug no. 14	P@50 Bar: 19.8*10^{-6} sec.	S1@50 Bar: 35.5*10^{-6} sec.	S2@50 Bar: 35.5*10^{-6} sec.
Dry	P@75 Bar: 19.7*10^{-6} sec.	S1@75 Bar: 35.3*10^{-6} sec.	S2@75 Bar: 35.2*10^{-6} sec.

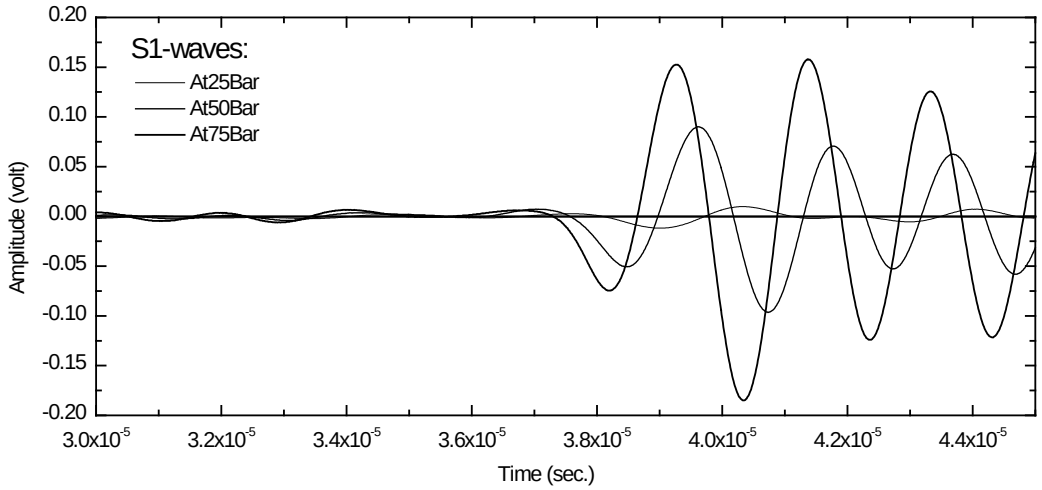


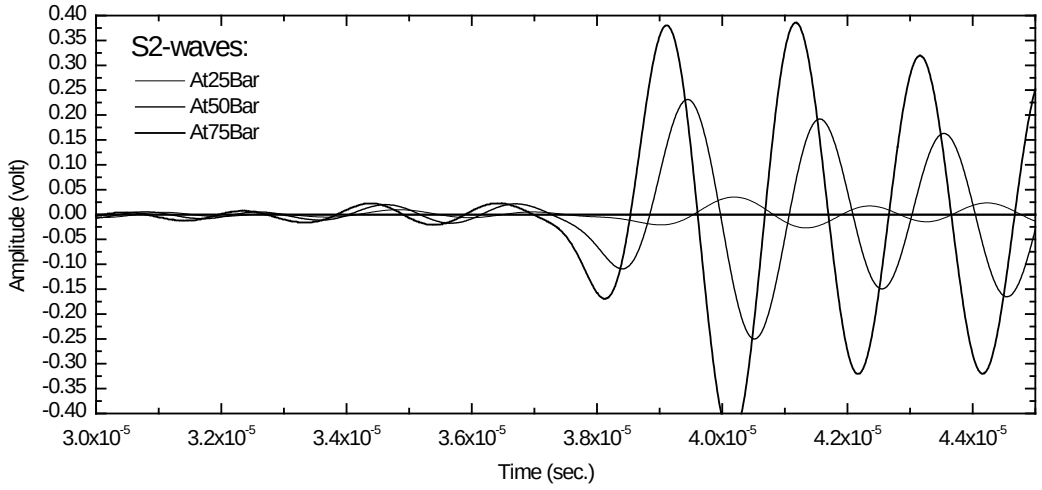




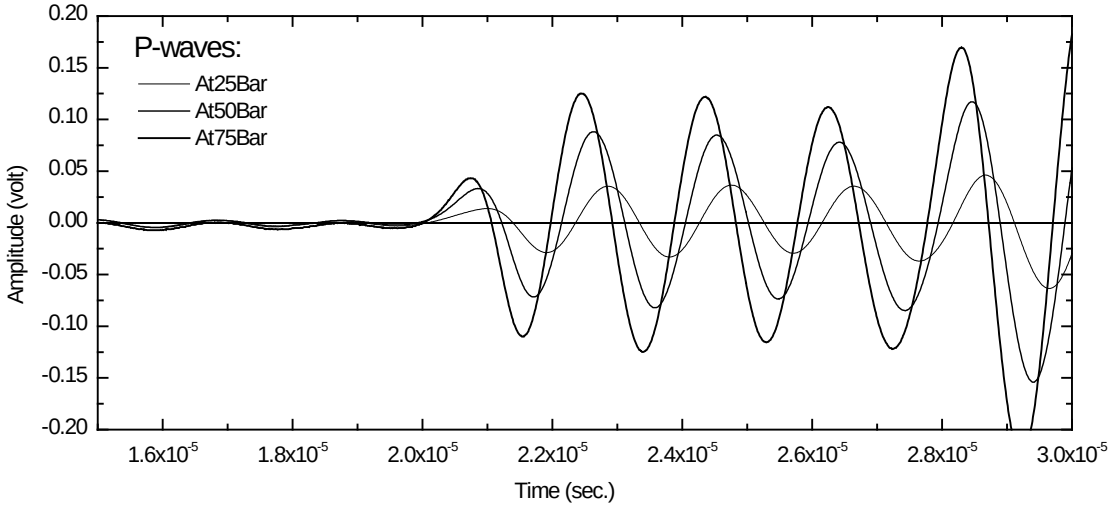
MFF-19P	P@25 Bar: 20.1*10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: ? *10^{-6} sec.
Plug no. 14	P@50 Bar: 19.9*10^{-6} sec.	S1@50 Bar: 37.4*10^{-6} sec.	S2@50 Bar: 37.5*10^{-6} sec.
Sat.	P@75 Bar: 19.7*10^{-6} sec.	S1@75 Bar: 37.1*10^{-6} sec.	S2@75 Bar: 37.2*10^{-6} sec.

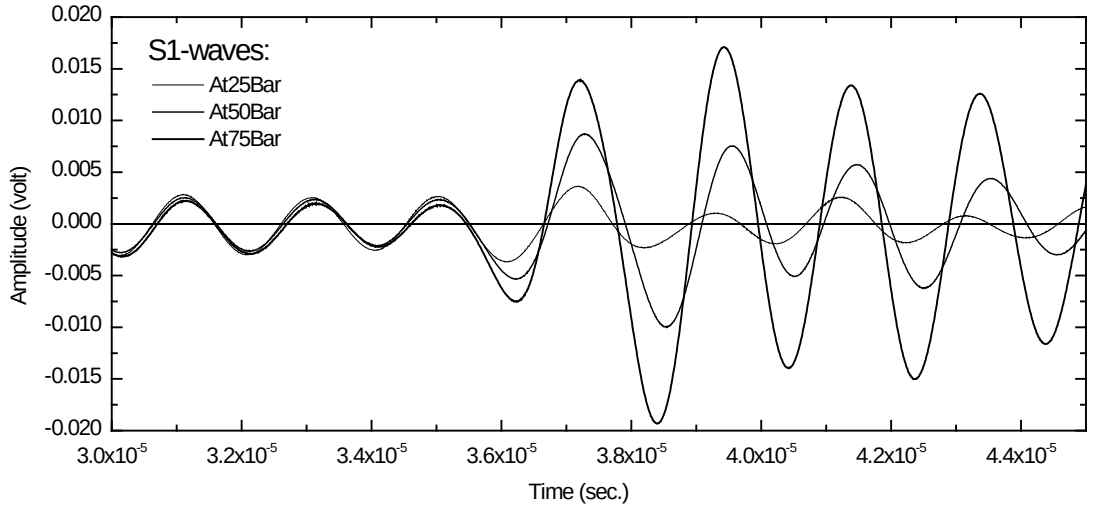


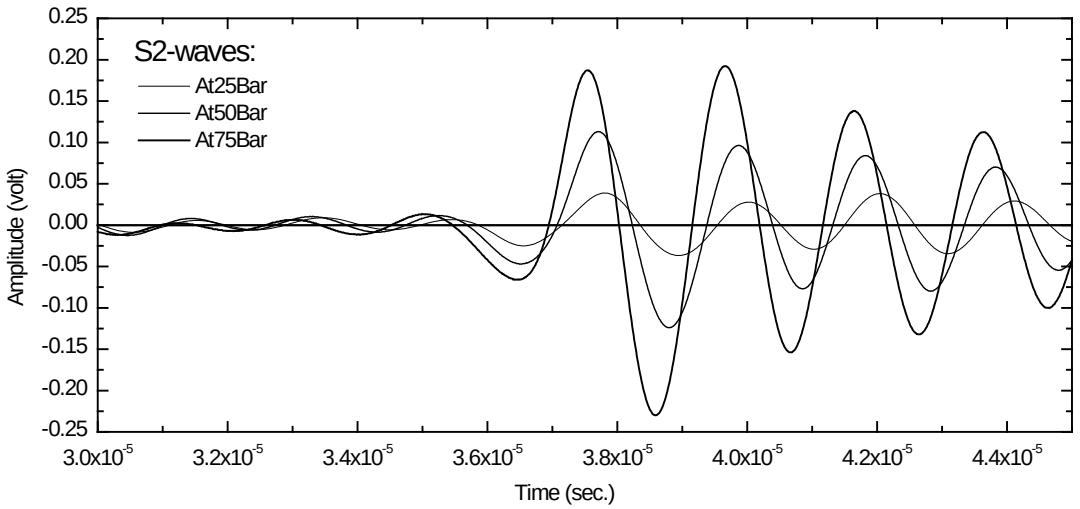




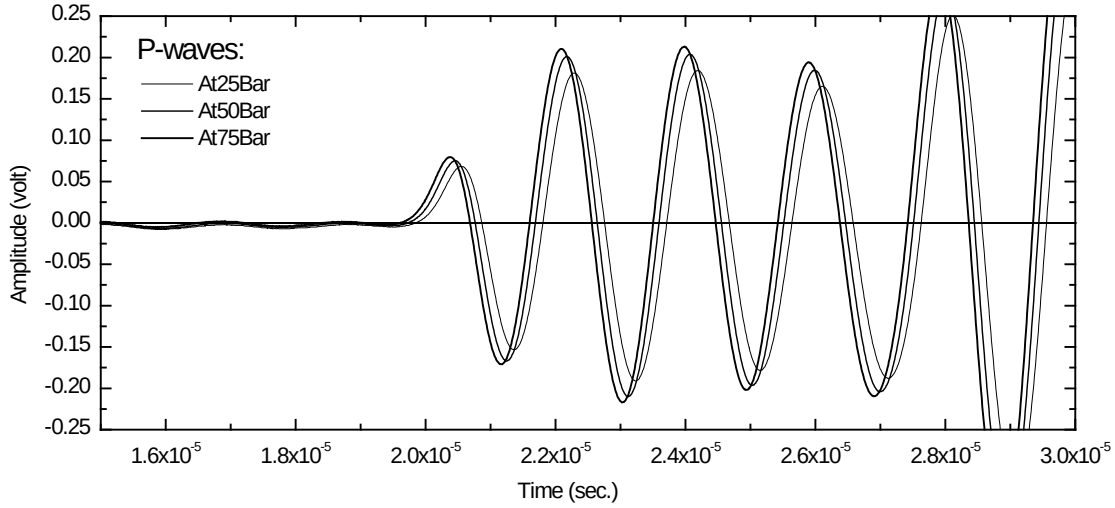
MFF-19P	P@25 Bar: 20.1*10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: 35.9*10^{-6} sec.
Plug no. 15	P@50 Bar: 20.0*10^{-6} sec.	S1@50 Bar: 35.5*10^{-6} sec.	S2@50 Bar: 35.7*10^{-6} sec.
Dry	P@75 Bar: 19.9*10^{-6} sec.	S1@75 Bar: 35.4*10^{-6} sec.	S2@75 Bar: 35.5*10^{-6} sec.

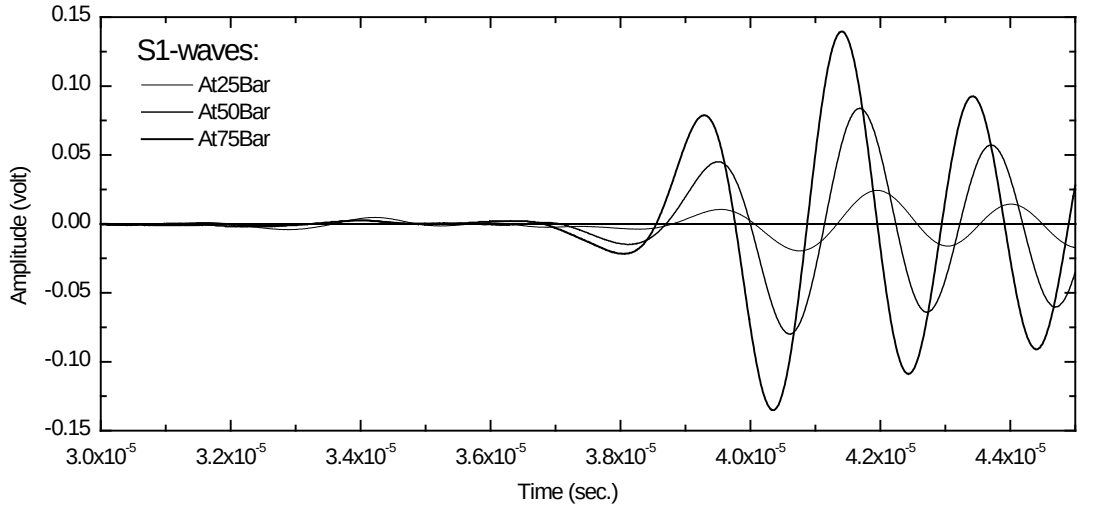


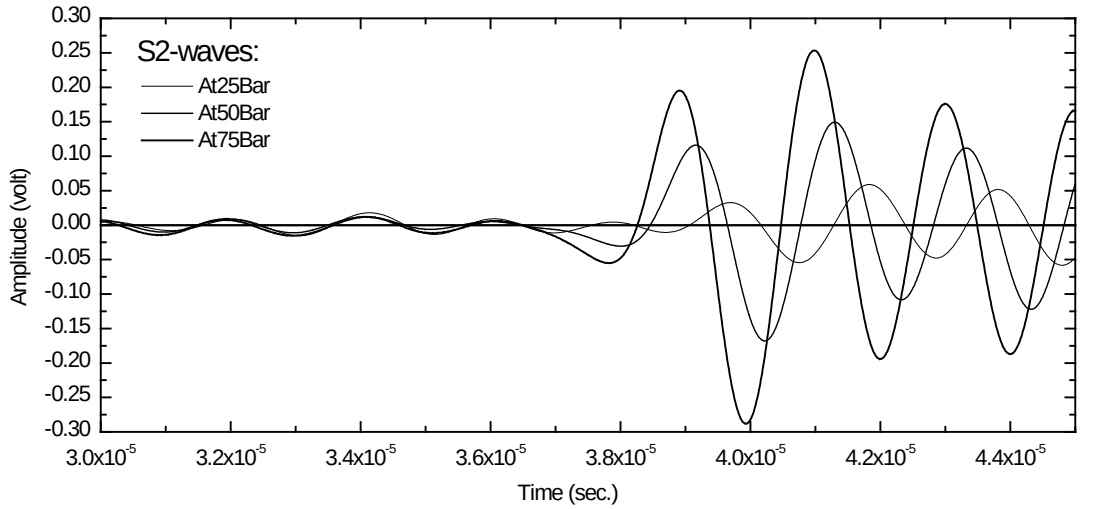




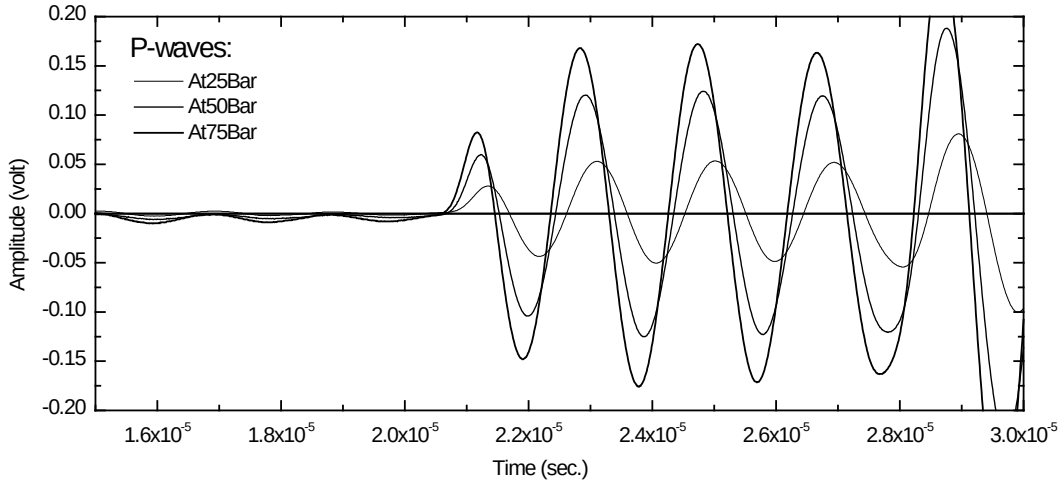
MFF-19P	P@25 Bar: 19.8*10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: ? *10^{-6} sec.
Plug no. 15	P@50 Bar: 19.7*10^{-6} sec.	S1@50 Bar: 37.0*10^{-6} sec.	S2@50 Bar: 36.6*10^{-6} sec.
Sat.	P@75 Bar: 19.6*10^{-6} sec.	S1@75 Bar: 36.8*10^{-6} sec.	S2@75 Bar: 36.6*10^{-6} sec.

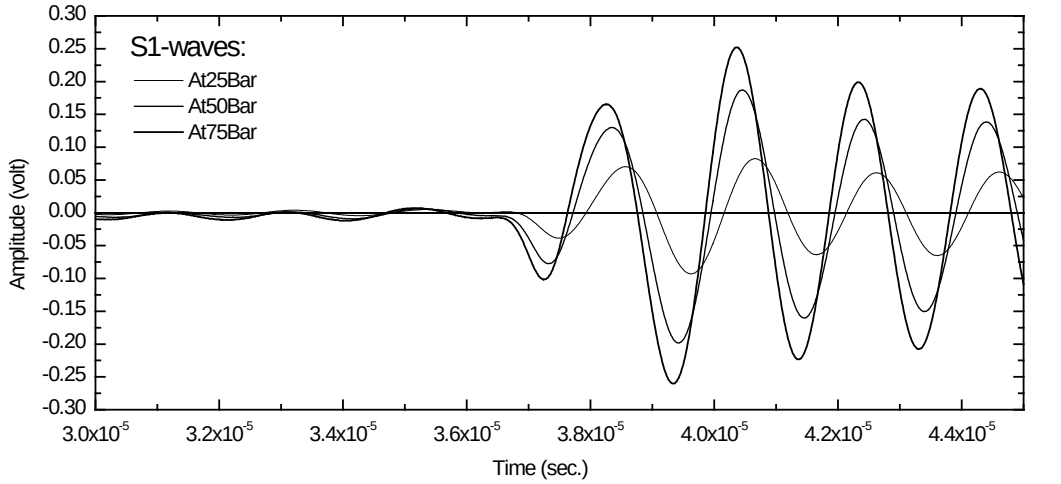


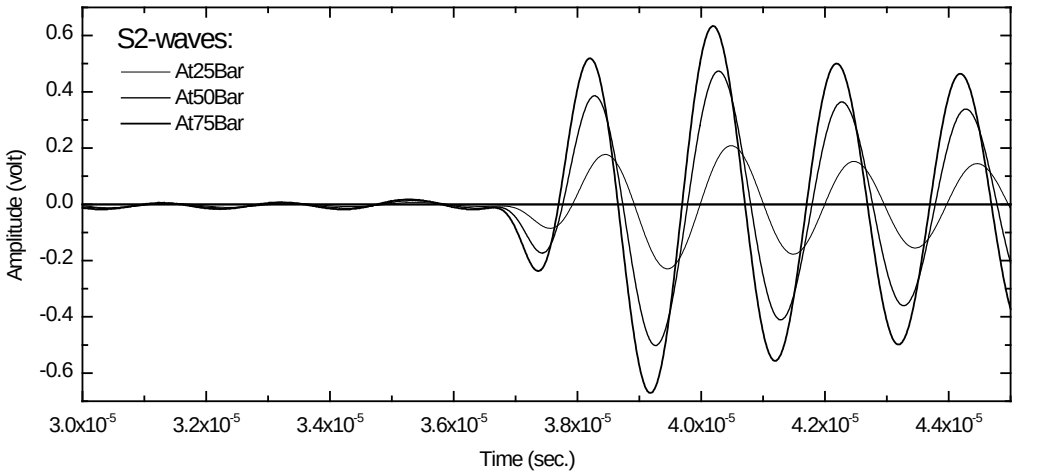




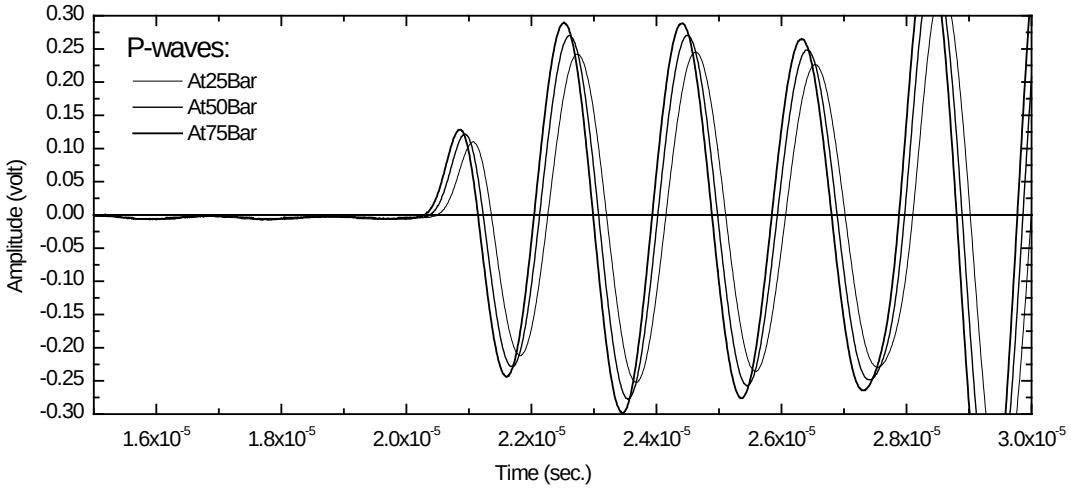
MFF-19P	P@25 Bar: $20.7*10^{-6}$ sec.	S1@25 Bar: $36.6*10^{-6}$ sec.	S2@25 Bar: $36.7*10^{-6}$ sec.
Plug no. 17	P@50 Bar: $20.5*10^{-6}$ sec.	S1@50 Bar: $36.5*10^{-6}$ sec.	S2@50 Bar: $36.6*10^{-6}$ sec.
dry.	P@75 Bar: $20.4*10^{-6}$ sec.	S1@75 Bar: $36.4*10^{-6}$ sec.	S2@75 Bar: $36.6*10^{-6}$ sec.

