[redacted]

LA-4942

Copy No. C.3 A

[redacted]

Hugoniot Equations of State of Li^6H, Li^6D, Li^nH, and Li^nD (U)

los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87544

[redacted]

APPROVED FOR PUBLIC RELEASE

Classified by John W. McDonald
ISD-6 Classification Officer

Excluded from automatic downgrading or declassification by Sec. 5B2 of Executive Order 11652.

APPROVED FOR PUBLIC RELEASE

[redacted]

This document consists of 29 pages
No. [redacted] of 40 copies, Series A

UNCLASSIFIED

LA-4942

[redacted]

ISSUED: July 1972

los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87544

Hugoniot Equations of State of Li^6H, Li^6D, Li^nH, and Li^nD (U)

by

S. P. Marsh

[redacted]

UNCLASSIFIED

APPR [redacted] RELEASE

[redacted]

APPROVED FOR PUBLIC RELEASE

[redacted]

U/P

HUGONIOT EQUATIONS OF STATE OF Li^6H, Li^6D, Li^nH, AND Li^nD

by

S. P. Marsh

Energy per gram

ABSTRACT [redacted]

An experimental value of 1.08 cm^3/g for $(\partial E/\partial P)_v$ was determined from the Hugoniot data on pressed Li^6D of various porosities which agrees well with the thermodynamic value of $(\partial E/\partial P)_v$. For each of the isotopic combinations Li^6H, Li^nH, Li^6D, and Li^nD crystal-density Hugoniots and equations of state were calculated from Hugoniot data on pressed material having porosity of 5% or less and from the thermodynamic values of $(\partial E/\partial P)_v$. No evidence of a polymorphic transition was observed.

Ultrasonic measurements of longitudinal and shear-wave velocities in these materials pressed to near crystal density were obtained, and the isotropic elastic moduli were calculated. In addition, elastic constants were determined for crystals of Li^nH, Li^7H, and Li^7D.

INTRODUCTION

Hugoniot data for Li^nH and Li^nD have been reported by a number of investigators. In 1954, Walsh[1] studied pressed Li^nH to pressures of 160 kbar. He also reported data[2] on single crystals of $Li^n(D_{0.80}H_{0.20})$ shocked to pressures above 500 kbar. In 1954, Burton and Landeen[3] obtained two Hugoniot data points on pressed Li^nH at pressures above 700 kbar using a spherically convergent driver system. In 1965, Kusubov[4] obtained data on pressed Li^6H, Li^6D, Li^7H, and Li^7D at pressures up to 500 kbar, as well as longitudinal and shear-wave velocities for each material. In 1969, May[5] and Guess[6] reported Hugoniot data below 200 kbar, obtained using quartz-gage detectors on pressed Li^nH. Guess also reported longitudinal and shear-wave velocities in this same material.

In this endeavor, we have determined the Hugoniots of Li^6D pressed to near crystal density and at porosities of approximately 5, 8, 17, 28, 36, and 44%. The wide range of initial densities enabled us to determine the average values of the Grüneisen gamma, $\gamma = V(\partial P/\partial E)_v$. These values are compared with the Grüneisen ratio determined from thermodynamic measurements at standard temperature and pressure. The Hugoniots of the isotopic combinations, Li^6H, Li^nH and Li^7H, and Li^nD for pressed samples with an initial 5% porosity have also been determined. Further, we have obtained Hugoniot data on a few crystals of Li^7H and Li^7D, and have determined elastic constants for crystals of Li^nH, Li^7H, and Li^7D.

MATERIAL

The crystals used in these experiments were prepared by Pretzel and Thrasher of LASL

Group CMB-3. All pressed materials and their chemical analysis and densities were obtained from Y-12 at Oak Ridge. The Li^6 had a composition of 95.5 at.% Li^6 and 4.5 at.% Li^7; the normal Li^n was 7.5 at.% Li^6 and 92.5 at.% Li^7; and the Li^7 was 100 at.% Li^7. The isotopic purity of the hydrogen and deuterium was above 99 at.%. The densities of the four pure isotopic combinations were calculated from the lattice parameters reported by Anderson et al.[7] We used these densities to compute the value of the crystal densities of the particular isotopic compositions used here. The Oak Ridge analysis provided an estimate of the oxygen in our samples, and we calculated their ideal or crystal density by mixing 2 wt% of the hydroxide or deuteroxide using the densities that Vier[8] reported and the density for oxygen-free materials. These densities were used to determine the porosity and are listed in Table I at the end of this report.

