Shock compressibility of water at a pressure of ~1 Mbar

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Very exact data on the shock compressibility of water at a pressure of ~1 Mbar were obtained by using the reflection method. These data make it possible to eliminate the uncertainty caused by the contradictory nature of existing experimental information.

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The possibility of appreciable oscillations of the shock adiabats, which are attributable to the electronic shell structure of the atom, has been pointed out in a number of mathematical and theoretical papers (for example, Refs. 1–3). Therefore, the problem of obtaining very precise experimental data on the shock compressibility of substances is very critical.

The experimental points of the shock adiabat of water at pressures of 1.04–1.14 Mbar, which could be considered as evidence for the appearance of such oscillation, were presented in Ref. 4. However, the data of other papers[5,6] indicate a low probability for such an assumption.

This paper is devoted to a study of the shock compressibility of water with the normal density $\rho_0 = 1$ g/cm^3 by using the reflection method within this fundamentally important range of pressures.

To ensure high accuracy, we performed measurements along the large bases under strong explosion conditions analogous to those of Refs. 7 and 8. Aluminum ($\rho_0 = 2.706$ g/cm^3) and iron ($\rho_0 = 7.857$ g/cm^3) were used as standards. The studies were performed by using the electrical contact method (8 sensors were placed on each contact surface between the standard plate and water). The time intervals were recorded by a multichannel analog recording system on a magnetic drum with an error of better than ± 0.04 μsec. The measurement base in the standard was 75 mm, and in water it was 62 mm.

Table I lists the wave velocities D (km/sec) at the middles of the measurement

TABLE I.

	Parameters / Substance	D	ΔD	δD	P	U	σ
1	Iron	11.374	2.6	1.1	4.010	14.608	1.713
	Water	12.270	2.2	1.5	0.954	7.607	2.542
2	Aluminum	12.673	1.3	0.7	1.863	5.507	1.787
	Water	12.168	1.8	1.5	0.937	7.566	2.570

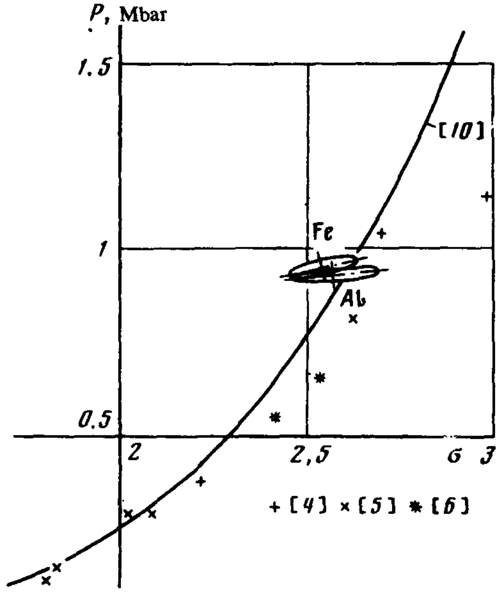

FIG. 1.

bases, the error ΔD (%), taking into account the non-steady-state gas-dynamic motion during the transition to these values at the contact surface, and the relative errors $\delta\Delta$ (%) at a 0.95 confidence level.

The processing of this information in accordance with the reflection method using the adiabats of the standard materials[9] gives the pressure P (Mbar), the mass velocity u (km/sec), and the compression $\sigma = \rho/\rho_0$ (ρ is the density of the shock:compresed substance) also listed in Table I.

In the experiments we measured the wave velocity in the water in front of the standard; this provides information about the location of the points of the shock adiabat for two-fold compression of water. According to the measurements with iron, the state $P = 1.66$ Mbar, $\sigma = 2.95$ becomes the state $P = 4.62$ Mbar, $\sigma = 4.18$; according to the measurements with aluminum, the state $P = 1.08$ Mbar, $\sigma = 2.68$ becomes the state $P = 2.01$ Mbar, $\sigma = 3.23$. The error in the wave velocity measurements along this base amounted to $\delta D = 2.5\%$; therefore, the given results must be assumed to be preliminary results.

Figure 1 compares the obtained data with those of other researchers and with the shock adiabat of water,[10] which takes into account all available experimental and theoretical information. The error ellipses, corresponding to the chosen confidence value, are shown.

The results obtained by means of the two standards are in good agreement and are close to the shock adiabat.[10] This indicates that the possible oscillations of the shock adiabat of water are smaller than those of Ref. 4 within the investigated range of pressures.

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