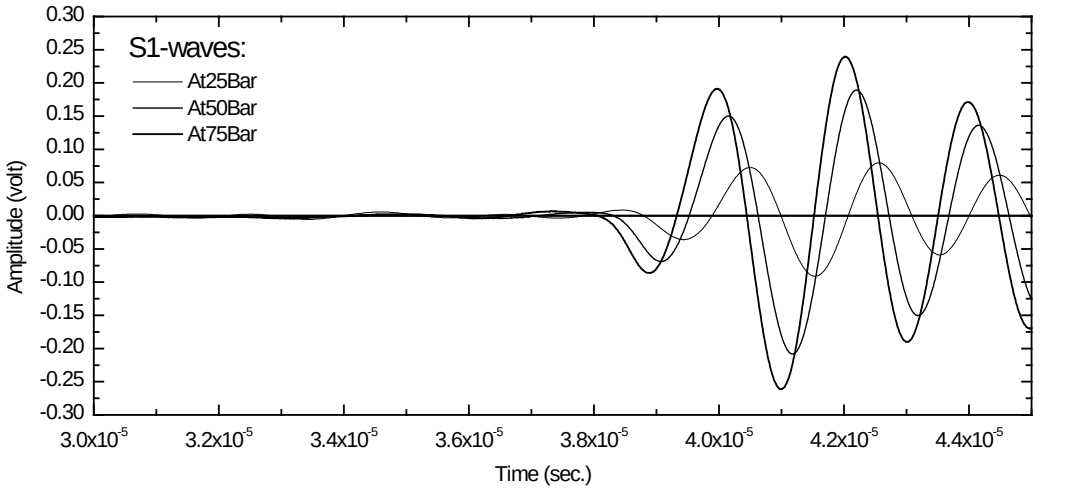


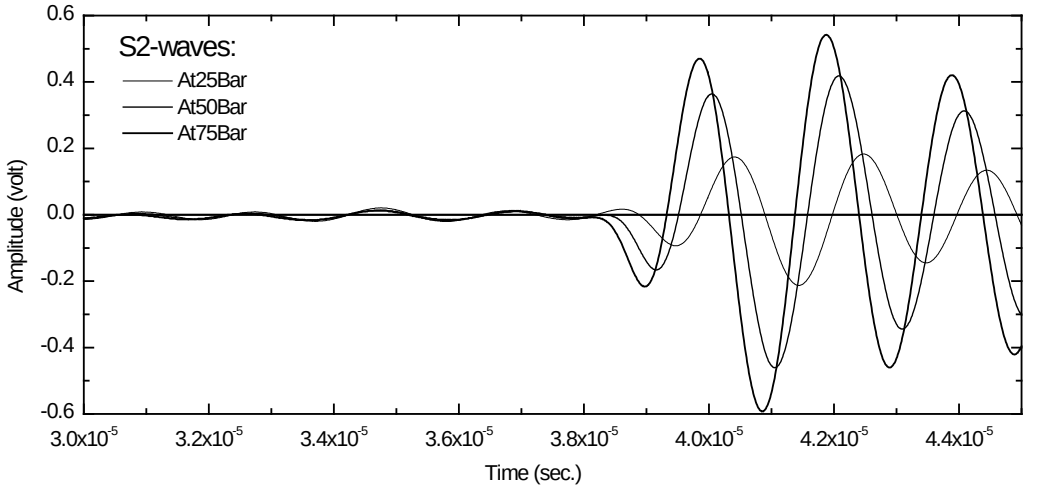




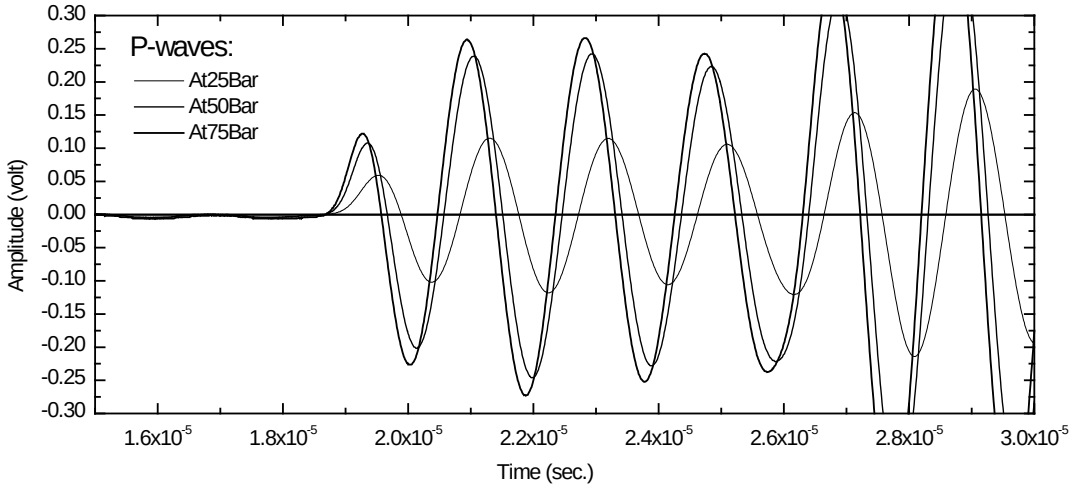
MFF-19P	P@25 Bar: $20.4*10^{-6}$ sec.	S1@25 Bar: $38.5*10^{-6}$ sec.	S2@25 Bar: $38.6*10^{-6}$ sec.
Plug no. 17	P@50 Bar: $20.3*10^{-6}$ sec.	S1@50 Bar: $38.0*10^{-6}$ sec.	S2@50 Bar: $38.3*10^{-6}$ sec.
Sat.	P@75 Bar: $20.2*10^{-6}$ sec.	S1@75 Bar: $37.8*10^{-6}$ sec.	S2@75 Bar: $38.1*10^{-6}$ sec.

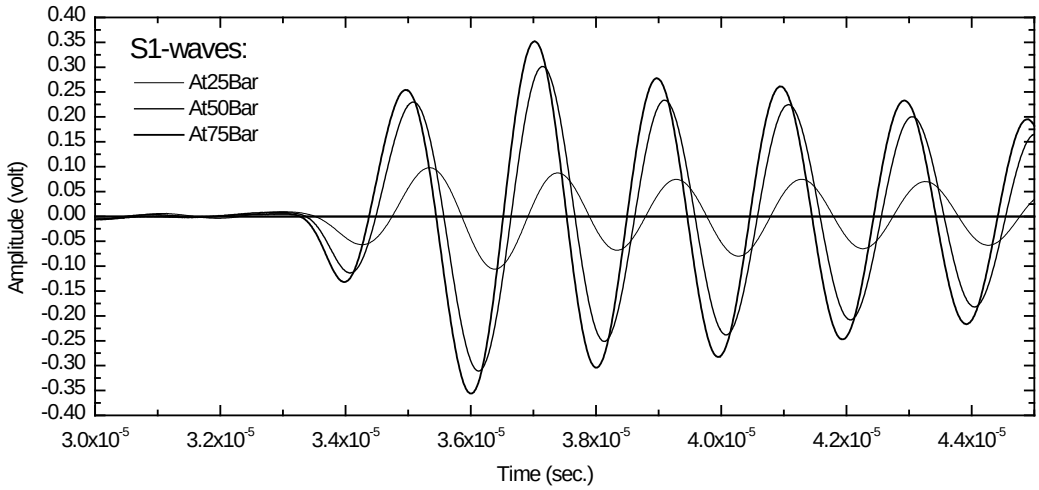


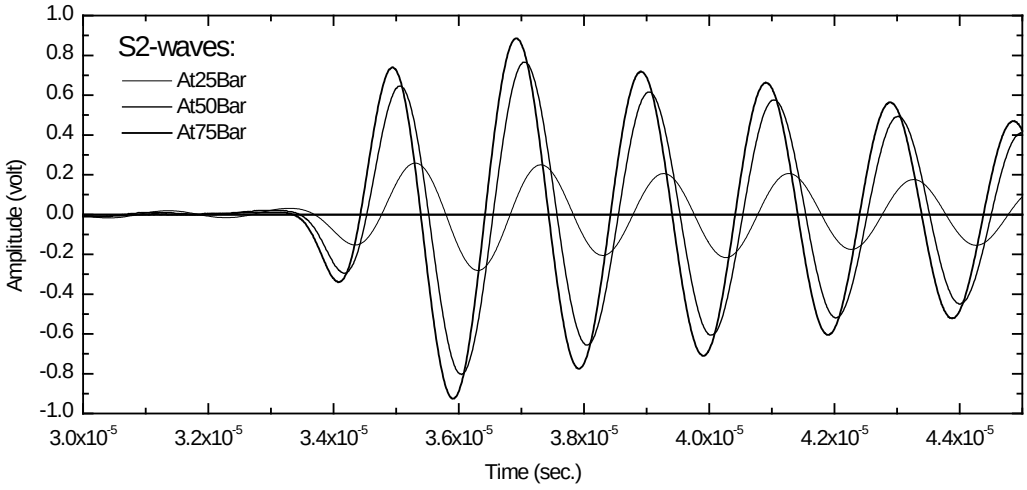




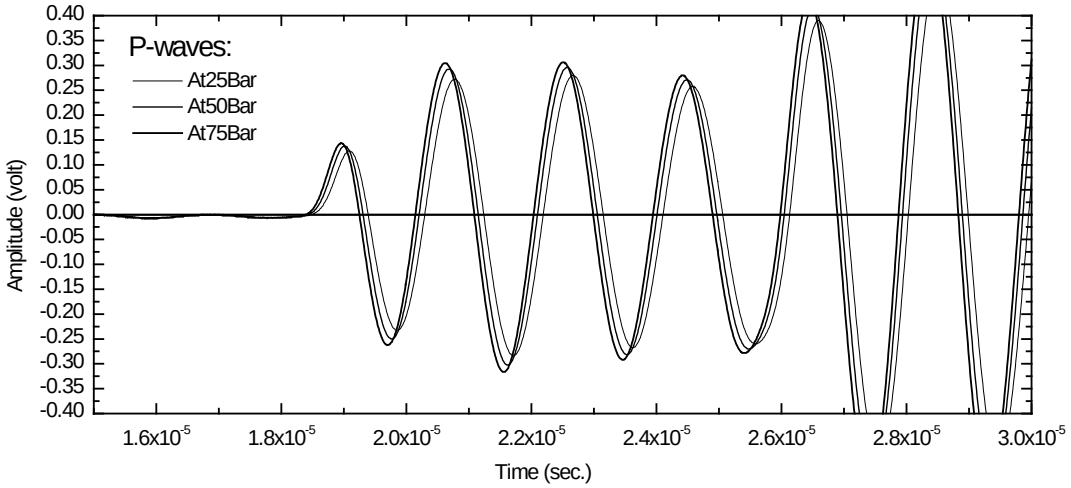
MFF-19P	P@25 Bar: $18.8*10^{-6}$ sec.	S1@25 Bar: $33.3*10^{-6}$ sec.	S2@25 Bar: $33.4*10^{-6}$ sec.
Plug no. 20	P@50 Bar: $18.7*10^{-6}$ sec.	S1@50 Bar: $33.2*10^{-6}$ sec.	S2@50 Bar: $33.2*10^{-6}$ sec.
Dry.	P@75 Bar: $18.6*10^{-6}$ sec.	S1@75 Bar: $33.1*10^{-6}$ sec.	S2@75 Bar: $33.2*10^{-6}$ sec.

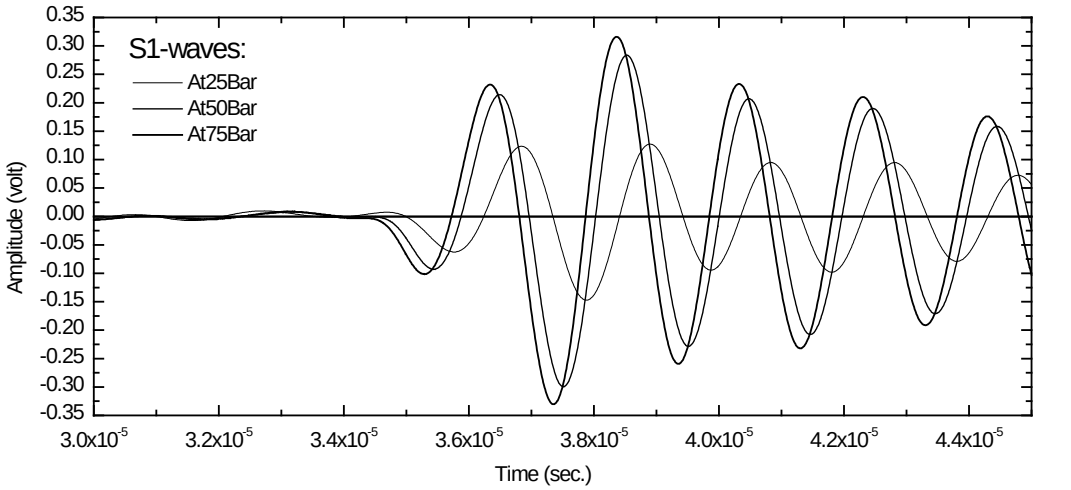


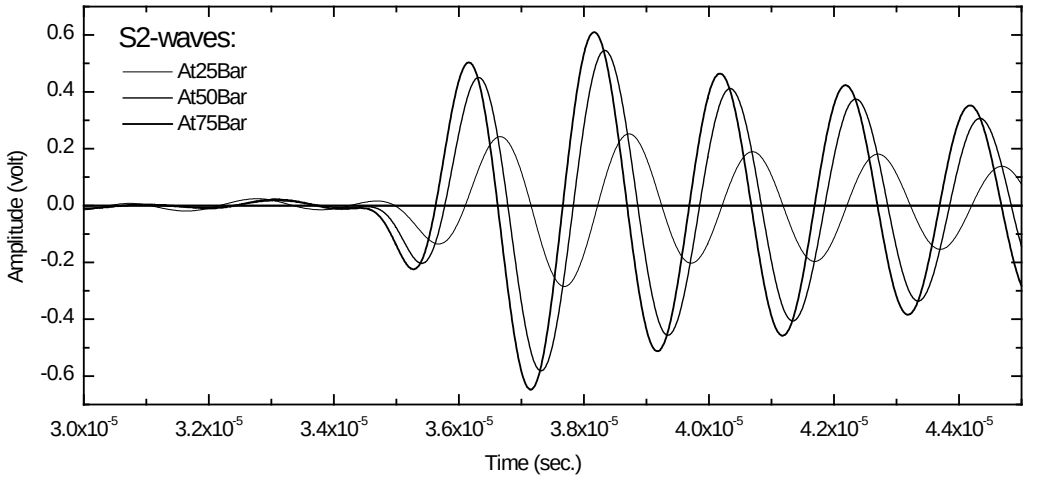




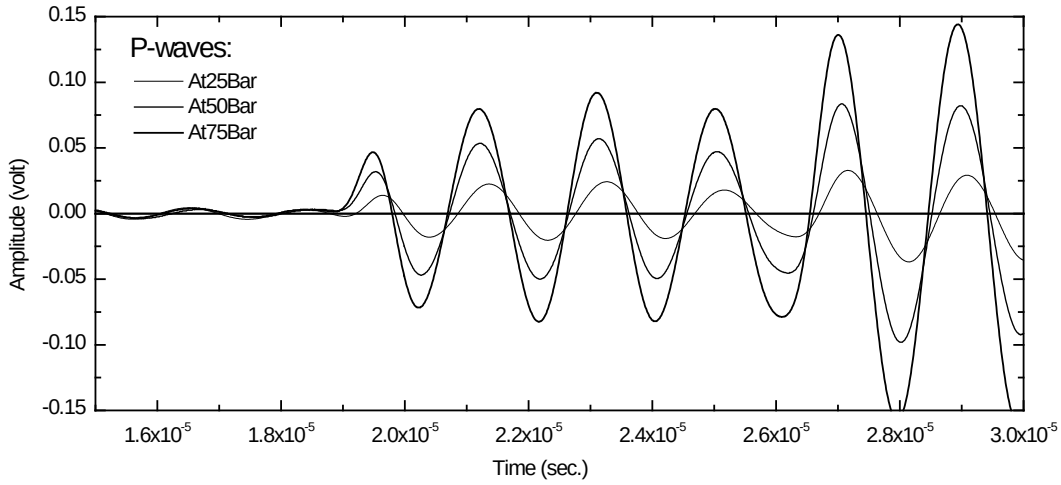
MFF-19P	P@25 Bar: $18.5*10^{-6}$ sec.	S1@25 Bar: $34.7*10^{-6}$ sec.	S2@25 Bar: $34.7*10^{-6}$ sec.
Plug no. 20	P@50 Bar: $18.4*10^{-6}$ sec.	S1@50 Bar: $34.5*10^{-6}$ sec.	S2@50 Bar: $34.5*10^{-6}$ sec.
Sat.	P@75 Bar: $18.3*10^{-6}$ sec.	S1@75 Bar: $34.4*10^{-6}$ sec.	S2@75 Bar: $34.4*10^{-6}$ sec.

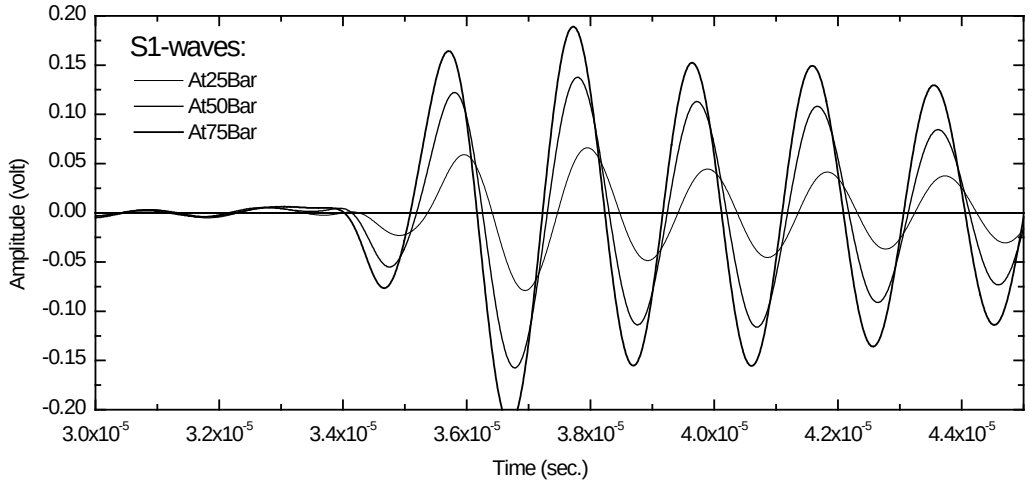


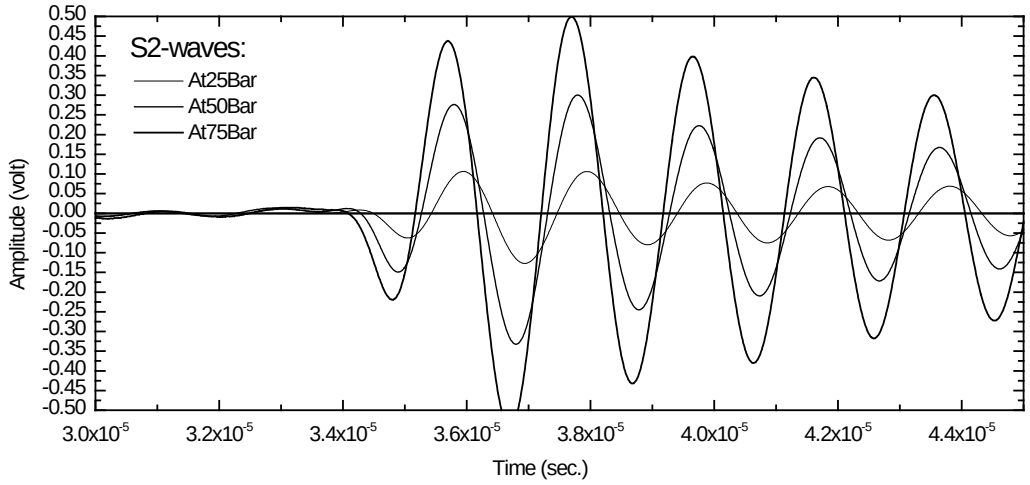




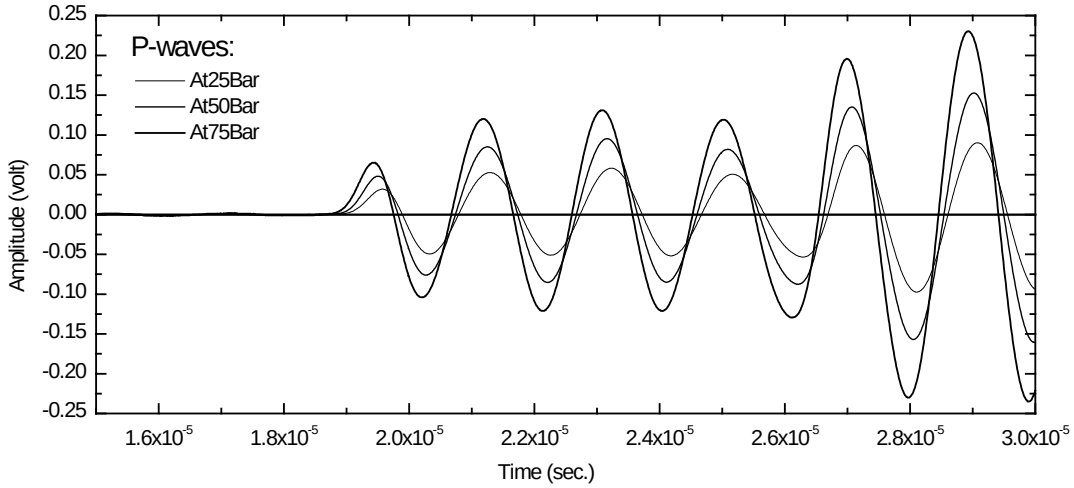
MFF-19P	P@25 Bar: $19.1*10^{-6}$ sec.	S1@25 Bar: $34.1*10^{-6}$ sec.	S2@25 Bar: $34.2*10^{-6}$ sec.
Plug no. 21	P@50 Bar: $19.0*10^{-6}$ sec.	S1@50 Bar: $34.0*10^{-6}$ sec.	S2@50 Bar: $34.0*10^{-6}$ sec.
Dry	P@75 Bar: $18.9*10^{-6}$ sec.	S1@75 Bar: $33.9*10^{-6}$ sec.	S2@75 Bar: $33.9*10^{-6}$ sec.

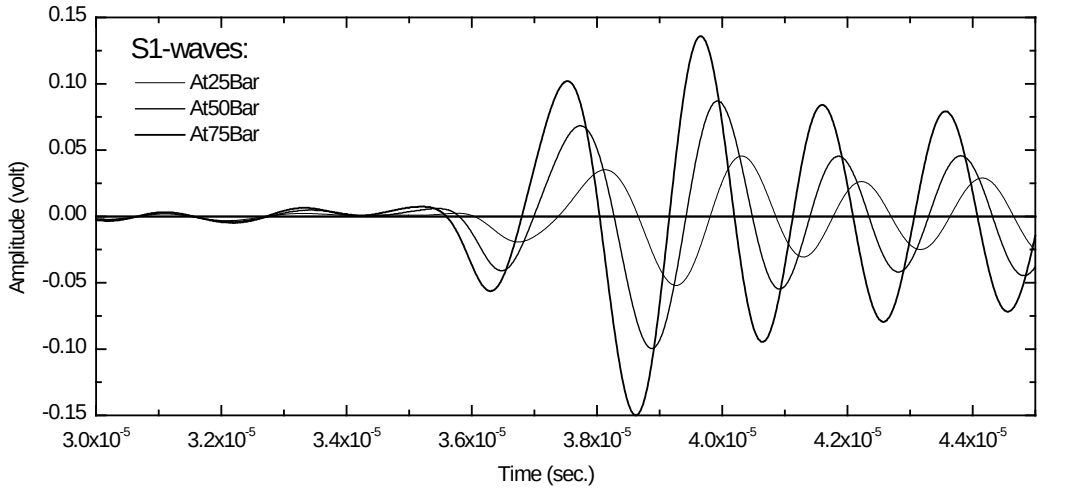


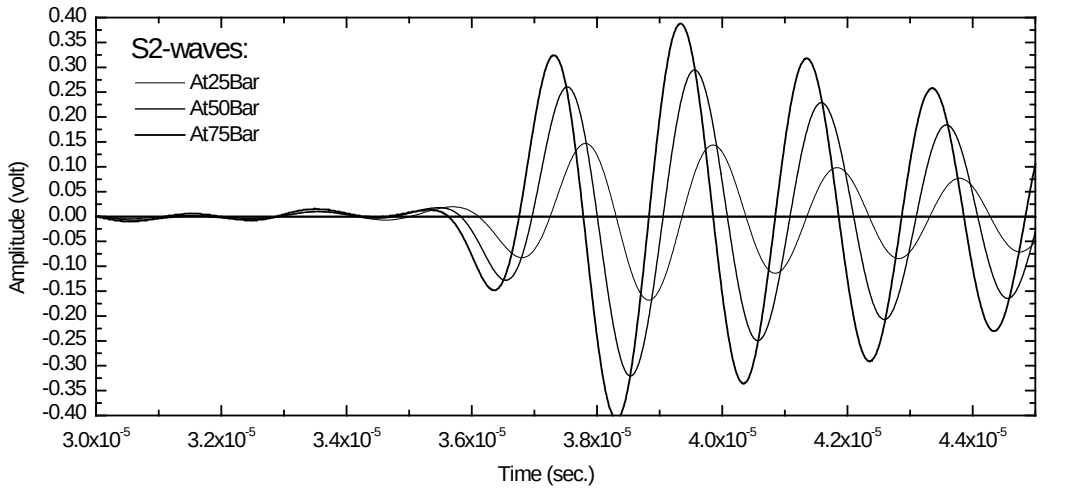




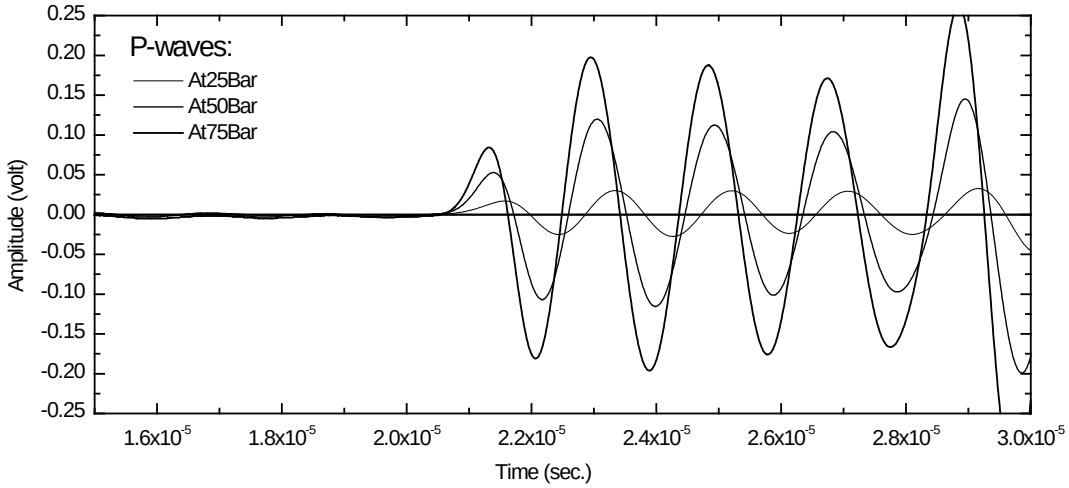
MFF-19P	P@25 Bar: 19.0*10^{-6} sec.	S1@25 Bar: 35.9*10^{-6} sec.	S2@25 Bar: 35.8*10^{-6} sec.
Plug no. 21	P@50 Bar: 18.9*10^{-6} sec.	S1@50 Bar: 35.6*10^{-6} sec.	S2@50 Bar: 35.6*10^{-6} sec.
Sat.	P@75 Bar: 18.8*10^{-6} sec.	S1@75 Bar: 35.4*10^{-6} sec.	S2@75 Bar: 35.4*10^{-6} sec.