ELASTIC CONSTANTS IN LITHIUM HYDRIDE AND LITHIUM DEUTERIDE

Elastic-wave velocities were determined ultrasonically using a pulse-echo method[9] on pressed isotropic samples at near crystal density for all isotopic compositions. The longitudinal and shear-wave velocities (V_L and V_s) were measured, and the bulk sound velocity (C_b) was calculated from the expression

$$C_b^2 = V_L^2 - 4/3\, V_s^2 .$$

Table II lists the results of sound-velocity measurements on the various isotopic combinations of lithium hydride at near crystal density and at approximately 5% porosity. The bulk modulus (B_s), shear modulus (μ), Young's modulus (Y), longitudinal modulus (B_L), and Poisson's ratio (σ) are also listed.

Using the same apparatus used for making pulse-echo sound-velocity measurements in pressed specimens, we determined the sound velocities in Li^nH, Li^7H, and Li^7D crystals. Because of the difficulty in seeing the arrival time of the echo signals, we used a different method of measurement in which we observed the arrival times through several different thicknesses of sample and obtained the velocity from the derivative of the resulting x-t data. Table III shows the results of these measurements for both the longitudinal and shear-wave velocities in the [100] direction and the longitudinal and two shear-wave velocities in the [110] direction. The errors in the longitudinal and shear-wave velocities are 0.5 and 1.0%, respectively. We obtained the elastic constants using the following set of equations which involve only the velocities in the [100] direction and the bulk sound velocities (C_b) deduced from sound-velocity measurements on pressed isotropic samples.

$$c_{11} = \rho V_L^2[100],$$

$$c_{44} = \rho V_s^2[100],$$

$$c_{12} = \frac{3\rho C_b^2 - \rho V_L^2[100]}{2} .$$

We compared the measured velocities in the [110] direction with the calculated velocities in that direction to check the derived elastic constants. The expressions used to calculate these velocities were

$$V_L[110] = \sqrt{\frac{c_{11} + c_{12} + 2c_{44}}{2\rho}},$$

$$V_{1s}[110] = \sqrt{\frac{c_{44}}{\rho}}$$ (for particle motion in the [001] direction),

$$V_{2s}[110] = \sqrt{\frac{c_{11} - c_{12}}{2\rho}}$$ (for particle motion in the $[1\bar{1}0]$ direction).

The measured and calculated velocities in this direction differ by several percent, a greater amount than would be anticipated from the error in the elastic constants, which is 1, 2, and 20% in c_{11}, c_{44}, and c_{12}, respectively. The reason for this discrepancy is not understood. Another disturbing feature observed in this table is that the c_{11} and c_{44} values for Li^7D are lower than the corresponding values for Li^nH and Li^7H. We feel that because the lattice spacing is smaller for Li^7D, the zero-point energy is also lower and, consequently, the elastic constants should be higher. We can give no reason for this apparent reversal. The differences in the elastic constants for Li^nH and Li^7H are not statistically significant.

The elastic moduli in Table II show a distinct relationship to isotopic composition. The bulk modulus, shear modulus, Young's modulus, and longitudinal modulus agree for Li^6H and Li^nH and are 3% smaller than the elastic moduli of the deuterides, which are also in agreement. In this case, the elastic moduli are consistent with the zero-point energy assumption mentioned above.

SHOCK-WAVE EXPERIMENTS

We used Walsh and Christian's shock-impedance match technique[10] with 2024 Al as a standard, and the optical flash-gap method to determine the Hugoniots. The shock velocities in both the standard and lithium hydride samples were measured with a sweeping-image camera. Having the equation of state of the standard and the shock velocities in both the standard and lithium hydride samples permits determination of the pressure and particle velocity. A linear shock-particle velocity Hugoniot,

$$U_s = 5.328 + 1.338\ U_p \text{ (in units of km/sec)},$$

and a constant value of

$$\rho\gamma = 5.57\ \text{g/cm}^3$$

(where ρ and γ are the density and Grüneisen parameter) specify the equation of state of the standard required for the impedance-match solution.

We determined the density and internal energy of the shocked materials using the Rankine-Hugoniot relations. Tables IV - XIII show the experimental data and derived Hugoniot parameters.

ANALYSIS AND INTERPRETATION

Performing shock-wave experiments on materials of different porosities allows examination of different pressure-energy regions because the greater the initial volume, the greater the pressure and internal energy at the same final density. This can be seen in Fig. 1 where the pressure-density shock-wave data for the Li^6D are plotted. The curve in this figure is a linear fit of the U_s-U_p data for the high-density samples, presented in Fig. 2.

An average $(\partial E/\partial P)_v$ value can be determined for each experimental point of the low-initial-density material by differencing its pressure and energy with the pressure and energy calculated at the same density from the fit of the high-density data. These $(\partial E/\partial P)_v$ values for the five most porous materials are shown in Fig. 3. The $(\partial E/\partial P)_v$ values calculated from porous-material data having small energy and pressure offsets from the high-density Hugoniot (which includes all the low-pressure data) have large errors; consequently, we show only $(\partial E/\partial P)_v$ values for which ΔP was larger than 15 kbar. The average $(\partial E/\partial P)_v$ value determined from these experiments is 1.08 cm^3/g, and within experimental error it does not appear to be a function of density or pressure.