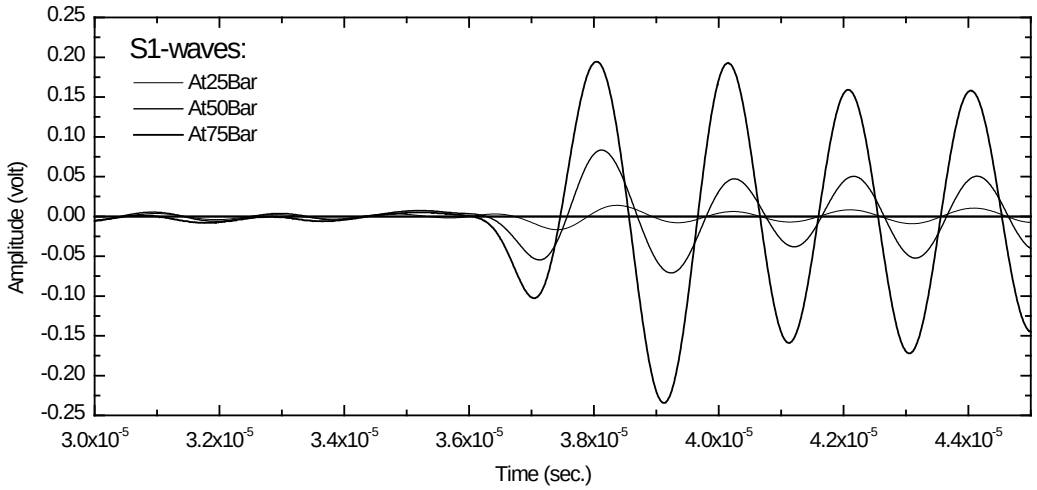


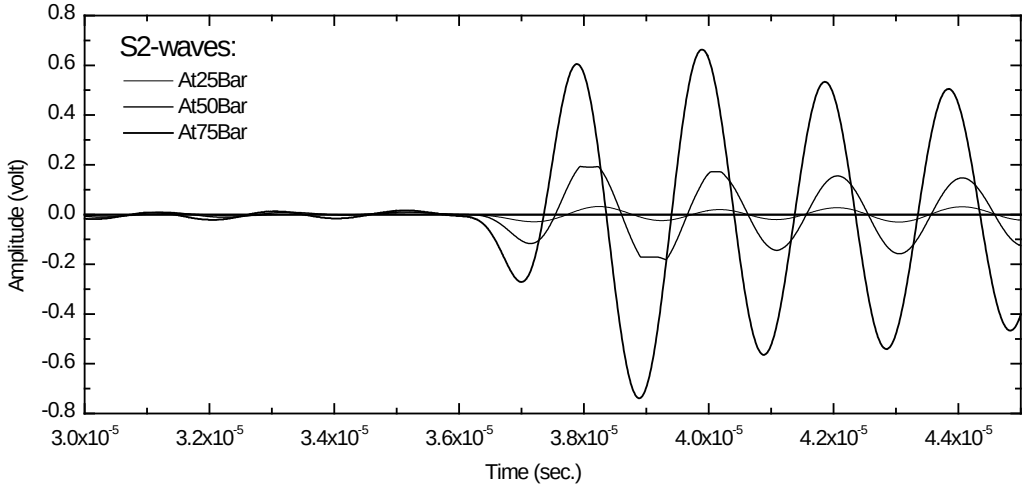




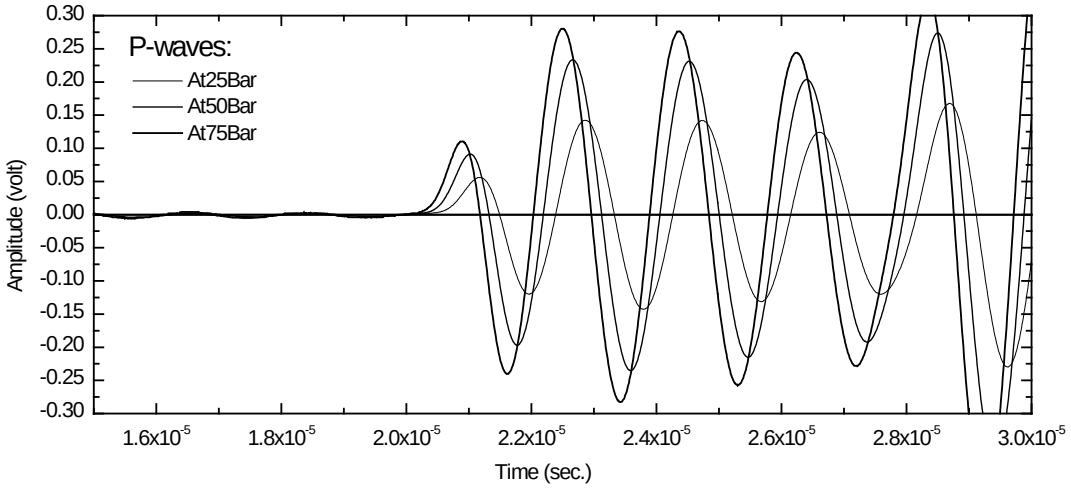
MFF-19P	P@25 Bar: $20.7*10^{-6}$ sec.	S1@25 Bar: $36.6*10^{-6}$ sec.	S2@25 Bar: $36.4*10^{-6}$ sec.
Plug no. 22	P@50 Bar: $20.6*10^{-6}$ sec.	S1@50 Bar: $36.1*10^{-6}$ sec.	S2@50 Bar: $36.2*10^{-6}$ sec.
Dry	P@75 Bar: $20.5*10^{-6}$ sec.	S1@75 Bar: $36.0*10^{-6}$ sec.	S2@75 Bar: $36.1*10^{-6}$ sec.

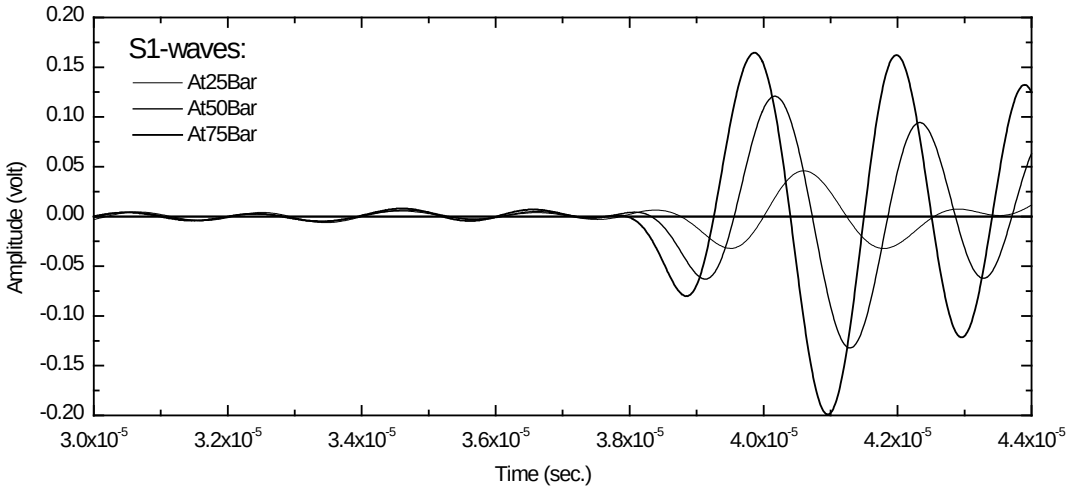


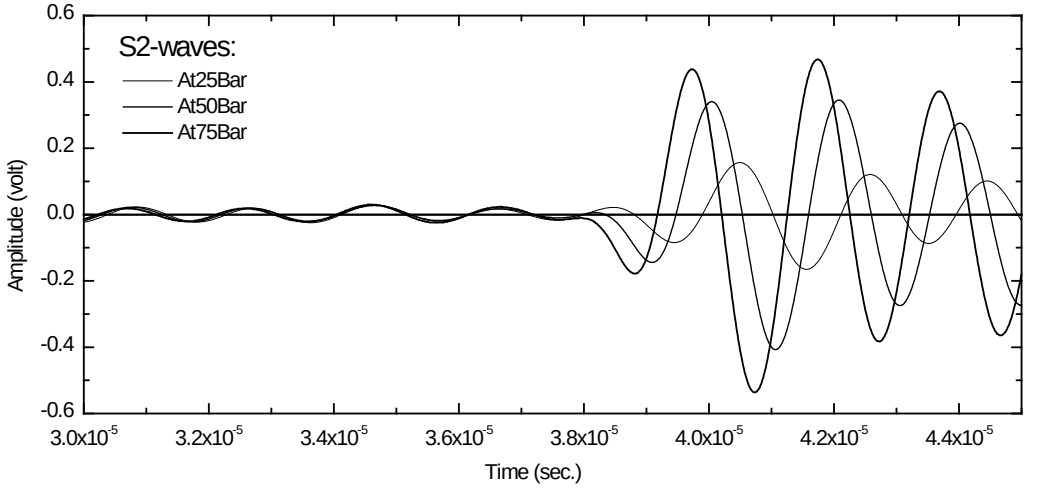




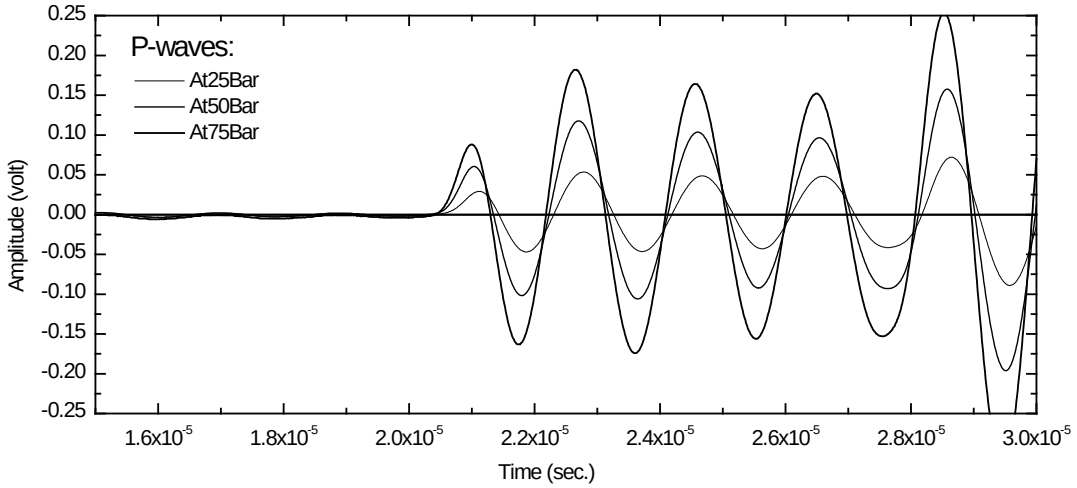
MFF-19P	P@25 Bar: $20.4*10^{-6}$ sec.	S1@25 Bar: $38.4*10^{-6}$ sec.	S2@25 Bar: $38.5*10^{-6}$ sec.
Plug no. 22	P@50 Bar: $20.3*10^{-6}$ sec.	S1@50 Bar: $38.1*10^{-6}$ sec.	S2@50 Bar: $38.2*10^{-6}$ sec.
Sat.	P@75 Bar: $20.2*10^{-6}$ sec.	S1@75 Bar: $37.8*10^{-6}$ sec.	S2@75 Bar: $37.9*10^{-6}$ sec.

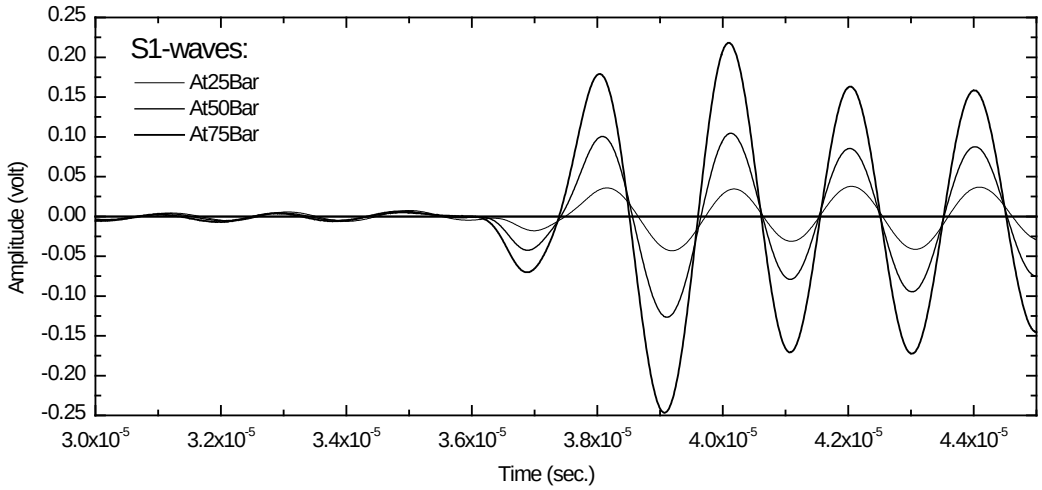


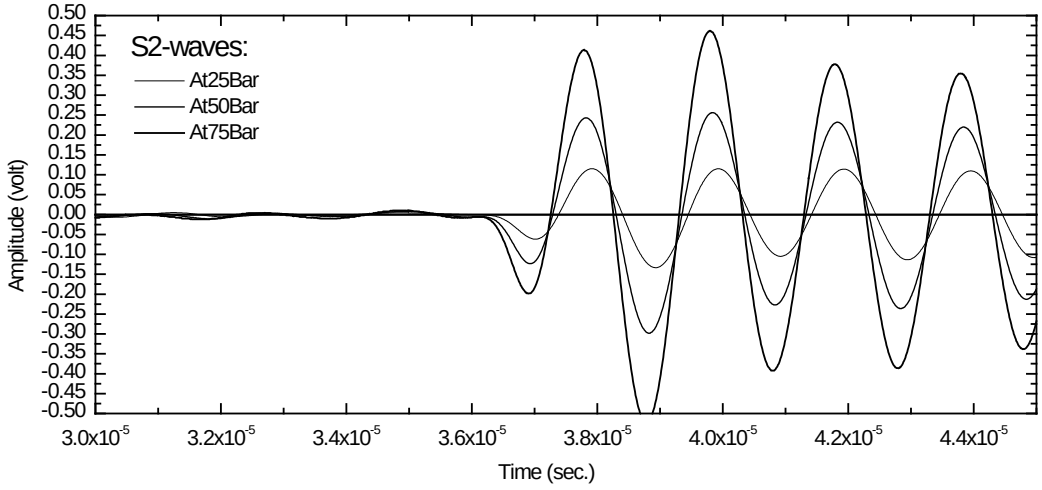




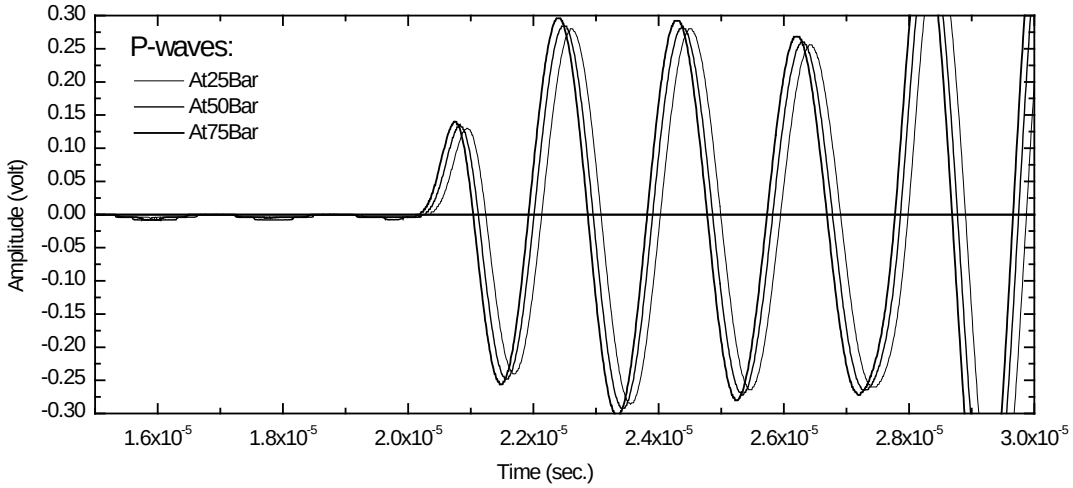
MFF-19P	P@25 Bar: $20.5*10^{-6}$ sec.	S1@25 Bar: $36.4*10^{-6}$ sec.	S2@25 Bar: $36.2*10^{-6}$ sec.
Plug no. 30	P@50 Bar: $20.4*10^{-6}$ sec.	S1@50 Bar: $36.2*10^{-6}$ sec.	S2@50 Bar: $36.1*10^{-6}$ sec.
Dry	P@75 Bar: $20.4*10^{-6}$ sec.	S1@75 Bar: $36.0*10^{-6}$ sec.	S2@75 Bar: $36.0*10^{-6}$ sec.

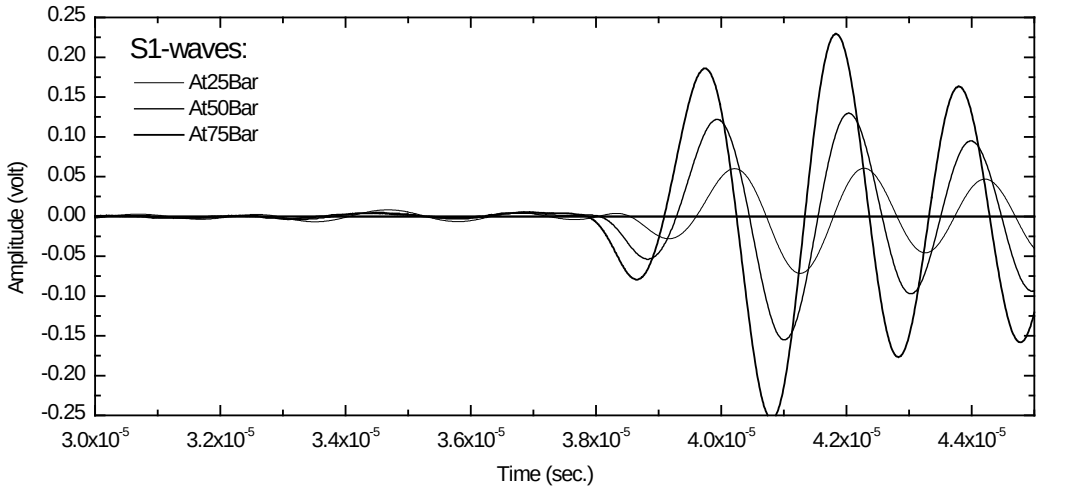


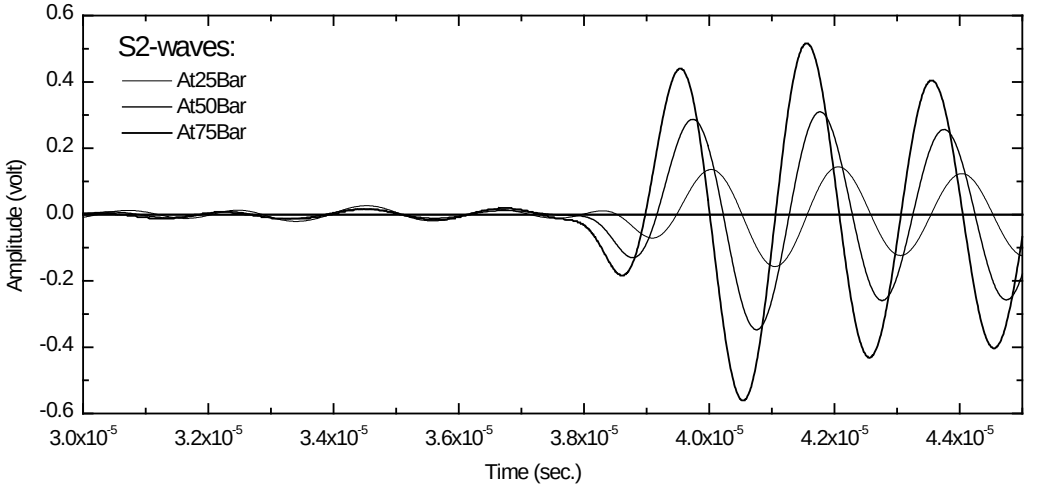




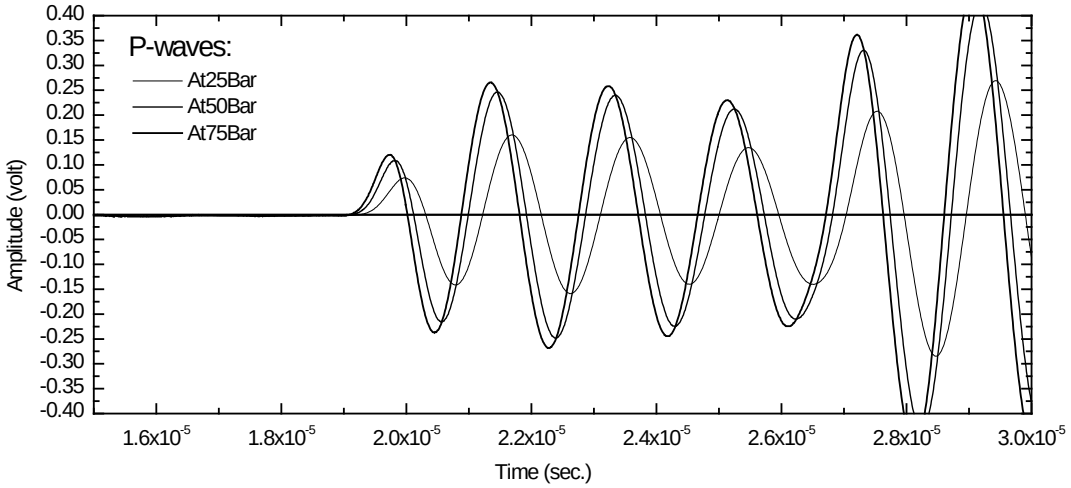
MFF-19P	P@25 Bar: $20.4*10^{-6}$ sec.	S1@25 Bar: $38.3*10^{-6}$ sec.	S2@25 Bar: $38.4*10^{-6}$ sec.
Plug no. 30	P@50 Bar: $20.3*10^{-6}$ sec.	S1@50 Bar: $38.0*10^{-6}$ sec.	S2@50 Bar: $37.9*10^{-6}$ sec.
Sat.	P@75 Bar: $20.2*10^{-6}$ sec.	S1@75 Bar: $37.8*10^{-6}$ sec.	S2@75 Bar: $37.7*10^{-6}$ sec.

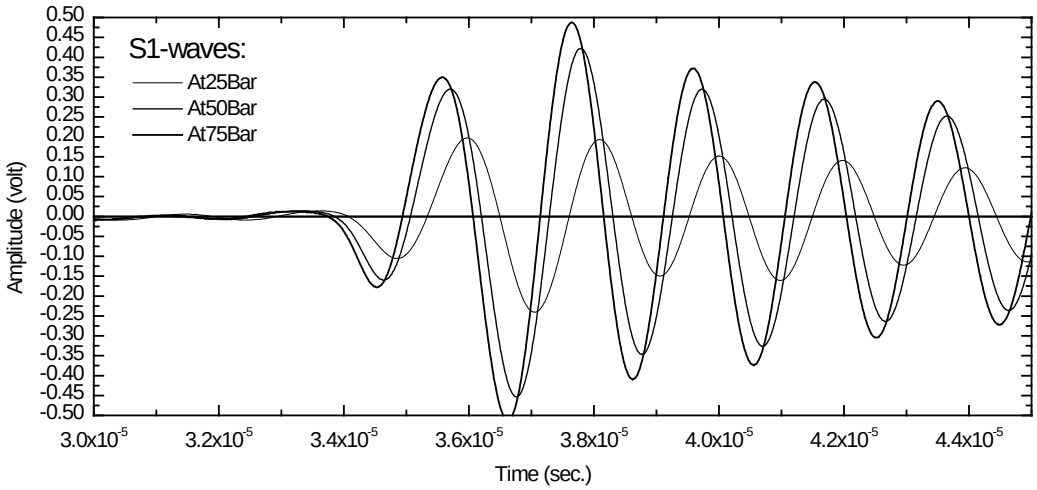


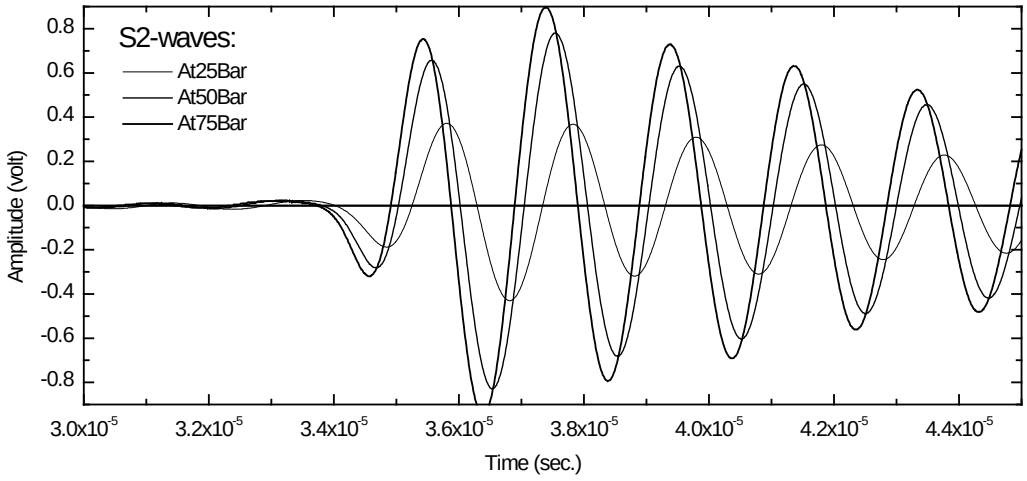




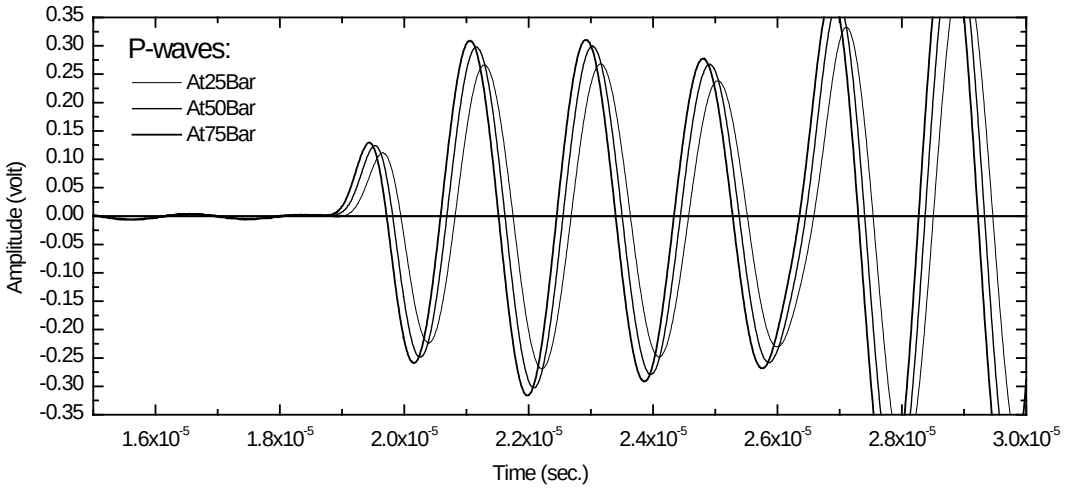
MFF-19P	P@25 Bar: 19.2*10^{-6} sec.	S1@25 Bar: 33.8*10^{-6} sec.	S2@25 Bar: 33.9*10^{-6} sec.
Plug no. 31	P@50 Bar: 19.1*10^{-6} sec.	S1@50 Bar: 33.7*10^{-6} sec.	S2@50 Bar: 33.8*10^{-6} sec.
Dry	P@75 Bar: 19.0*10^{-6} sec.	S1@75 Bar: 33.6*10^{-6} sec.	S2@75 Bar: 33.7*10^{-6} sec.

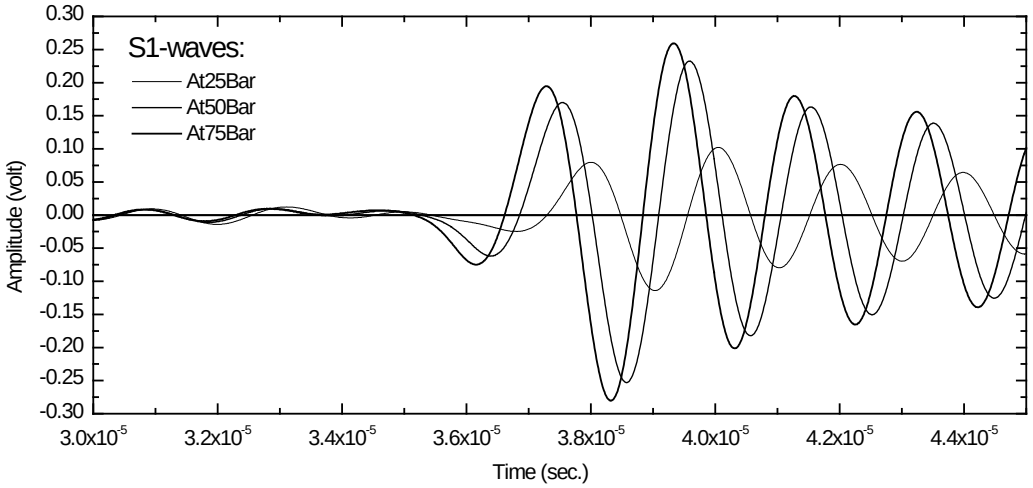


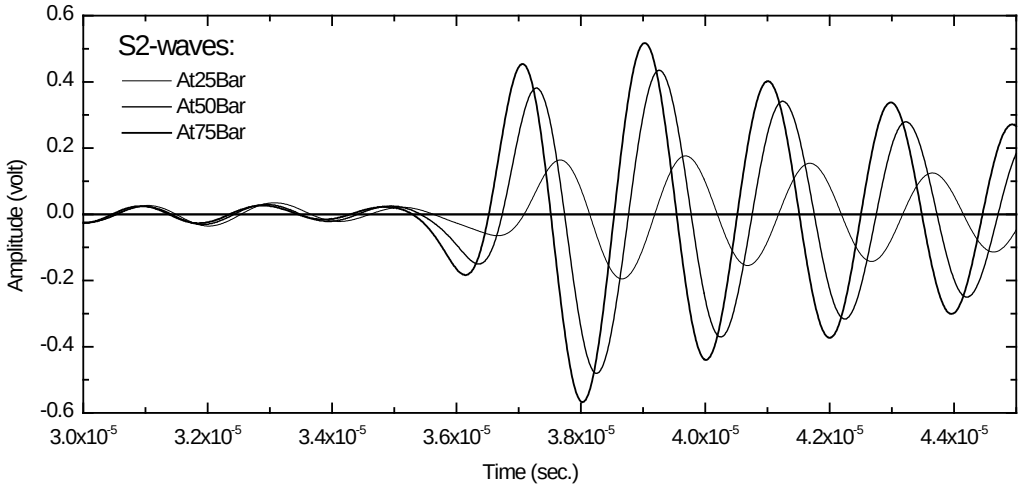




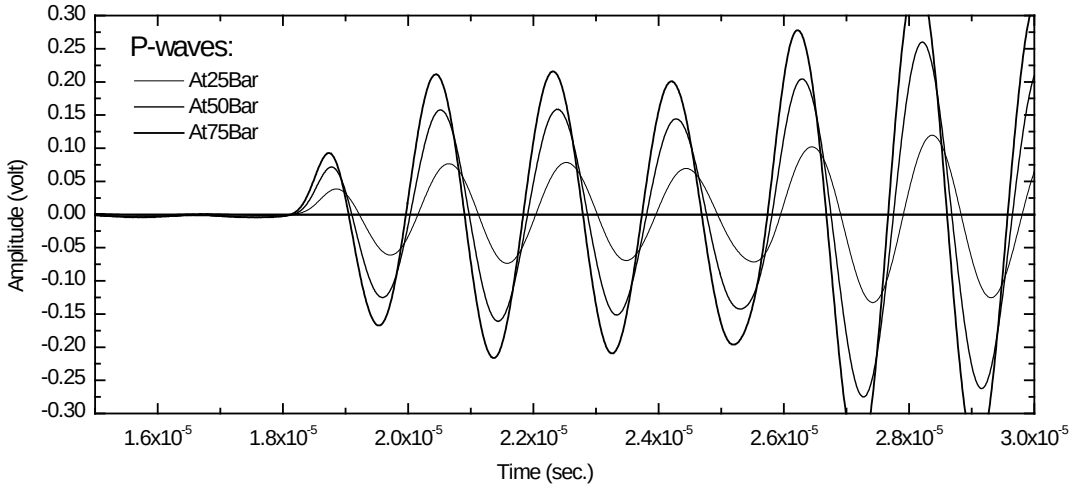
MFF-19P	P@25 Bar: 19.0*10^{-6} sec.	S1@25 Bar: 35.5*10^{-6} sec.	S2@25 Bar: 35.6*10^{-6} sec.
Plug no. 31	P@50 Bar: 18.9*10^{-6} sec.	S1@50 Bar: 35.4*10^{-6} sec.	S2@50 Bar: 35.4*10^{-6} sec.
Sat.	P@75 Bar: 18.8*10^{-6} sec.	S1@75 Bar: 35.3*10^{-6} sec.	S2@75 Bar: 35.3*10^{-6} sec.

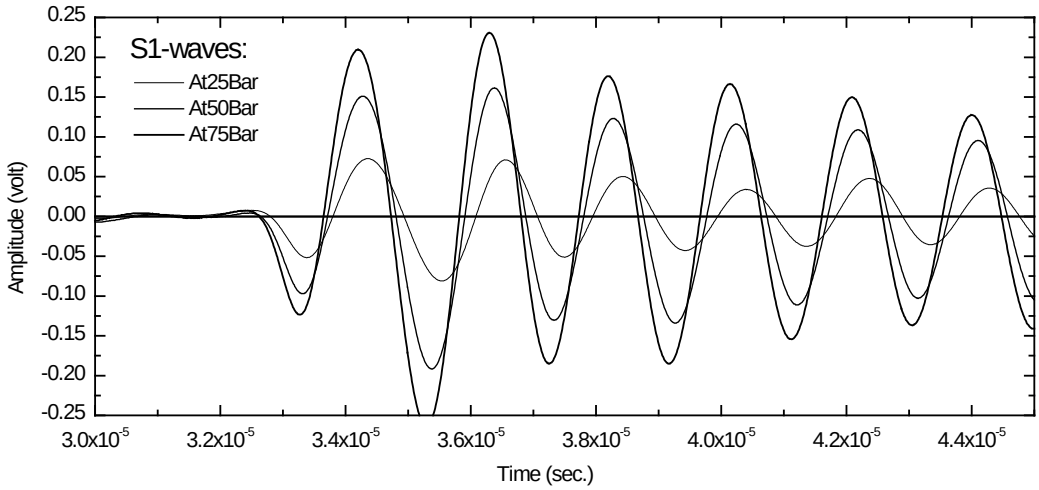


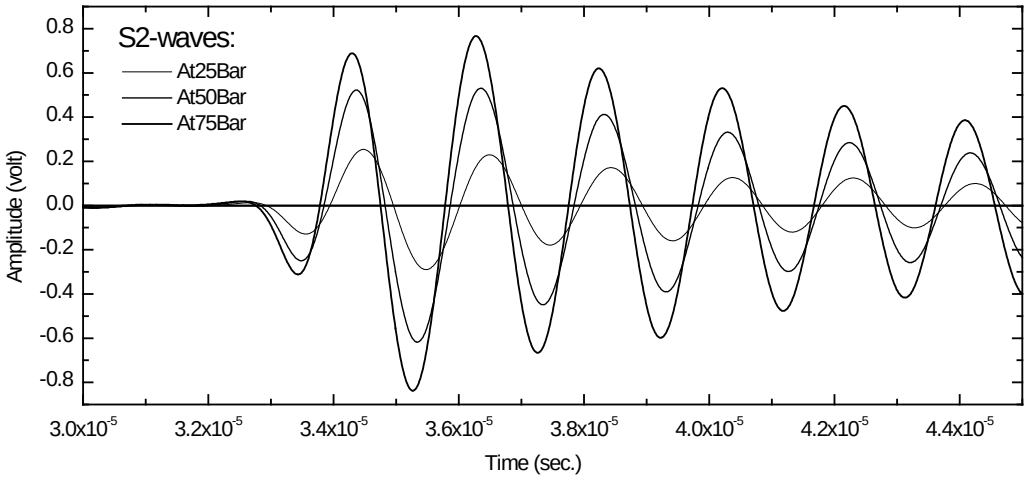




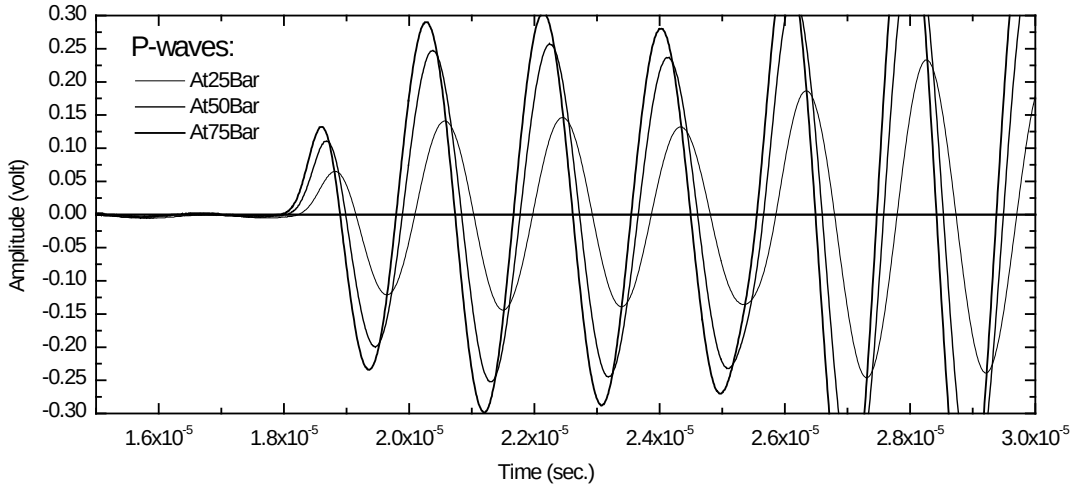
MFF-19P	P@25 Bar: $18.2*10^{-6}$ sec.	S1@25 Bar: $32.7*10^{-6}$ sec.	S2@25 Bar: $32.8*10^{-6}$ sec.
Plug no. 32	P@50 Bar: $18.1*10^{-6}$ sec.	S1@50 Bar: $32.6*10^{-6}$ sec.	S2@50 Bar: $32.7*10^{-6}$ sec.
Dry	P@75 Bar: $18.0*10^{-6}$ sec.	S1@75 Bar: $32.6*10^{-6}$ sec.	S2@75 Bar: $32.6*10^{-6}$ sec.

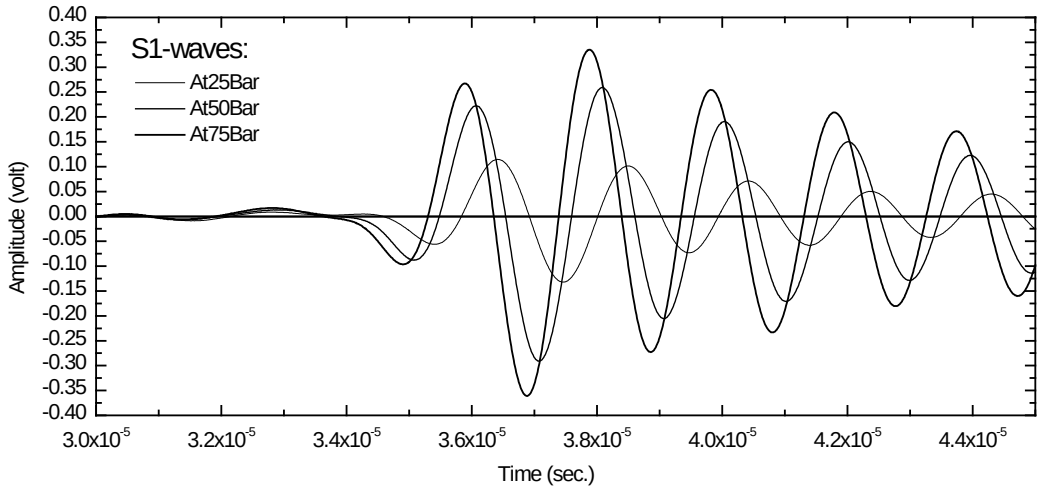


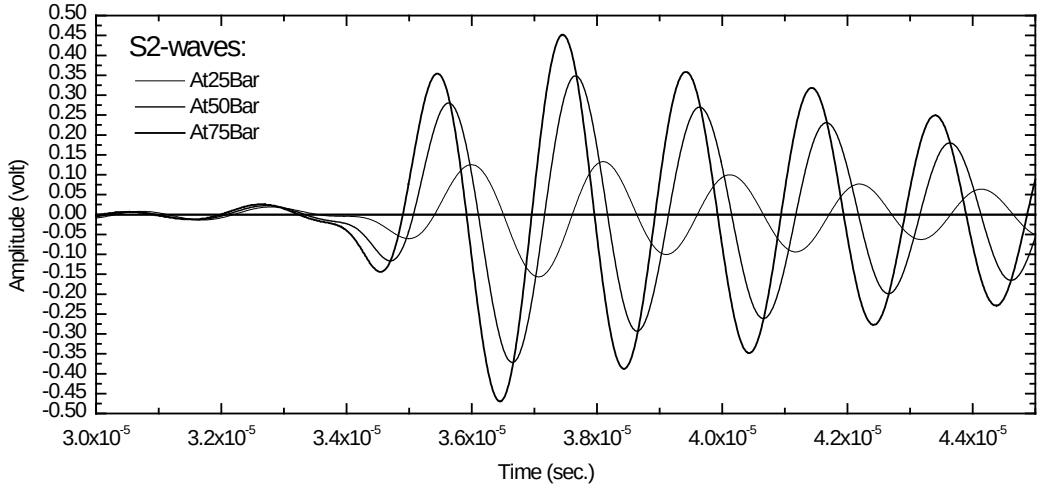




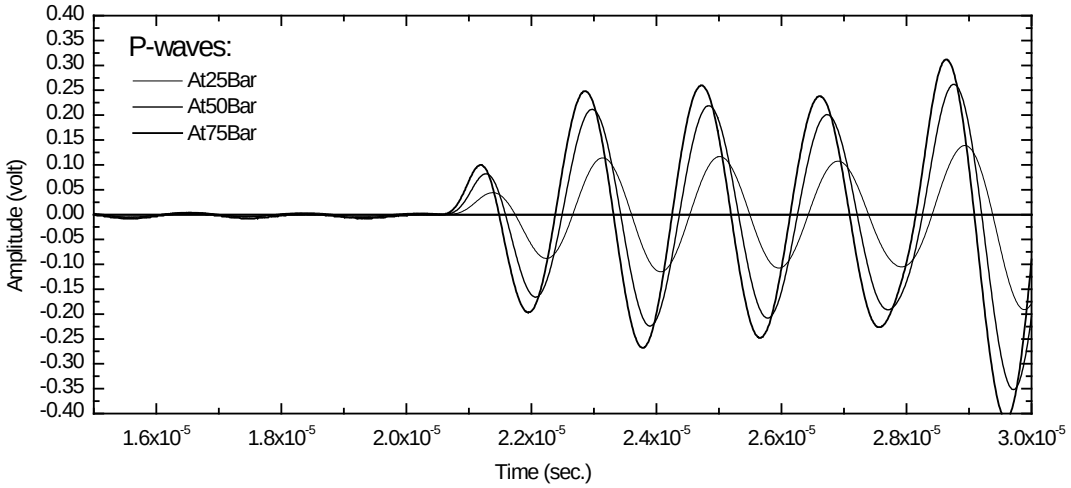
MFF-19P	P@25 Bar: $18.2*10^{-6}$ sec.	S1@25 Bar: $34.2*10^{-6}$ sec.	S2@25 Bar: $33.8*10^{-6}$ sec.
Plug no. 32	P@50 Bar: $18.1*10^{-6}$ sec.	S1@50 Bar: $33.8*10^{-6}$ sec.	S2@50 Bar: $33.7*10^{-6}$ sec.
Sat.	P@75 Bar: $18.0*10^{-6}$ sec.	S1@75 Bar: $33.6*10^{-6}$ sec.	S2@75 Bar: $33.5*10^{-6}$ sec.

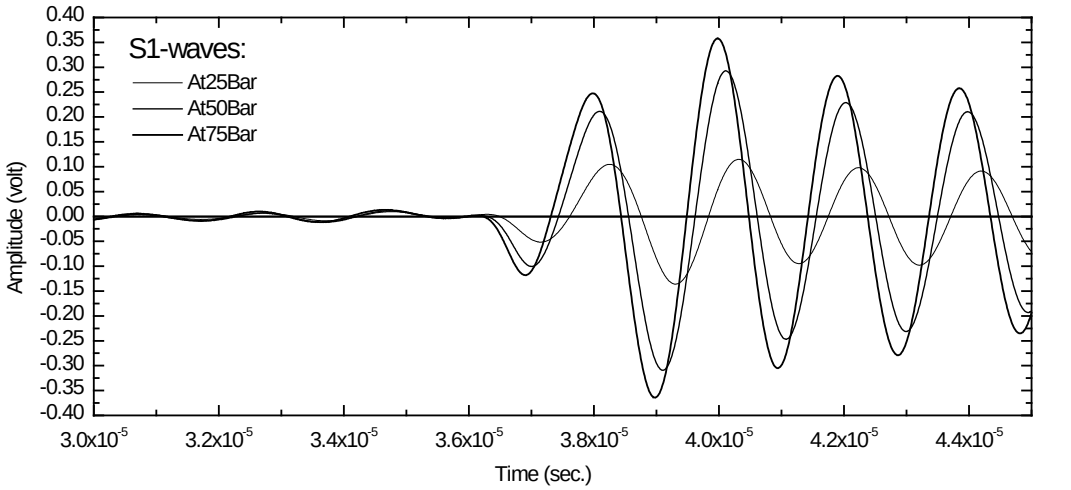


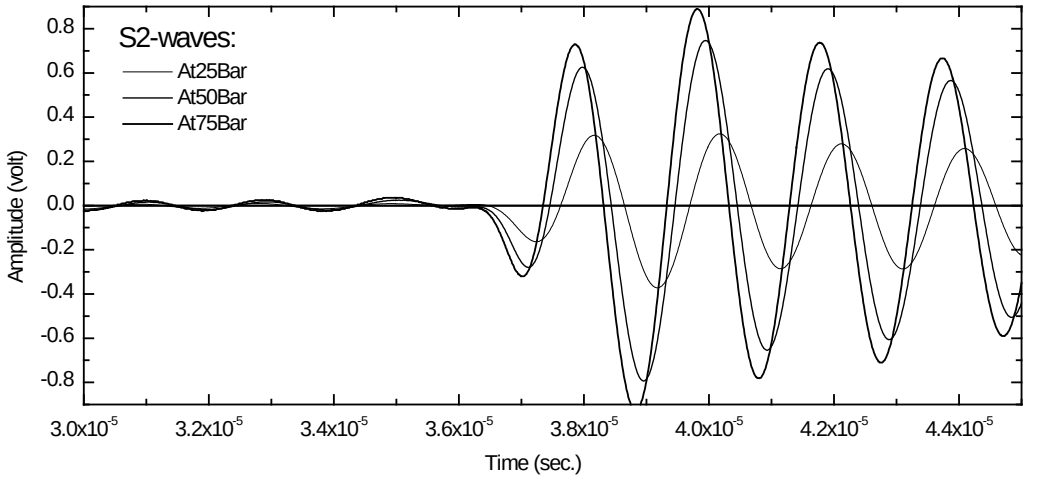




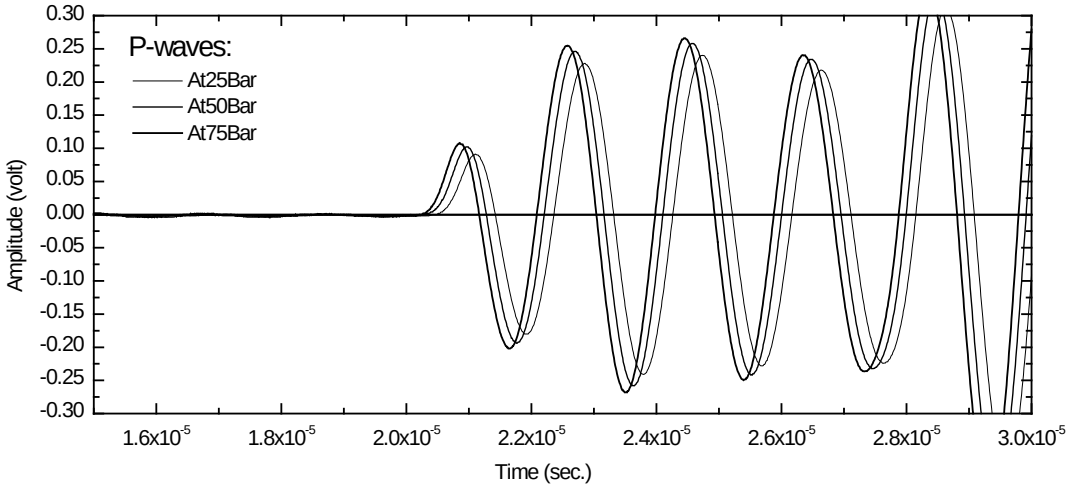
MFF-19P	P@25 Bar: $20.8*10^{-6}$ sec.	S1@25 Bar: $36.4*10^{-6}$ sec.	S2@25 Bar: $36.4*10^{-6}$ sec.
Plug no. 35	P@50 Bar: $20.7*10^{-6}$ sec.	S1@50 Bar: $36.3*10^{-6}$ sec.	S2@50 Bar: $36.3*10^{-6}$ sec.
Dry	P@75 Bar: $20.6*10^{-6}$ sec.	S1@75 Bar: $36.2*10^{-6}$ sec.	S2@75 Bar: $36.3*10^{-6}$ sec.