We calculated the Grüneisen γ's at standard conditions, along with the corresponding $(\partial E/\partial P)_v$ values, using the expressions

$$\gamma = \frac{\beta C_b^2}{c_p}, \quad \gamma = V_0/(\partial E/\partial P)_v .$$

We obtained the values of β (volume coefficient of thermal expansion at 25°C) for all isotopic compositions by interpolating the thermal-expansion data of Anderson et al.[7] (Fig. 4) and used them for our isotopic compositions. The resulting Li^7H value (31.0×10^{-6}/°K) is somewhat lower than that obtained by a number of other investigators,[11-14] but it agrees with the compilation by Goldsmith et al.[15] for Li^nH at 25°C. The 6.682-cal/mol°K value of c_p (specific heat at a constant pressure) for Li^nH was obtained from the JANAF Tables.[16] This value was used for all isotopic compositions. The specific volume (V_0)

[redacted]

and bulk sound velocities are those given in Table I (for chemically pure compounds) and Table II. A summary of these values and the resulting values of γ and $(\partial E/\partial P)_V$ is given in Table XIV. The experimental (1.08-cm^3/g) value of $(\partial E/\partial P)_V$ for Li^6D agrees well with the thermodynamic value of 1.13 cm^3/g shown in this table.

The values of $(\partial E/\partial P)_V$ in Table XIV were used to transform the Hugoniot data obtained on the porous samples to pressures and energies corresponding to samples at crystal density.[9] These transformations are made at constant volume. The recentered Hugoniot data and a linear least-squares fit of the U_s-U_p points are shown in the U_s-U_p plane and the P-ρ plane in Figs. 5-12 along with the bulk sound velocities with which the intercepts should agree if there are no transitions. The least-squares fits summarized in Table XV were determined only from points having $U_p > 0.9$ km/sec. We chose this lower particle-velocity limit to avoid the extreme sensitivity of the transformed U_s-U_p points to small errors in the original data at low pressure. The bulk sound velocities and the Hugoniot intercepts agree well.

From these Hugoniots and the thermodynamic data in Table XIV, one can determine a complete equation of state for each material.[9] Tables XVI-XIX list the thermodynamic parameters on the Hugoniot, the foot of the release isentrope, and the isotherms at room temperature and at 0°K. The zero-pressure parameters used in calculating these loci are summarized at the head of each table.

In Figs. 13-16 our Hugoniot results are compared with the results of other investigators studying similar isotopic compositions. We converted isothermal compression data to Hugoniot shock velocity-particle velocity points using the equations of state shown in Tables XVI-XIX. Stevens and Lilley's results[17] generally show less compressibility than ours, and Kusubov's results[4] for Li^6H and Li^6D show considerably greater compressibility. Burton and Landeen's high-pressure data[3] for Li^6H are also more compressible than our extrapolated Hugoniot.

TRANSITION IN LITHIUM HYDRIDE AND LITHIUM DEUTERIDE

Several investigators have postulated a transition from the NaCl to the CsCl structure in lithium hydride, but no transformation has been observed. Schumacher,[18] using two different Born-Mayer potentials for lithium hydride, calculates a transition at 3 to 4 kbar involving a volume change of about 0.4%. Voronov et al.[19] showed experimentally that there is a linear relationship of compressibility to pressure up to 20 kbar which did not fit the simple Born model. Using Schumacher's potential function, he predicted that the transition should occur at 140 kbar with a volume change of 14%. Other experimenters[20,21] have also examined lithium hydride and have found no evidence for a transformation. Stephens and Lilley[17] determined the isothermal compressibility of Li^6H, Li^6D, Li^7H, and Li^7D up to 40 kbar and found that their data fit the simple Born-Mayer model, but observed no transition.

There is no evidence of a transition for any of the isotopic combinations in the pressure region (60 to 450 kbar) that we investigated. The data for the low-porosity Li^6D are particularly important, and although the low-pressure data have considerable scatter there is no evidence of a kink indicative of a transition in the U_s-U_p curve. It is somewhat more difficult to detect transitions in the more porous samples, however. Although we see no evidence for a transition in our data, it may possibly be present but have too small a volume change to be observed as a discontinuity in the shock-wave data.