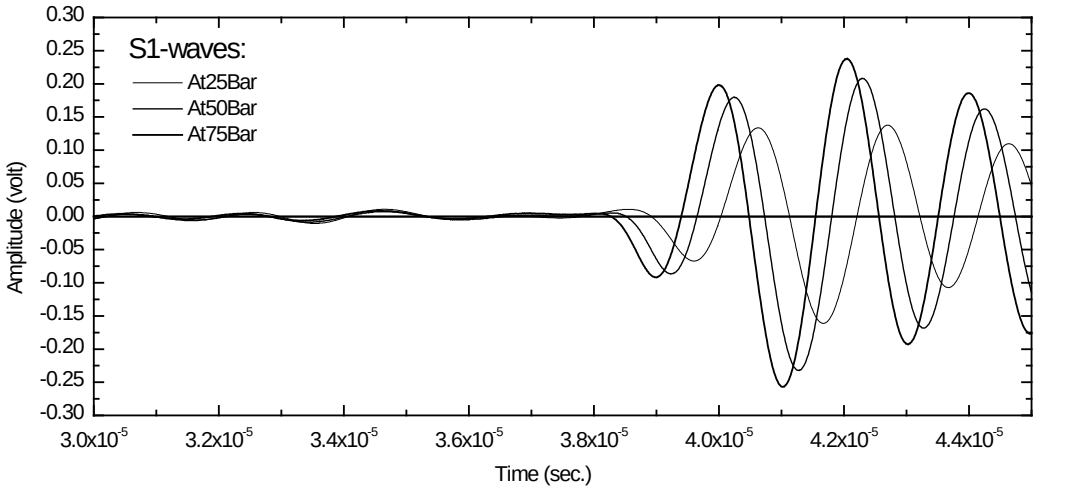


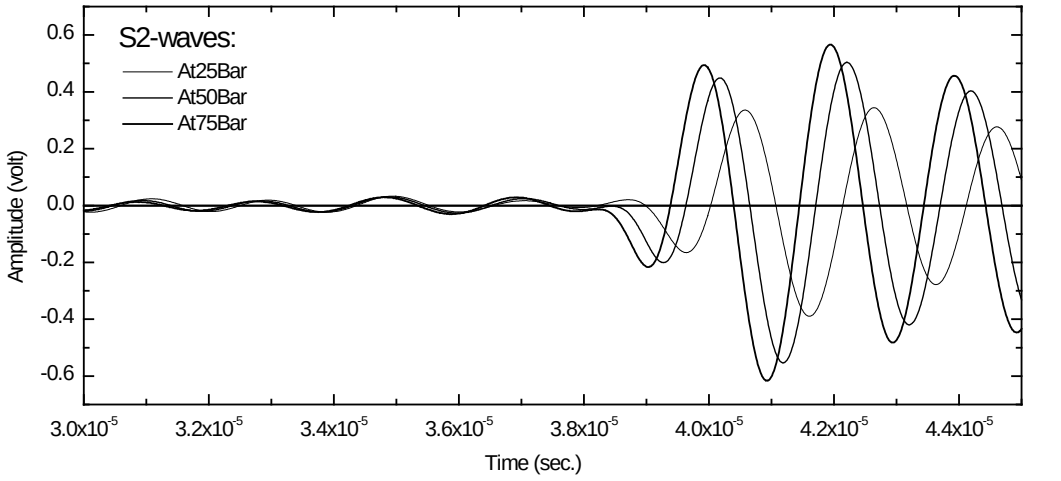




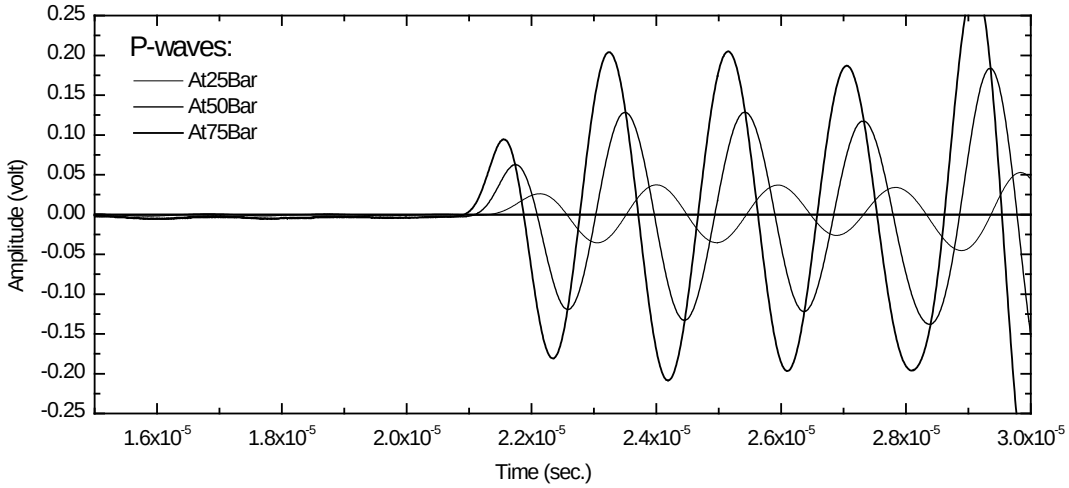
MFF-19P	P@25 Bar: $20.5*10^{-6}$ sec.	S1@25 Bar: $38.7*10^{-6}$ sec.	S2@25 Bar: $38.7*10^{-6}$ sec.
Plug no. 35	P@50 Bar: $20.4*10^{-6}$ sec.	S1@50 Bar: $38.4*10^{-6}$ sec.	S2@50 Bar: $38.5*10^{-6}$ sec.
Sat.	P@75 Bar: $20.3*10^{-6}$ sec.	S1@75 Bar: $38.2*10^{-6}$ sec.	S2@75 Bar: $38.3*10^{-6}$ sec.

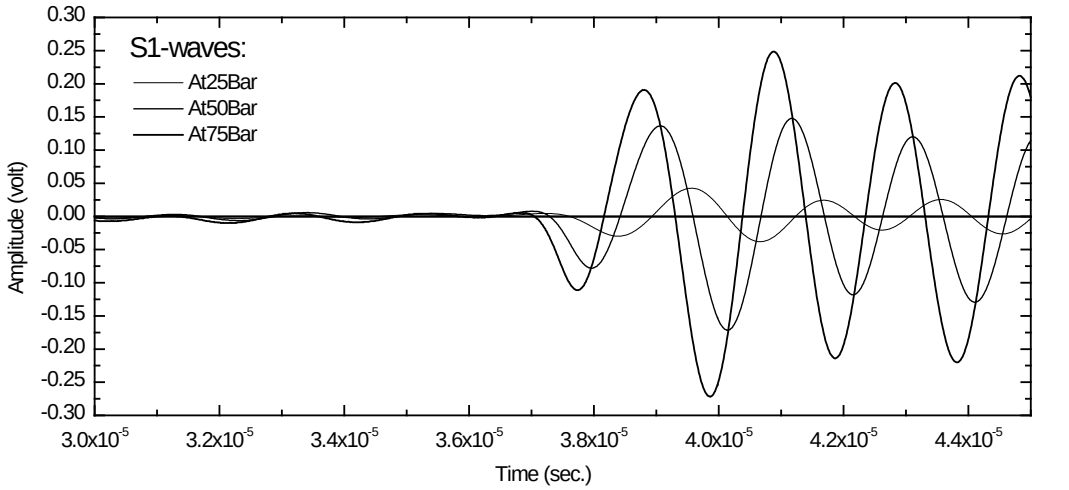


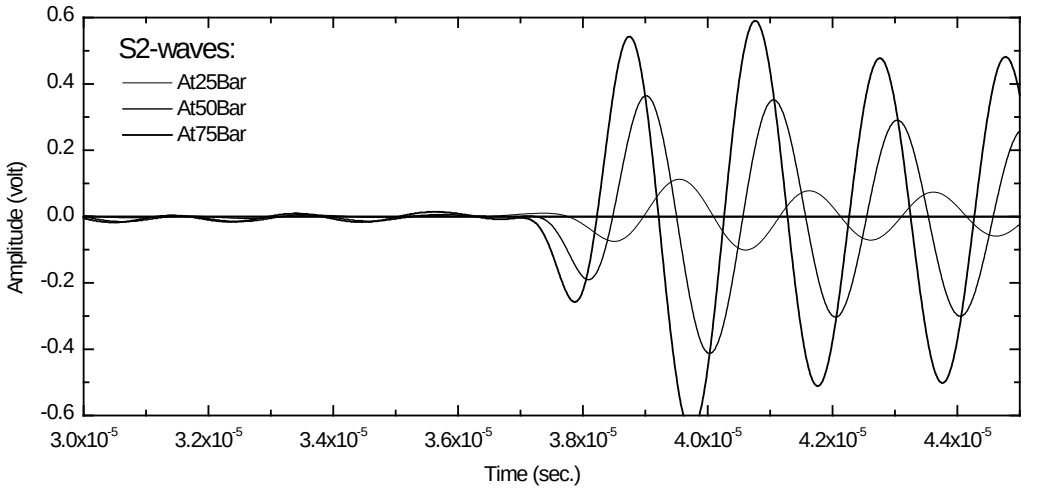




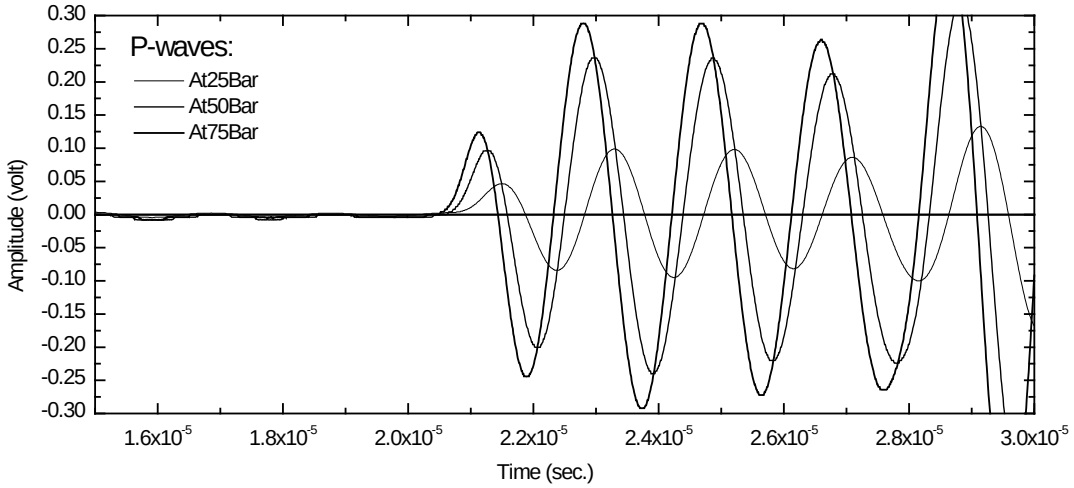
MFF-19P	P@25 Bar: $21.2*10^{-6}$ sec.	S1@25 Bar: $37.4*10^{-6}$ sec.	S2@25 Bar: $37.5*10^{-6}$ sec.
Plug no. 37	P@50 Bar: $20.9*10^{-6}$ sec.	S1@50 Bar: $37.1*10^{-6}$ sec.	S2@50 Bar: $37.1*10^{-6}$ sec.
Dry	P@75 Bar: $20.8*10^{-6}$ sec.	S1@75 Bar: $36.9*10^{-6}$ sec.	S2@75 Bar: $36.9*10^{-6}$ sec.

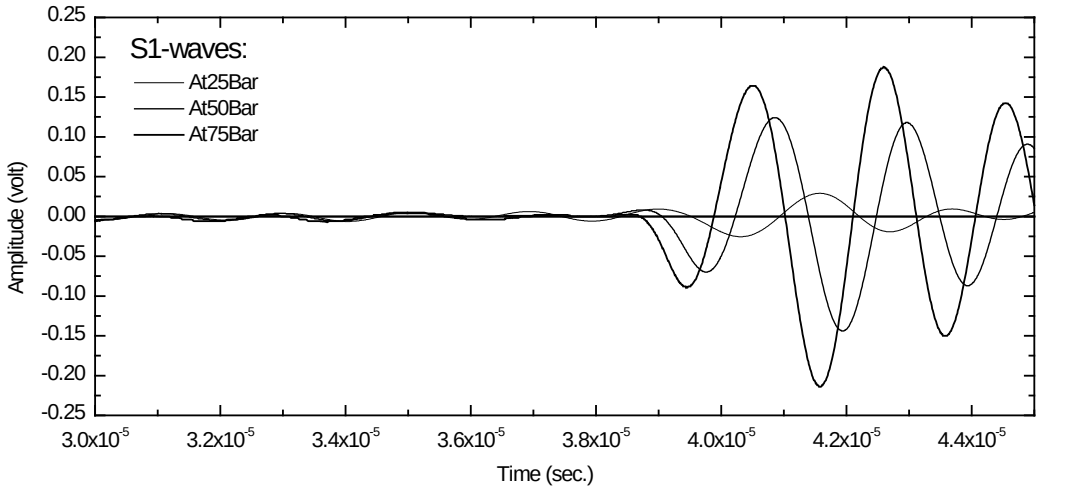


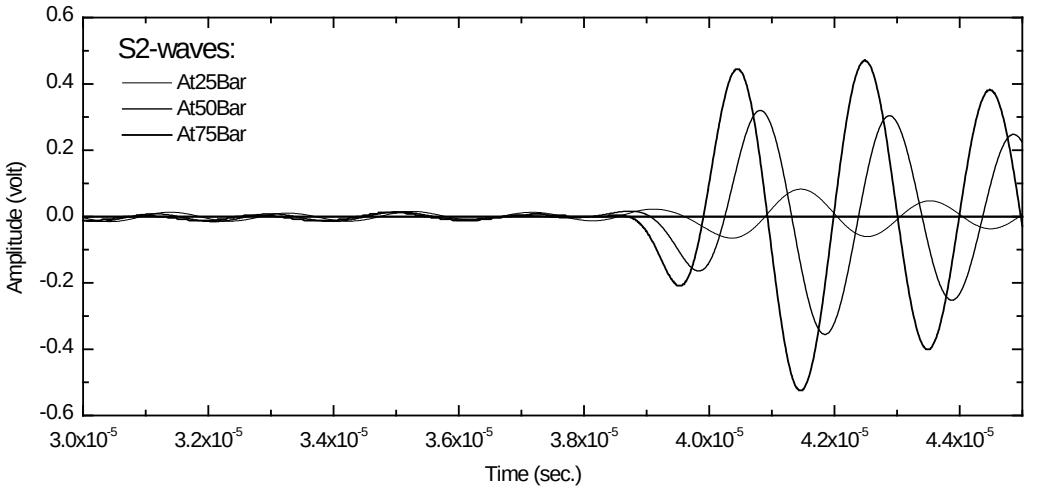




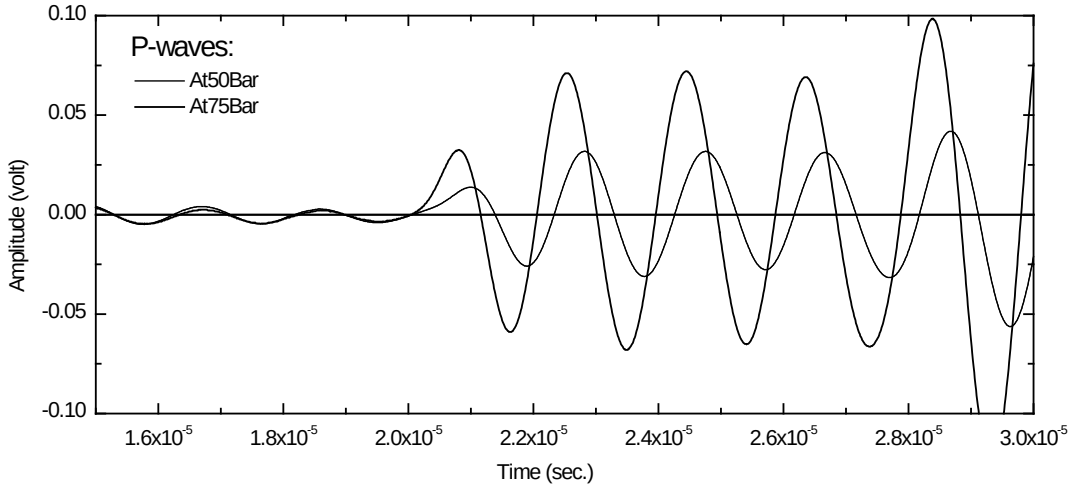
MFF-19P	P@25 Bar: $20.7*10^{-6}$ sec.	S1@25 Bar: $39.1*10^{-6}$ sec.	S2@25 Bar: $39.2*10^{-6}$ sec.
Plug no. 37	P@50 Bar: $20.6*10^{-6}$ sec.	S1@50 Bar: $38.8*10^{-6}$ sec.	S2@50 Bar: $38.8*10^{-6}$ sec.
Sat.	P@75 Bar: $20.5*10^{-6}$ sec.	S1@75 Bar: $38.7*10^{-6}$ sec.	S2@75 Bar: $38.6*10^{-6}$ sec.

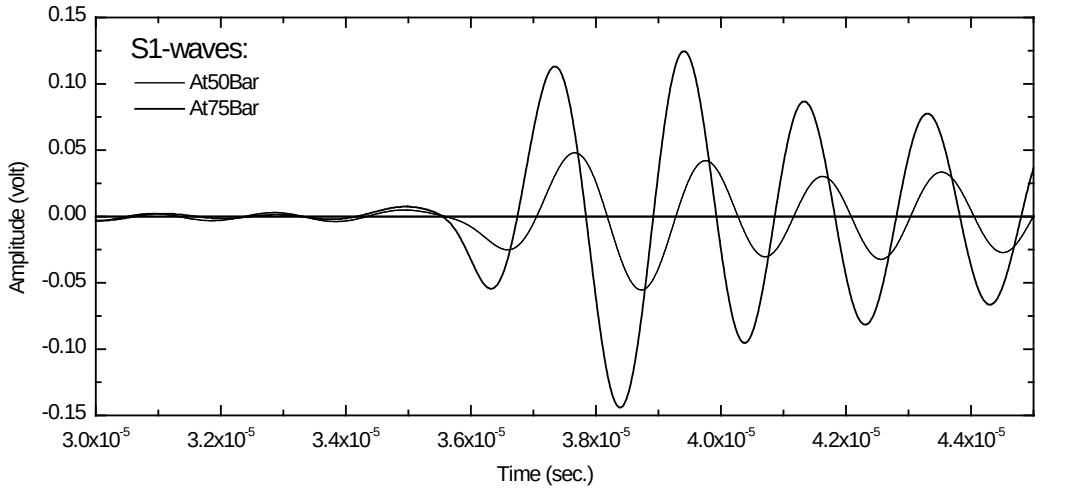


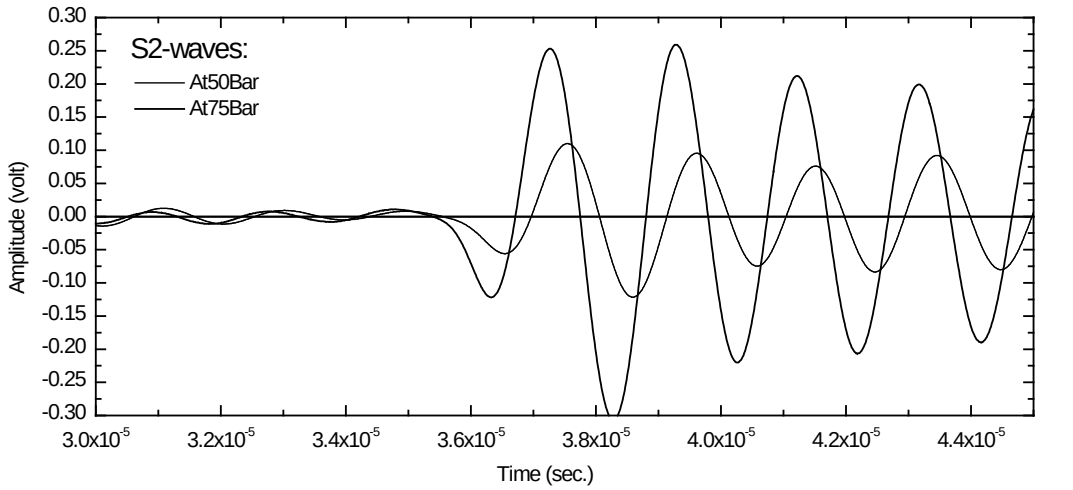




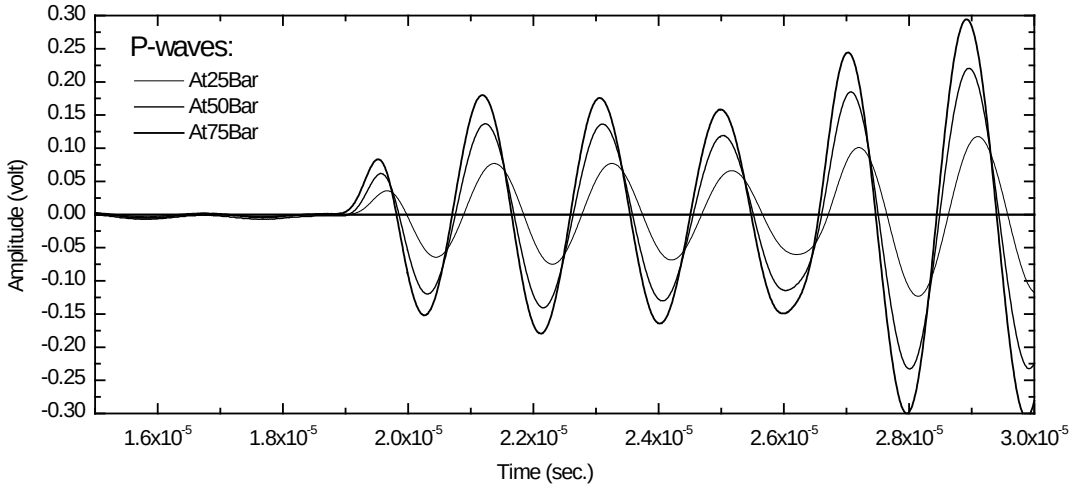
MFB-7	P@25 Bar: ? *10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: ? *10^{-6} sec.
Plug no. 166	P@50 Bar: 20.2*10^{-6} sec.	S1@50 Bar: 35.5*10^{-6} sec.	S2@50 Bar: 35.5*10^{-6} sec.
Dry	P@75 Bar: 20.1*10^{-6} sec.	S1@75 Bar: 35.4*10^{-6} sec.	S2@75 Bar: 35.4*10^{-6} sec.

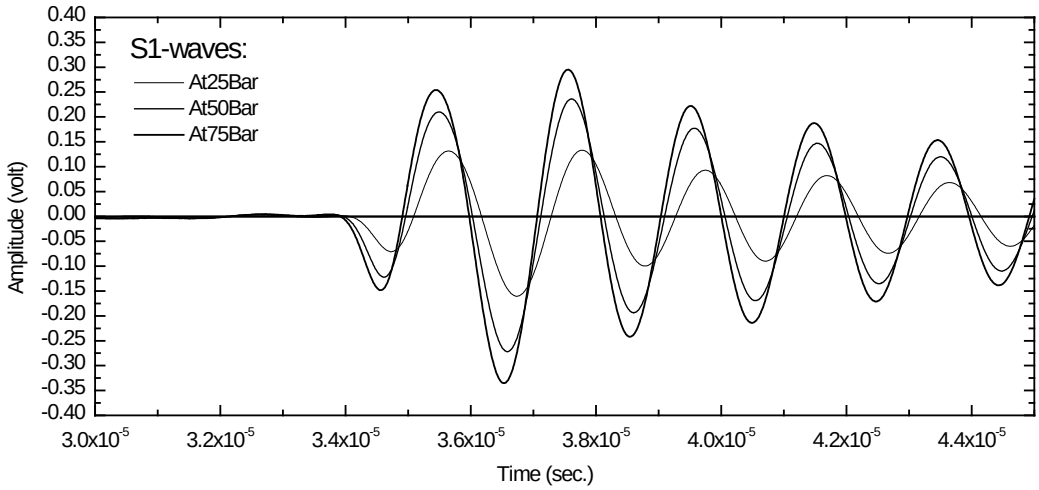


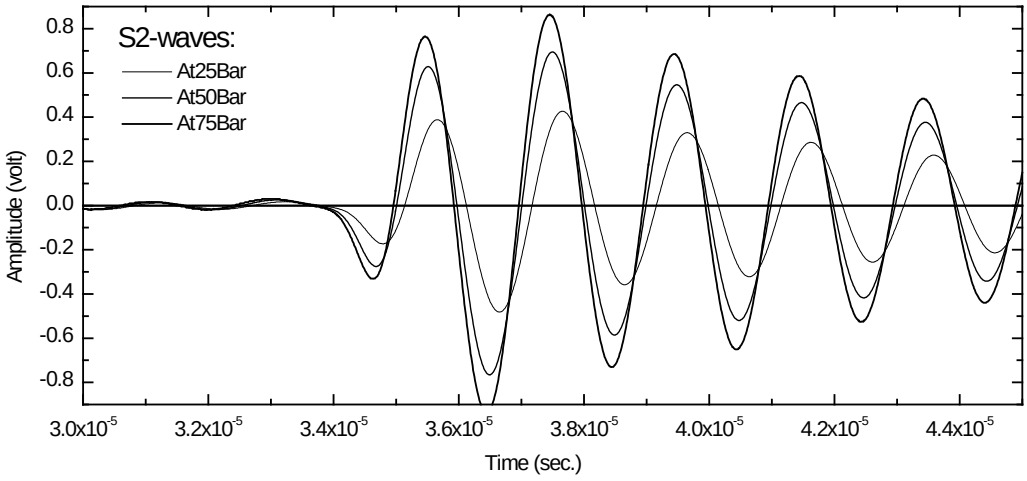




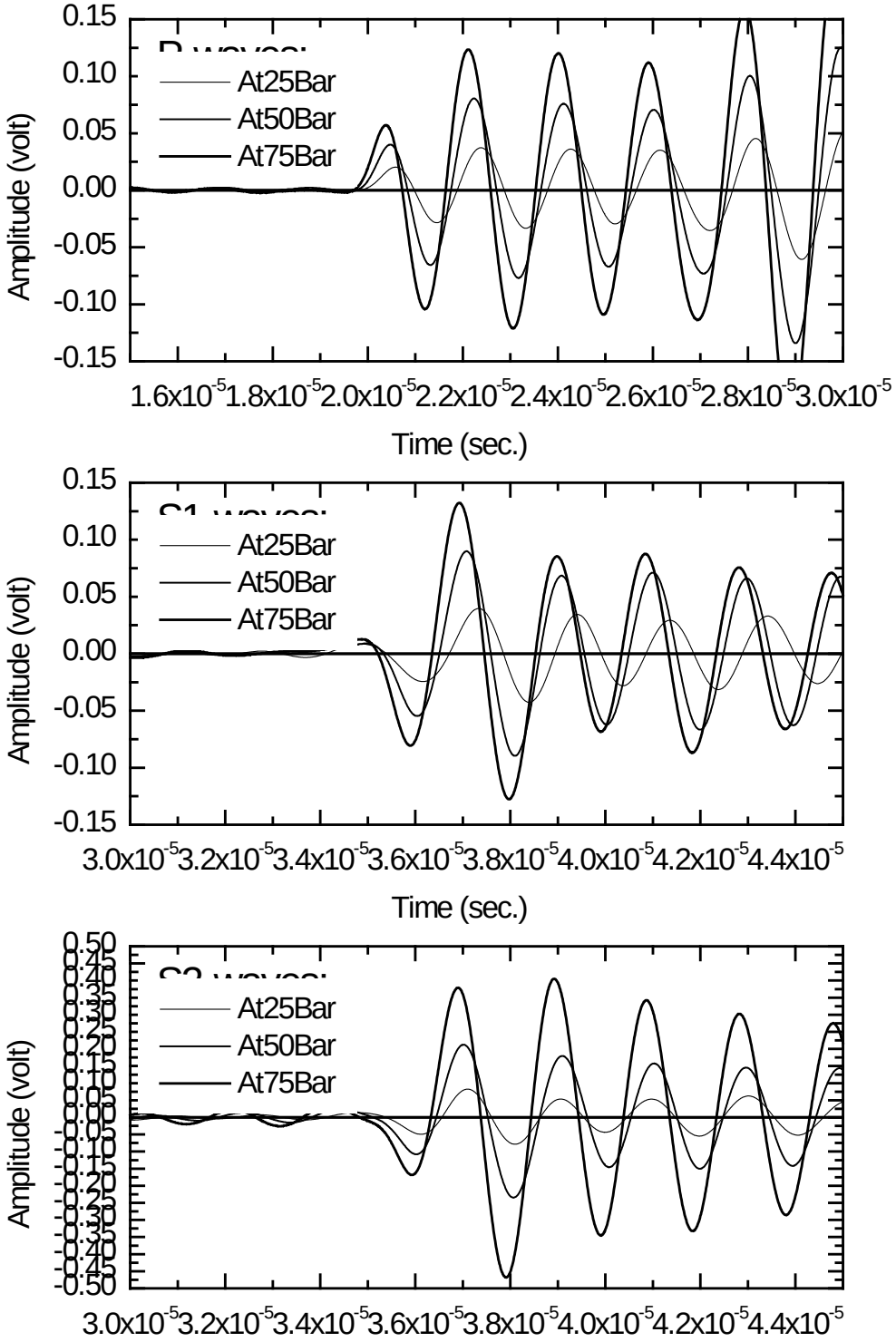
MFB-7	P@25 Bar: 19.1*10^{-6} sec.	S1@25 Bar: 34.0*10^{-6} sec.	S2@25 Bar: 34.0*10^{-6} sec.
Plug no. 167	P@50 Bar: 19.0*10^{-6} sec.	S1@50 Bar: 33.9*10^{-6} sec.	S2@50 Bar: 33.9*10^{-6} sec.
Dry	P@75 Bar: 18.9*10^{-6} sec.	S1@75 Bar: 33.8*10^{-6} sec.	S2@75 Bar: 33.8*10^{-6} sec.



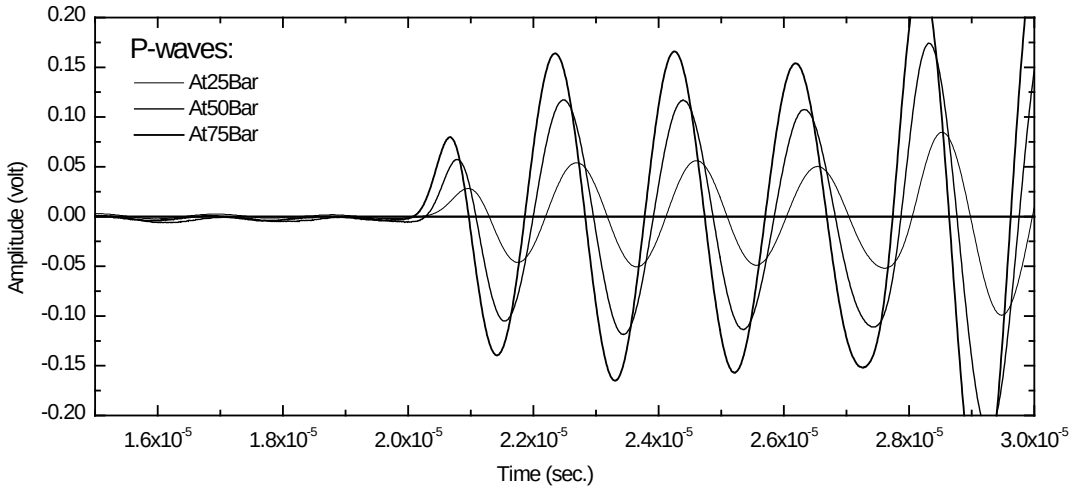


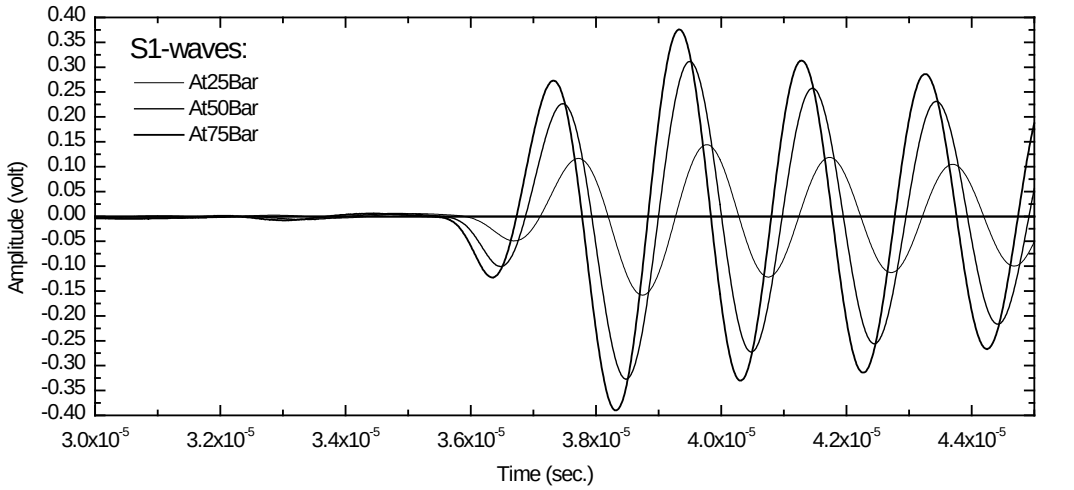


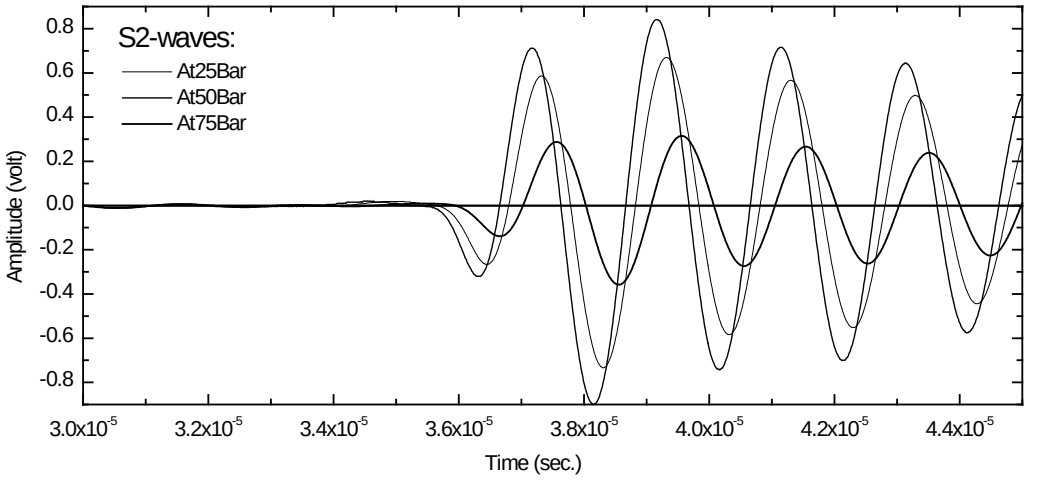
MFB-7	P@25 Bar: $19.8*10^{-6}$ sec.	S1@25 Bar: $35.4*10^{-6}$ sec.	S2@25 Bar: $35.4*10^{-6}$ sec.
Plug no. 169	P@50 Bar: $19.7*10^{-6}$ sec.	S1@50 Bar: $35.2*10^{-6}$ sec.	S2@50 Bar: $35.2*10^{-6}$ sec.
Dry	P@75 Bar: $19.6*10^{-6}$ sec.	S1@75 Bar: $35.1*10^{-6}$ sec.	S2@75 Bar: $35.1*10^{-6}$ sec.



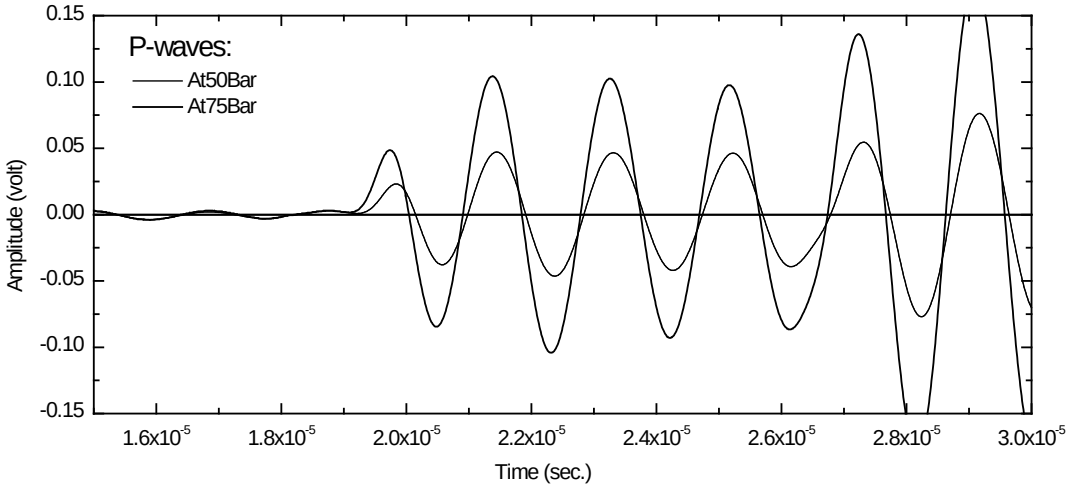
MFB-7	P@25 Bar: $20.4*10^{-6}$ sec.	S1@25 Bar: $35.8*10^{-6}$ sec.	S2@25 Bar: $35.7*10^{-6}$ sec.
Plug no. 170	P@50 Bar: $20{,}2*10^{-6}$ sec.	S1@50 Bar: $35.6*10^{-6}$ sec.	S2@50 Bar: $35.6*10^{-6}$ sec.
Dry	P@75 Bar: $20.0*10^{-6}$ sec.	S1@75 Bar: $35.5*10^{-6}$ sec.	S2@75 Bar: $35.5*10^{-6}$ sec.

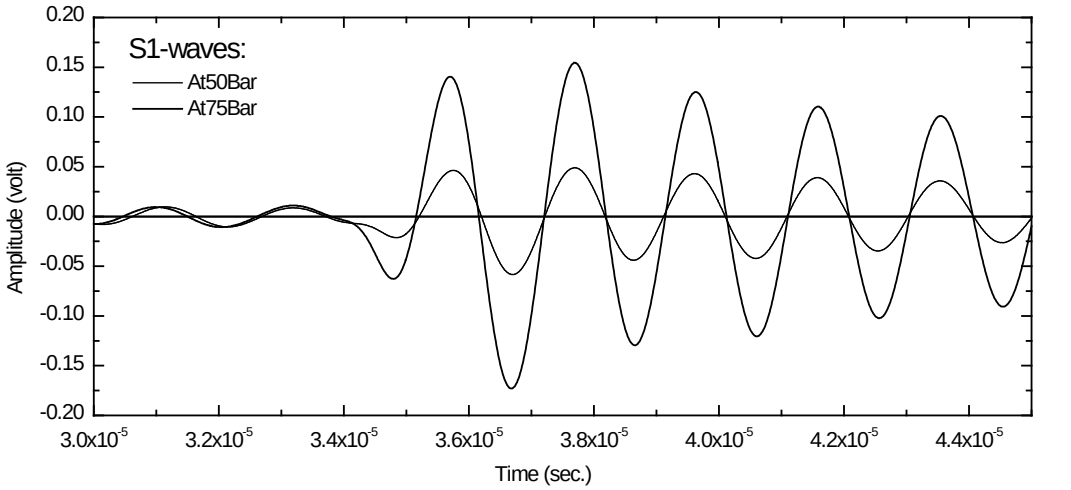


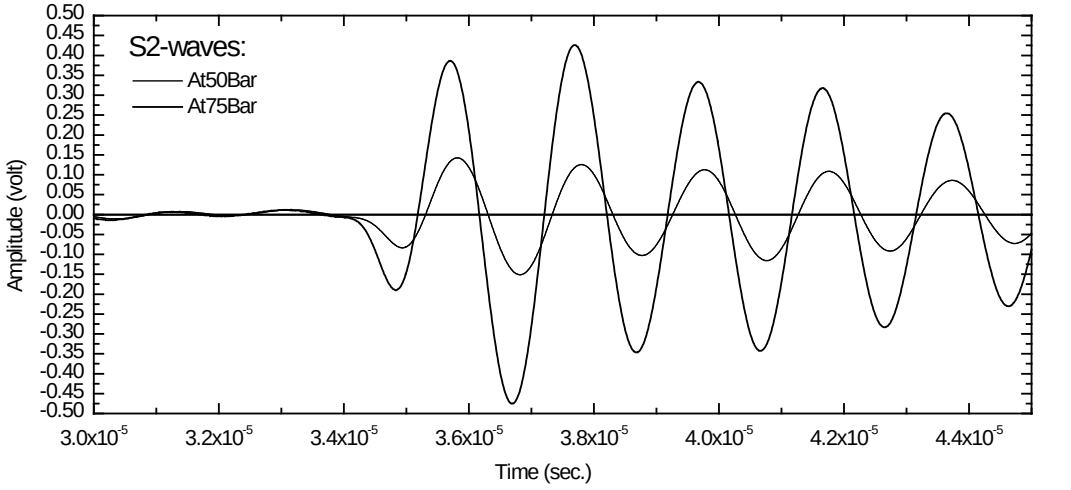




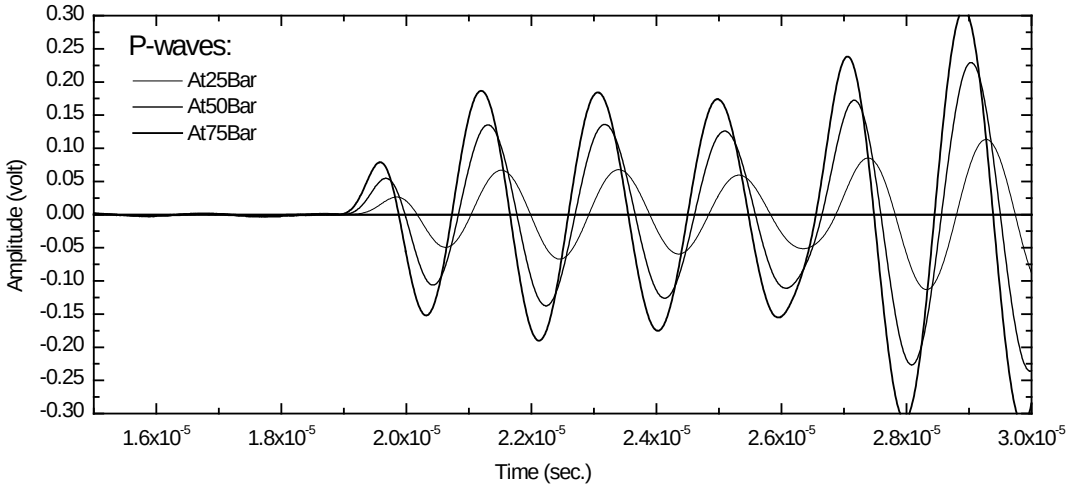
MFB-7	P@25 Bar: ? *10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: ? *10^{-6} sec.
Plug no. 171	P@50 Bar: 19.2*10^{-6} sec.	S1@50 Bar: 34.0*10^{-6} sec.	S2@50 Bar: 34.0*10^{-6} sec.
Dry	P@75 Bar: 19.1*10^{-6} sec.	S1@75 Bar: 33.9*10^{-6} sec.	S2@75 Bar: 33.9*10^{-6} sec.

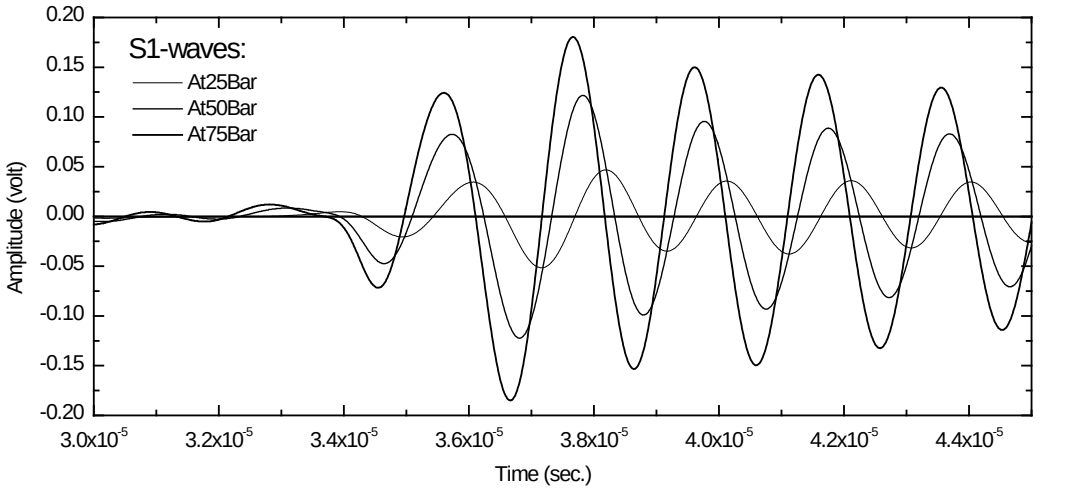


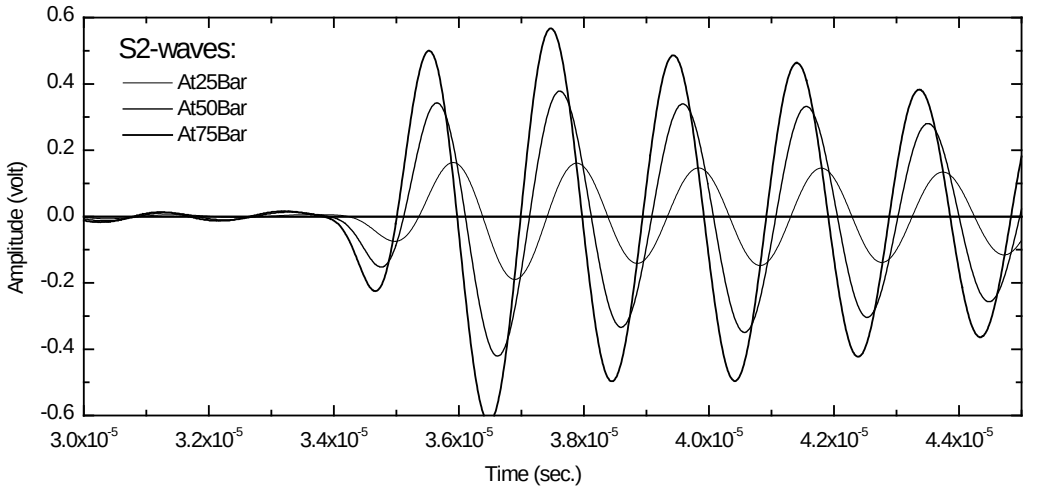




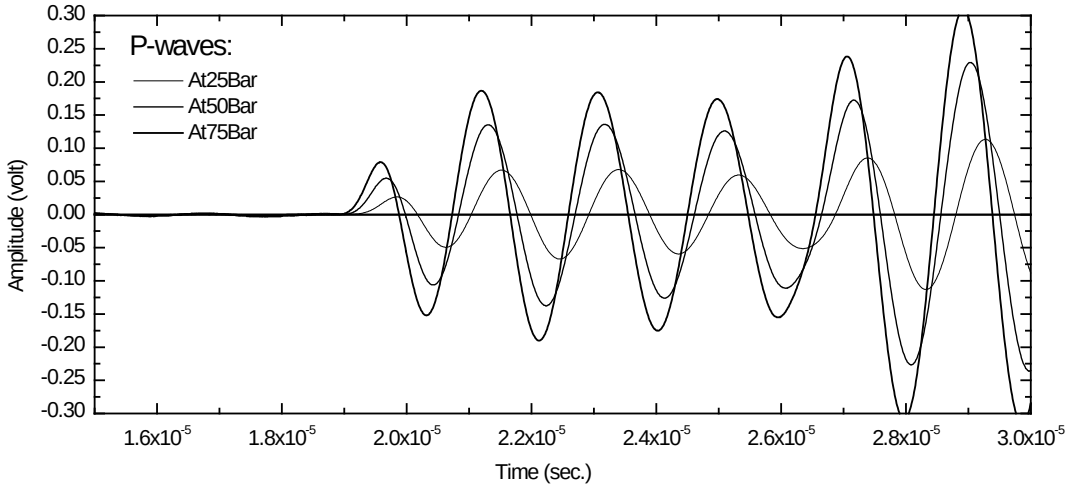
MFB-7	P@25 Bar: 19.1*10^{-6} sec.	S1@25 Bar: 34.0*10^{-6} sec.	S2@25 Bar: 34.0*10^{-6} sec.
Plug no. 172	P@50 Bar: 19.0*10^{-6} sec.	S1@50 Bar: 33.8*10^{-6} sec.	S2@50 Bar: 33.8*10^{-6} sec.
Dry	P@75 Bar: 18.9*10^{-6} sec.	S1@75 Bar: 33.6*10^{-6} sec.	S2@75 Bar: 33.7*10^{-6} sec.

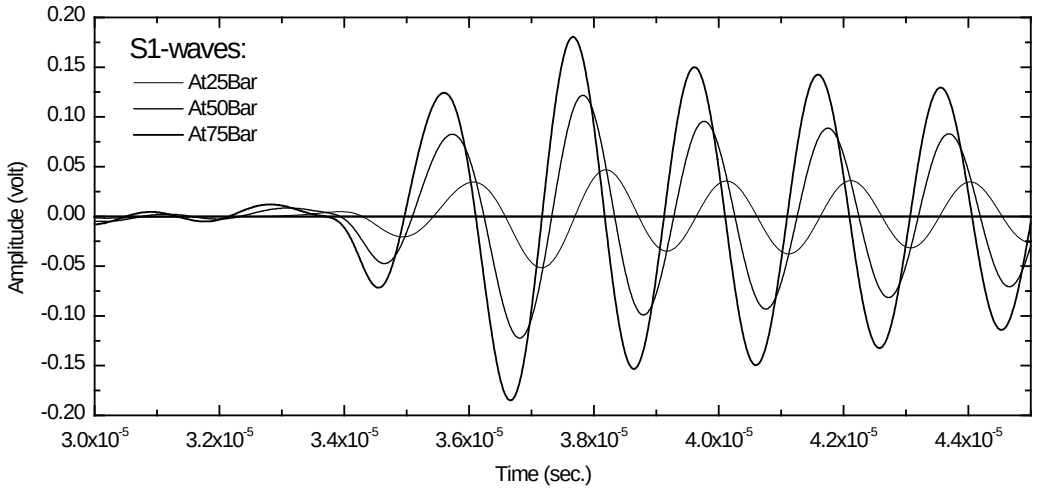


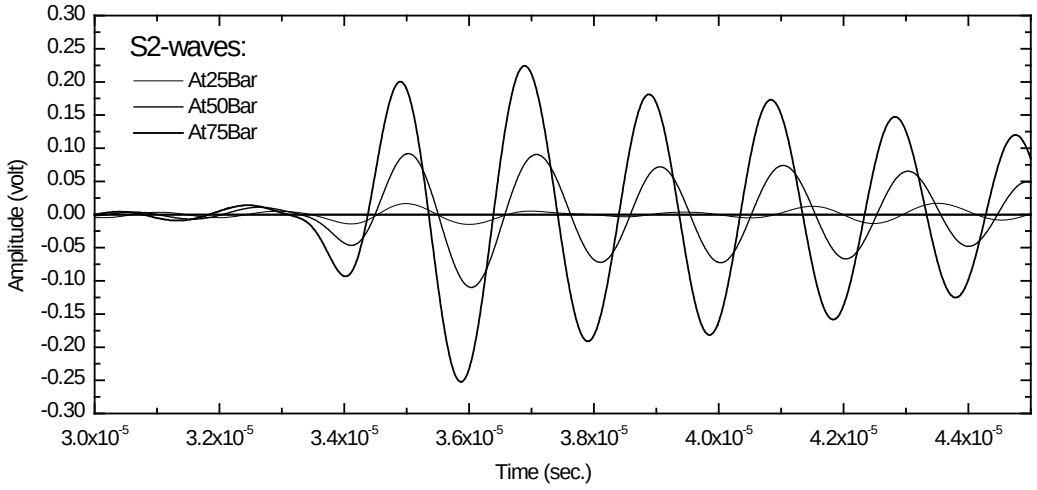




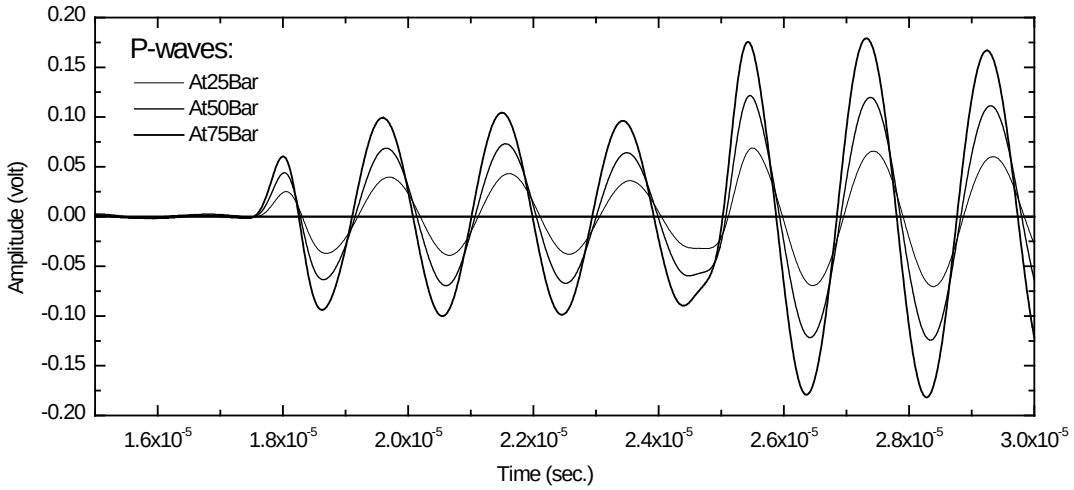
MFB-7	P@25 Bar: 18.6*10^{-6} sec.	S1@25 Bar: ? *10^{-6} sec.	S2@25 Bar: ? *10^{-6} sec.
Plug no. 175	P@50 Bar: 18.5*10^{-6} sec.	S1@50 Bar: 33.3*10^{-6} sec.	S2@50 Bar: 33.4*10^{-6} sec.
Dry	P@75 Bar: 18.4*10^{-6} sec.	S1@75 Bar: 33.2*10^{-6} sec.	S2@75 Bar: 33.2*10^{-6} sec.

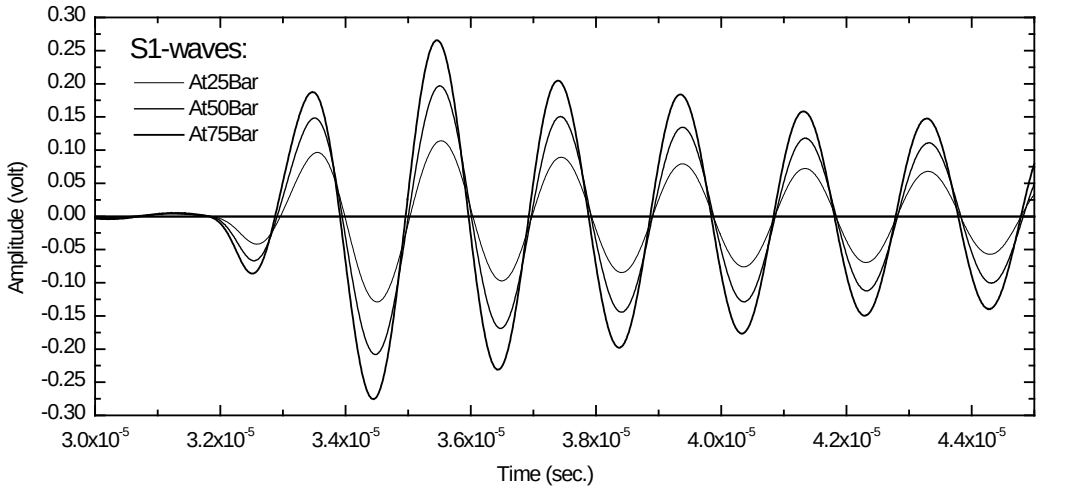


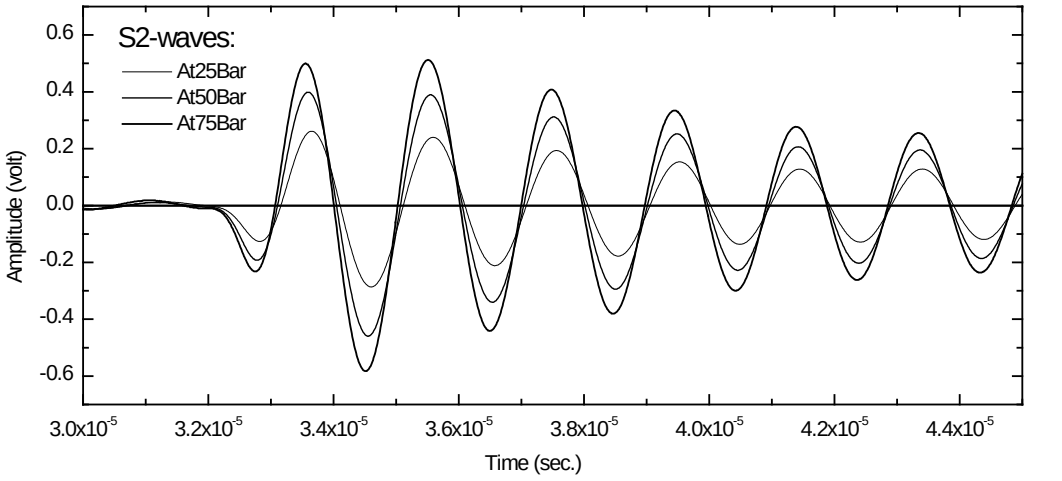




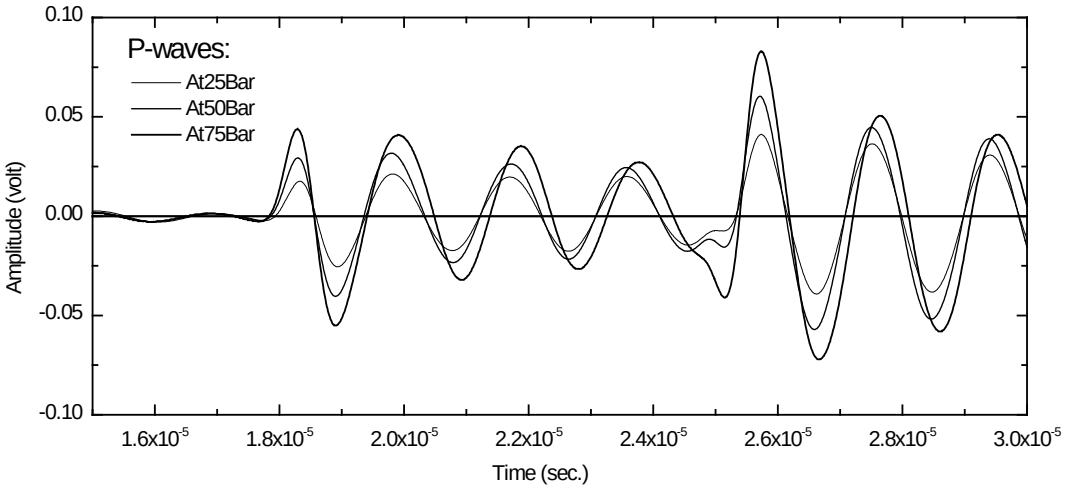
N-13	P@25 Bar: $17.6*10^{-6}$ sec.	S1@25 Bar: $32.0*10^{-6}$ sec.	S2@25 Bar: $32.1*10^{-6}$ sec.
Plug no. 176	P@50 Bar: $17.5*10^{-6}$ sec.	S1@50 Bar: $31.9*10^{-6}$ sec.	S2@50 Bar: $31.9*10^{-6}$ sec.
Dry	P@75 Bar: $17.5*10^{-6}$ sec.	S1@75 Bar: $31.8*10^{-6}$ sec.	S2@75 Bar: $31.8*10^{-6}$ sec.

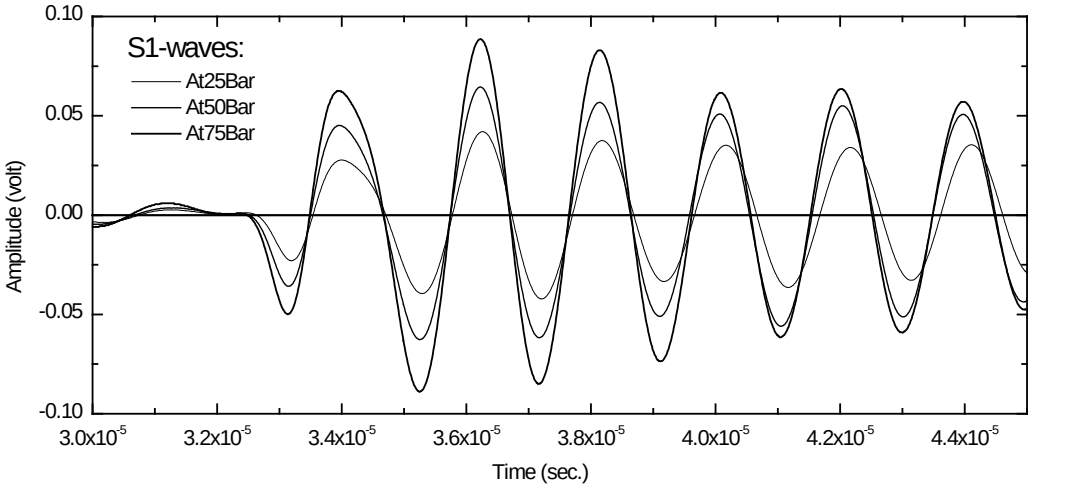


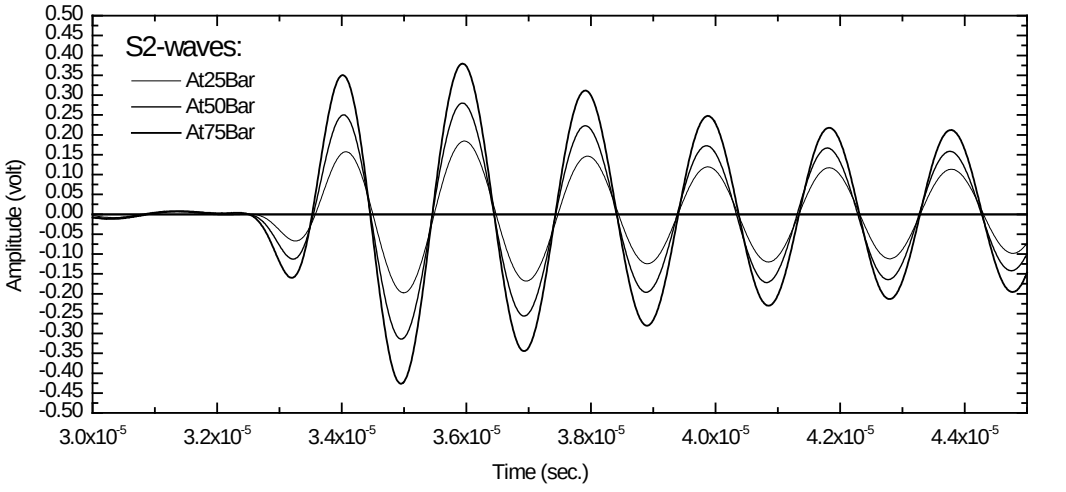




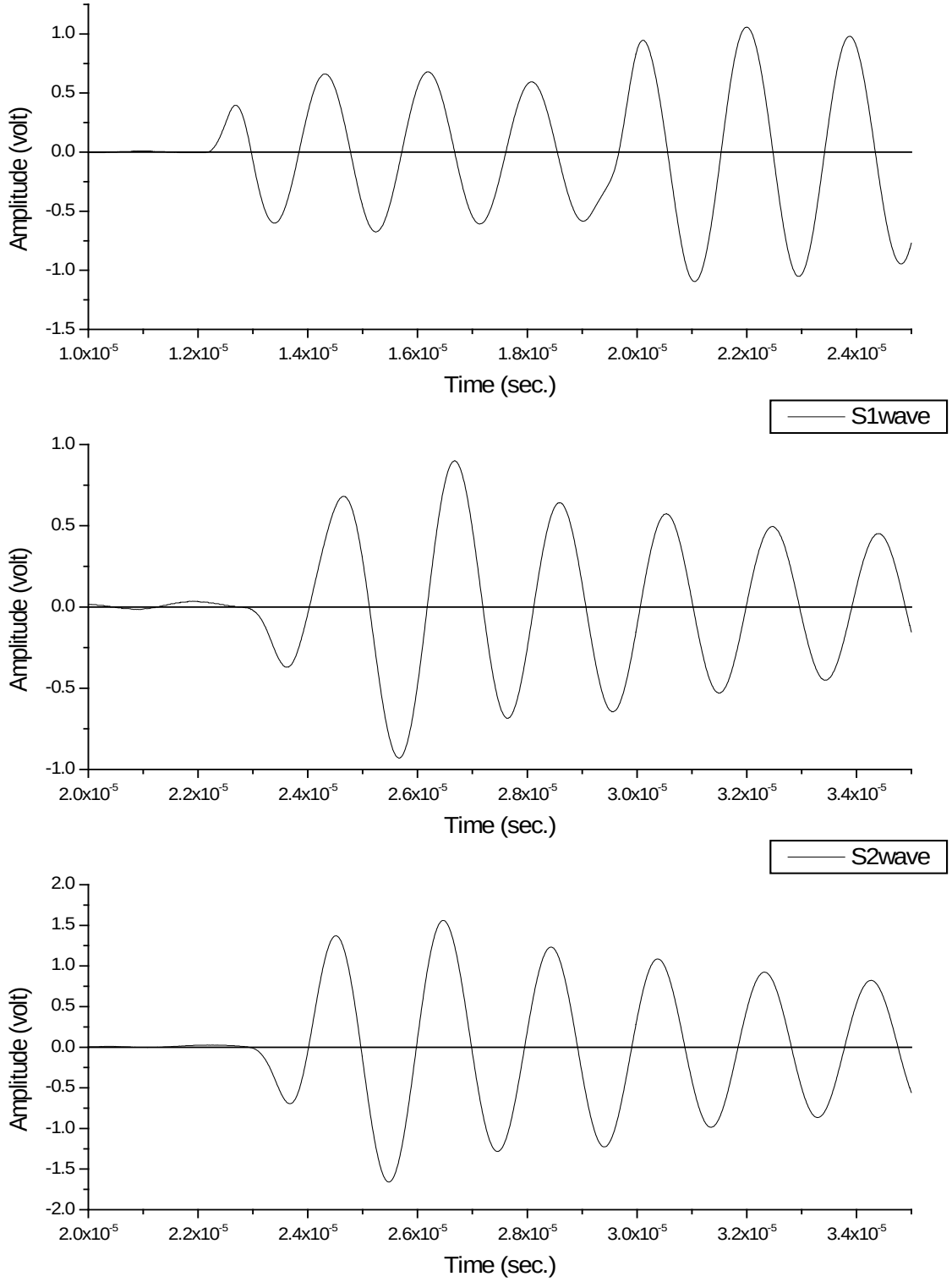
MFB-7	P@25 Bar: $17.9*10^{-6}$ sec.	S1@25 Bar: $32.6*10^{-6}$ sec.	S2@25 Bar: $32.6*10^{-6}$ sec.
Plug no. 177	P@50 Bar: $17.8*10^{-6}$ sec.	S1@50 Bar: $32.5*10^{-6}$ sec.	S2@50 Bar: $32.5*10^{-6}$ sec.
Dry	P@75 Bar: $17.7*10^{-6}$ sec.	S1@75 Bar: $32.4*10^{-6}$ sec.	S2@75 Bar: $32.4*10^{-6}$ sec.



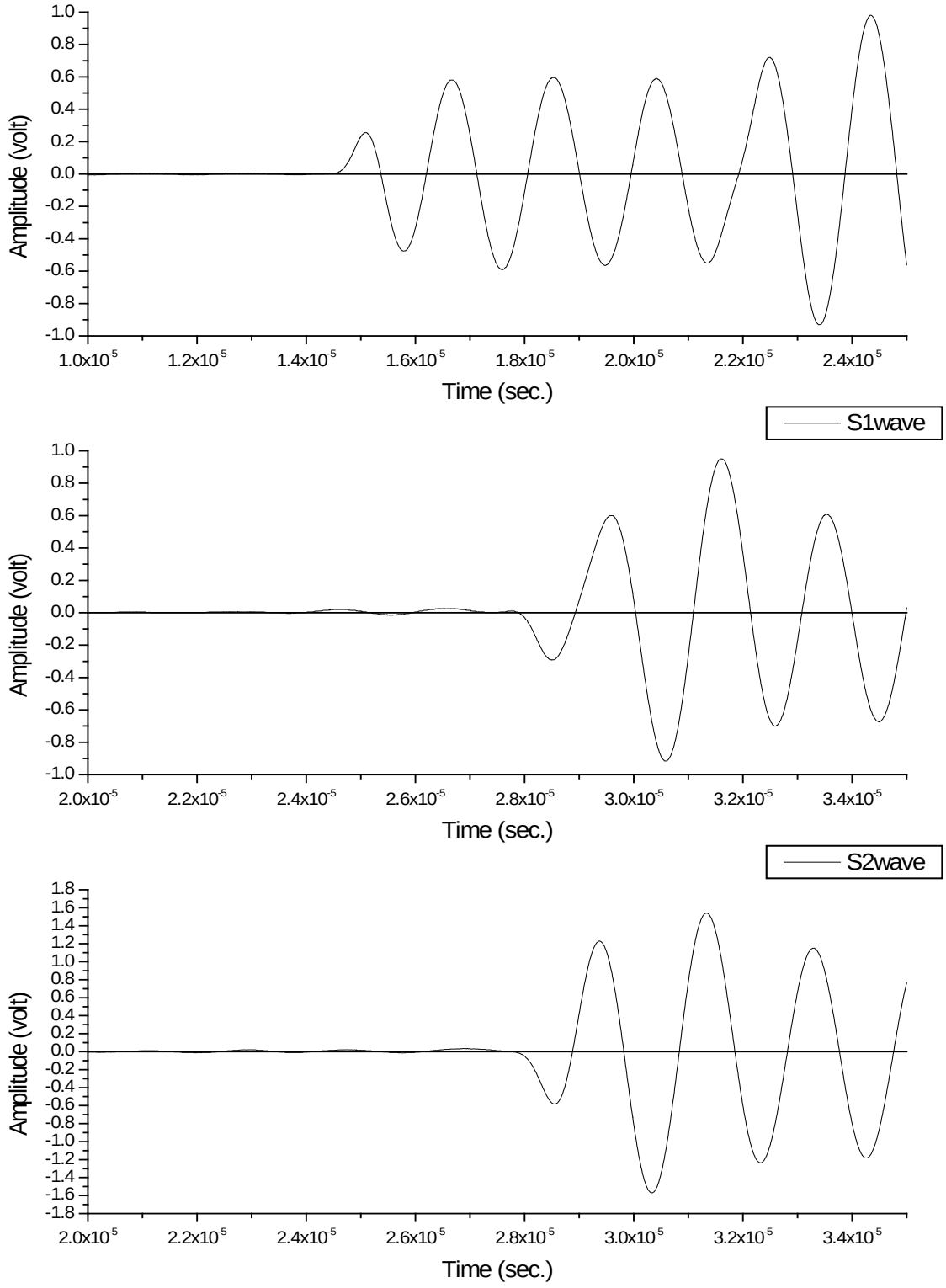




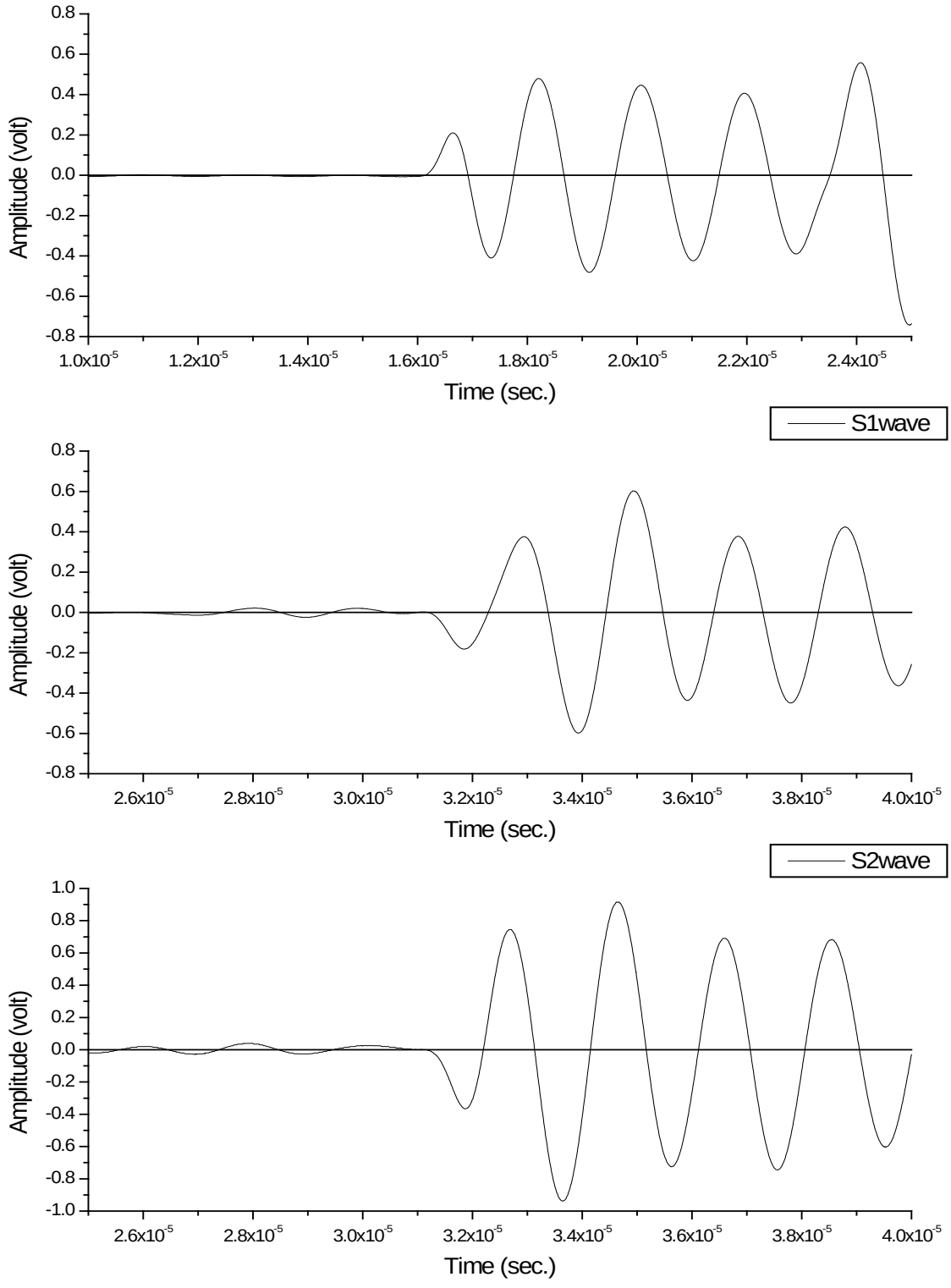
System delay time
No plug
Transducers P@100 Bar: $12.16*10^{-6}$ sec. S1@100 Bar: $22.90*10^{-6}$ sec. S2@100 Bar: $22.92*10^{-6}$ sec.



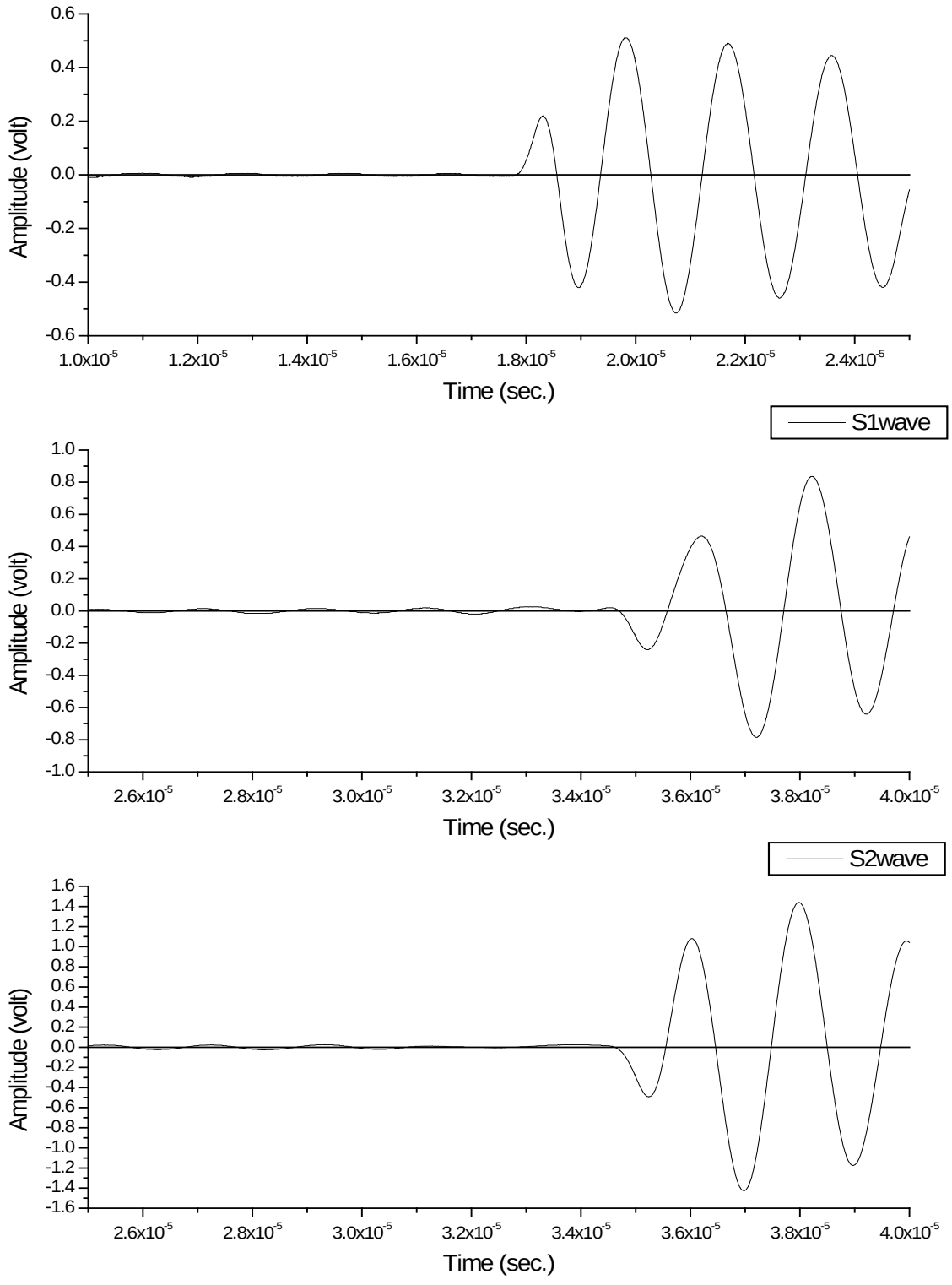
System delay time
14.94 mm plug
Aluminium P@100 Bar: $14.55*10^{-6}$ sec. S1@100 Bar: $27.80*10^{-6}$ sec. S2@100 Bar: $27.82*10^{-6}$ sec.



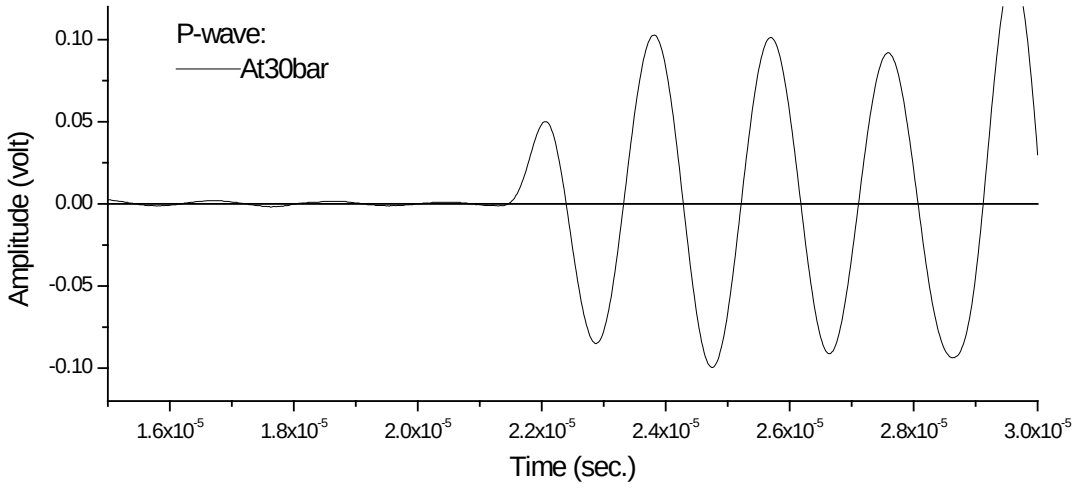
System delay time
24.93 mm plug
Aluminium P@100 Bar: $16.05*10^{-6}$ sec. S1@100 Bar: $31.15*10^{-6}$ sec. S2@100 Bar: $31.14*10^{-6}$ sec.

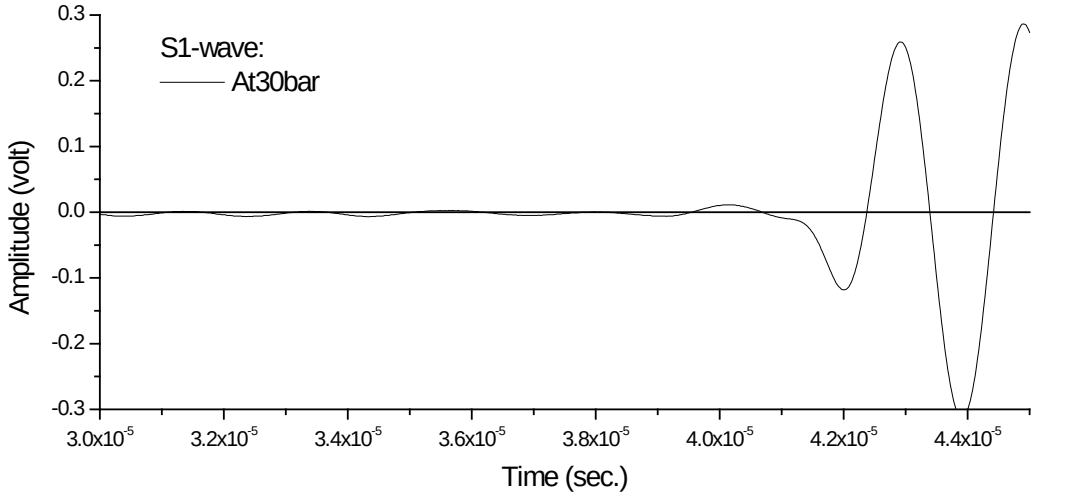


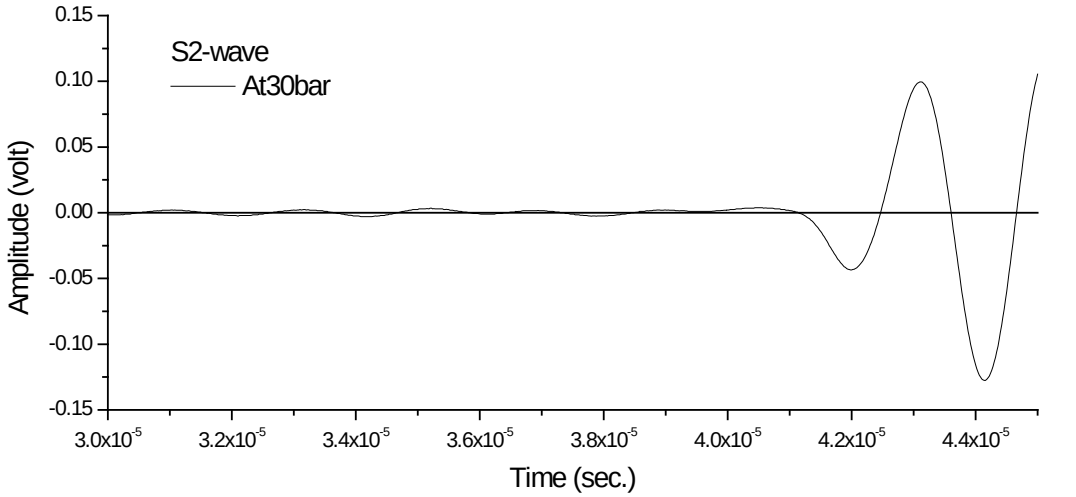
System delay time
35.90 mm plug
Aluminium P@100 Bar: $17.83*10^{-6}$ sec. S1@100 Bar: $34.53*10^{-6}$ sec. S2@100 Bar: $34.50*10^{-6}$ sec.



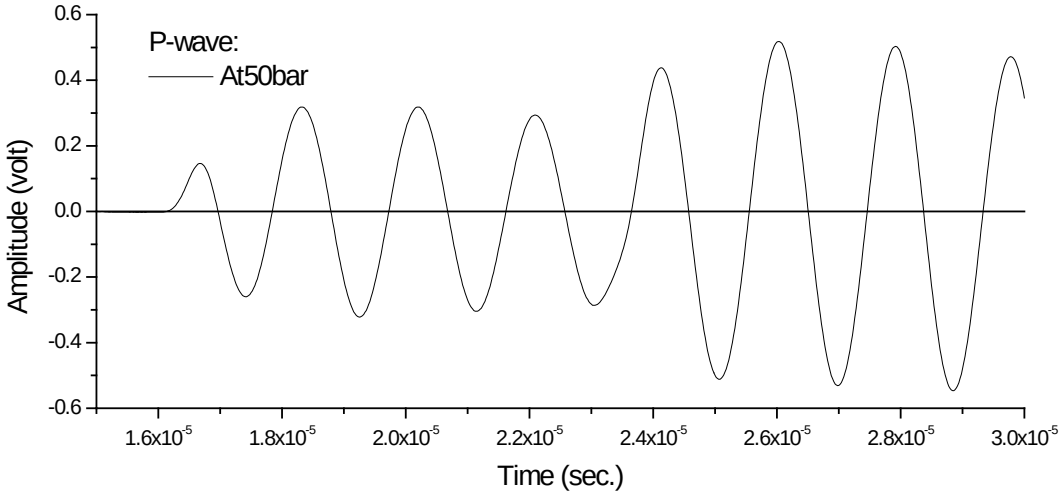
Reference plug
25.44 mm plug
Acrylic P@30 Bar: $21.45*10^{-6}$ sec. S1@30 Bar: $41.15*10^{-6}$ sec. S2@30 Bar: $41.30*10^{-6}$ sec.

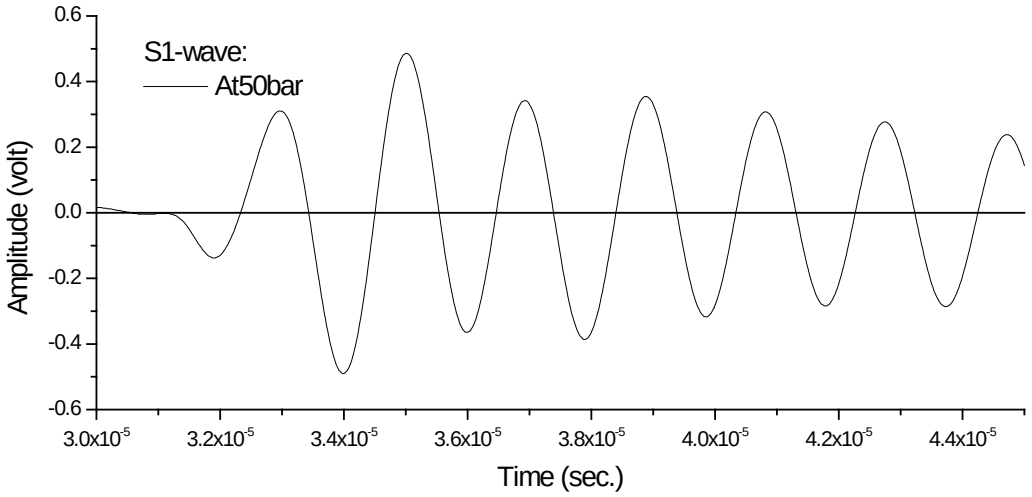


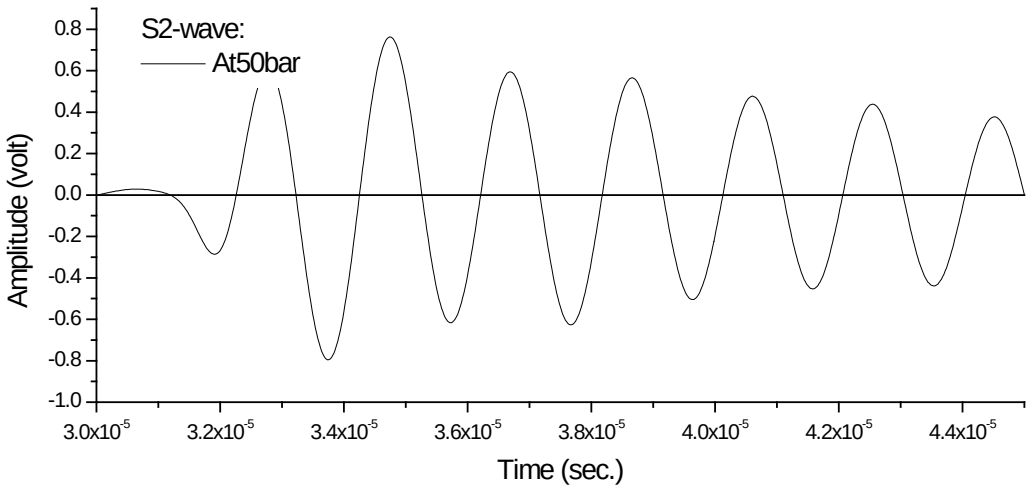


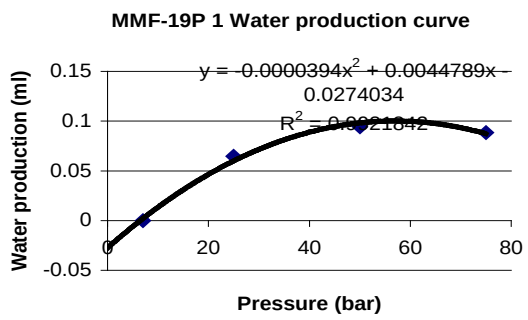


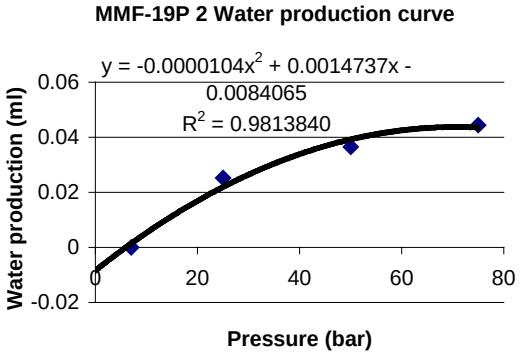
Reference plug
25.40 mm plug
Aluminium P@30 Bar: $16.14*10^{-6}$ sec. S1@30 Bar: $30.98*10^{-6}$ sec. S2@30 Bar: $31.06*10^{-6}$ sec.

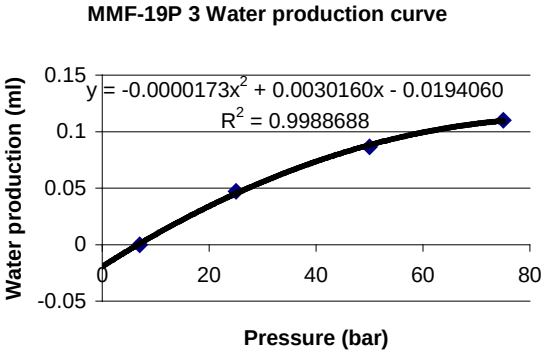


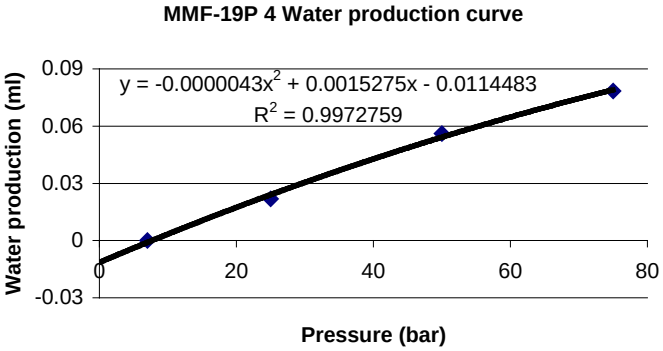


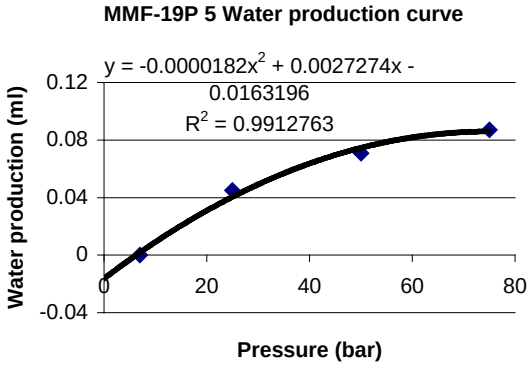












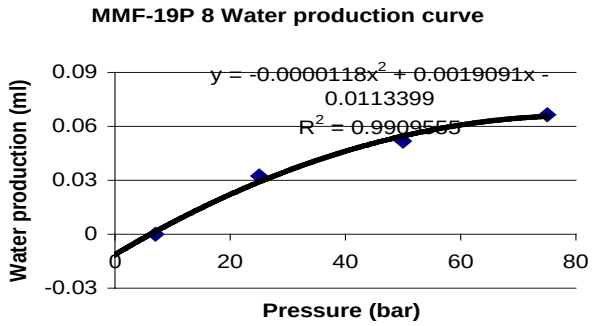
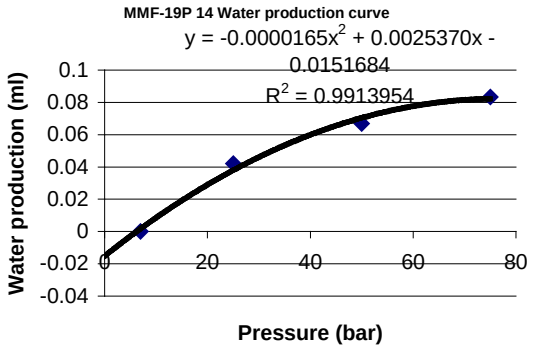
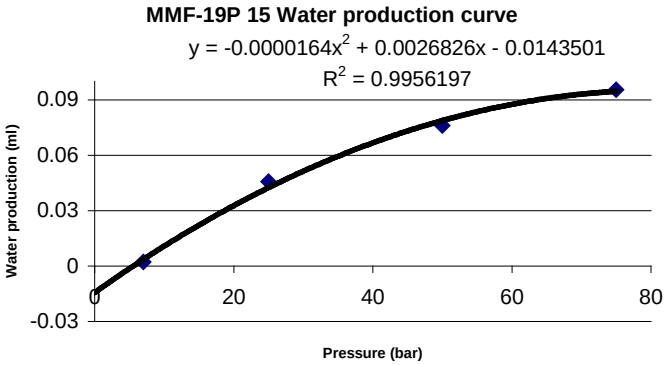


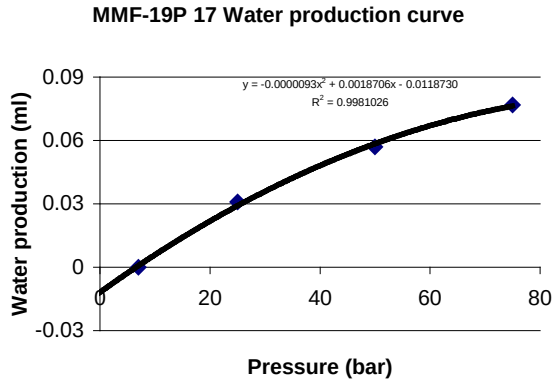
Table 5.x: Measured and corrected water production.

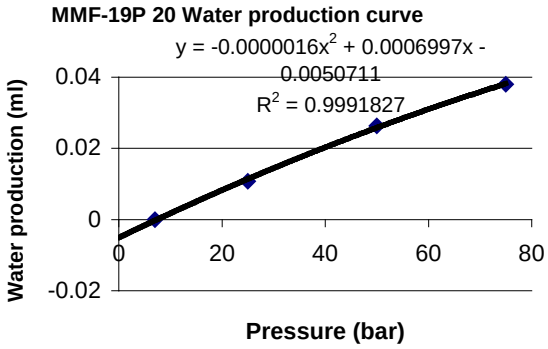
Pressure	1		2		3	
	Measured	Corrected	Measured	Corrected	Measured	Corrected
bar	ml	ml	ml	ml	ml	ml
7	0.0000	0.0274	0.0000	0.0084	0.0000	0.0194
25	0.0647	0.0921	0.0252	0.0336	0.0472	0.0666
50	0.0942	0.1216	0.0365	0.0449	0.0865	0.1059
75	0.0884	0.1158	0.0444	0.0528	0.1101	0.1295

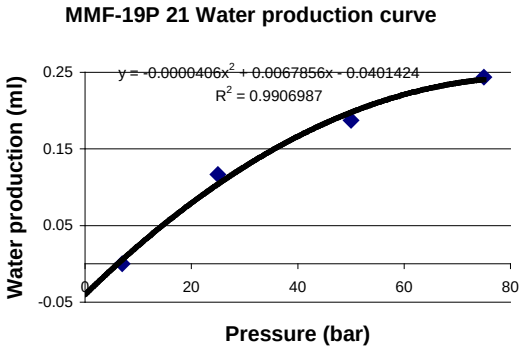
Pressure	4		5		8	
	Measured	Corrected	Measured	Corrected	Measured	Corrected
bar	ml	ml	ml	ml	ml	ml
7	0.0000	0.0114	0.0000	0.0163	0.0000	0.0113
25	0.0218	0.0332	0.0449	0.0612	0.0324	0.0437
50	0.0561	0.0675	0.0709	0.0872	0.0518	0.0631
75	0.0784	0.0898	0.0871	0.1034	0.0664	0.0777











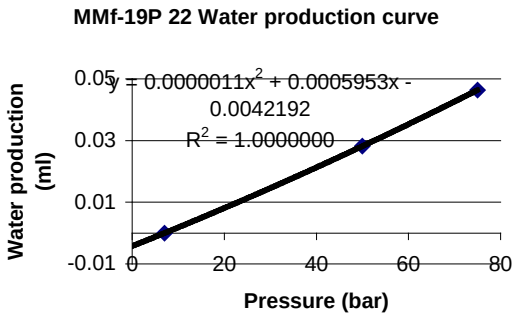
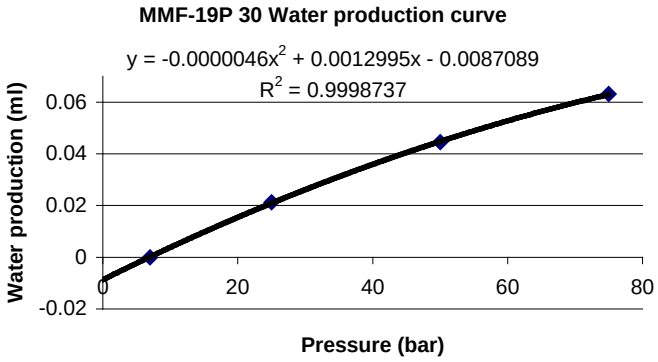
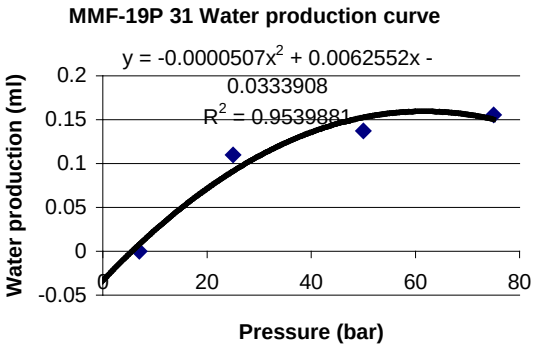


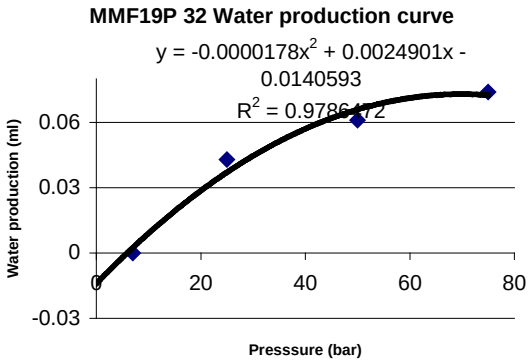
Table 5.x: Measured and corrected water production.

Pressure bar	14 Measured ml	Corrected ml	15 Measured ml	Corrected ml	17 Measured ml	Corrected ml
7	0.0000	0.0152	0.0022	0.0166	0.0000	0.0119
25	0.0421	0.0573	0.0458	0.0602	0.0309	0.0428
50	0.0669	0.0821	0.0760	0.0904	0.0570	0.0689
75	0.0833	0.0985	0.0955	0.1099	0.0768	0.0887

Pressure bar	20 Measured ml	Corrected ml	21 Measured ml	Corrected ml	22 Measured ml	Corrected ml
7	0.0000	0.015	0.0000	0.0401	0.0000	0.0045
25	0.0108	0.0258	0.1167	0.1568	-	-
50	0.02630	0.0413	0.1872	0.2273	0.0282	0.0327
75	0.03800	0.0530	0.2439	0.2840	0.0464	0.0509







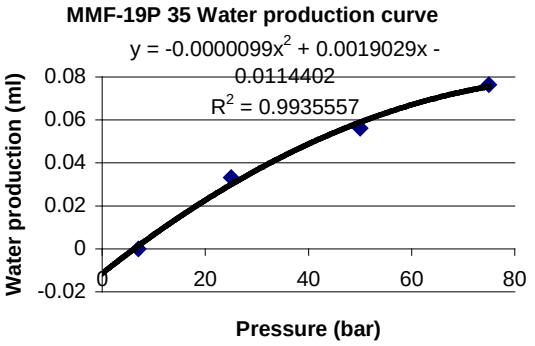


Table 5.x: Measured and corrected water production.

Pressure bar	30 Measured ml	Corrected ml	31 Measured ml	Corrected ml	32 Measured ml	Corrected ml
7	0.0000	0.0087	0.0000	0.0334	0.0000	0.0141
25	0.0213	0.0300	0.1098	0.1432	0.0429	0.0570
50	0.0445	0.0532	0.1371	0.1705	0.0610	0.0751
75	0.0631	0.0718	0.1554	0.1888	0.0740	0.0881

Pressure bar	35 Measured ml	Corrected ml				
7	0.0000	0.0114				
25	0.0332	0.0446				
50	0.0562	0.0676				
75	0.0764	0.0878				