REFERENCES

1. J. M. Walsh, LASL internal document (June 1954).

2. J. M. Walsh, LASL internal document (November 1956).

[redacted]

3. B. L. Burton and S. A. Landeen, LASL internal Progress Report, August 16, 1954, to September 15, 1954.

4. A. Kusubov, "Dynamic Equation of State of Li^6H and Li^6D," LRL report COTMA 67-9, STN # 97 (May 14, 1965).

5. R. P. May, "High Pressure Shock Wave Study of Lithium Hydride (Li^7H) in the Solid and Distended States," Sandia Laboratories report SC-DR-68-875 (February 1969).

6. T. R. Guess, "Low-Pressure Equation of State Studies on Lithium Hydride (Li^7H) in the Distended Sates," Sandia Laboratories report SC-DR-69-762 (November 1969).

7. J. L. Anderson, J. Nasise, K. Philipson, and F. E. Pretzel, J. Phys. Chem. Solids 31, 613 (1970).

8. D. T. Vier, "Calculated Density of Lithium Hydride and Lithium Hydroxide for Various Isotopic Compositions," Los Alamos Scientific Laboratory report LAMS-3047 (March 1964).

9. R. G. McQueen, S. P. Marsh, J. W. Taylor, J. N. Fritz, and W. J. Carter, "The Equation of State of Solids from Shock Wave Studies," in High-Velocity Impact Phenomena, R. Kinslow, Ed. (Academic Press, New York, 1970).

10. J. M. Walsh and R. H. Christian, Phys. Rev. 97, 1544 (1955).

11. A. Zalkin, "The Thermal Expansion of LiH," University of California Radiation Laboratory report UCRL-4239 (November 1953).

12. H. Laquer, "Low-Temperature Thermal Expansion of Various Materials," Los Alamos Scientific Laboratory report LA-1505 (December 1952).

13. H. Laquer and E. Head, private communication to Tannenbaum (see Ref. 14).

14. I. R. Tannenbaum and F. H. Ellinger, "The Thermal Expansion of Lithium Hydride in the Temperature Range 0-500°C," Los Alamos Scientific Laboratory report LAMS-1650 (July 1954).

15. A. Goldsmith, T. E. Waterman, and H. J. Hirschhorn, "Thermophysical Properties of Solid Materials," Vol. IV, Wright Air Development Division report WADC-TR-58-476 (November 1960).

16. JANAF Thermochemical Tables (D. R. Stull, Project Director), The Thermal Research Laboratory, Dow Chemical Company, Midland, Michigan (September 1967).

17. D. R. Stephens and E. M. Lilley, J. Appl. Phys. 39, 177 (1968).

18. D. P. Schumacher, Phys. Rev. 126, 1679 (1962).

19. F. F. Voronov, V. A. Goncharova, O. V. Stal'gorova, and T. A. Agapova, Soviet Physics - Solid State 8, 1313 (1966).

20. D. T. Griggs, W. G. McMillan, E. D. Michael, and C. P. Nash, Phys. Rev. 109, 1858 (1958).

21. R. Weil and A. W. Lawson, J. Chem. Phys. 37, 2730 (1962).

[redacted]

TABLE I

CRYSTAL DENSITIES OF Li^6H, Li^6D, Li^nH, AND Li^nD

Pure Isotopes		Isotopic Purity for this Study		Corrected for Assumed 2 wt% Hydroxide or Deuteroxide
Material	Density (g/cm^3)	Material	Density (g/cm^3)	Density (g/cm^3)
Li^6H	0.6842	$(Li^6_{0.955}Li^7_{0.045})H$	0.689	0.696
Li^6D	.7905	$(Li^6_{0.955}Li^7_{0.045})D$	.795	.802
Li^7H	.7830	$(Li^6_{0.075}Li^7_{0.925})H$	.776	.783
Li^7D	.8900	$(Li^6_{0.075}Li^7_{0.925})D$	.883	.890

TABLE II

SOUND VELOCITIES AND ELASTIC MODULI OF Li^6H, Li^6D, Li^nH, AND Li^nD

	Density	Sound Velocities (km/sec)			Elastic Moduli (kbar)				
Material	(g/cm^3)	V_L	V_S	C_b	B_S	μ	Y	B_L	σ
Li^6H	0.698	10.67	7.18	6.72	314	359	781	794	0.086
Li^6D	.799	10.10	6.80	6.35	322	369	802	815	.085
Li^nH	.782	10.05	6.75	6.34	314	356	776	789	.089
Li^nD	.894	9.56	6.43	6.02	324	369	803	817	.087
Li^6H	.666	10.42	6.86						
Li^6D	.764	9.72	6.53						
Li^nH	.743	9.84	6.61						
Li^nD	.840	9.36	6.31						

TABLE III

ELASTIC CONSTANTS OF Li^nH, Li^7H, AND Li^7D

Mat	ρ_0 (g/cm^3)	$V_L[100]$ (km/sec)	$V_S[100]$ (km/sec)	C_b (km/sec)	c_{11} (kbar)	c_{44} (kbar)	c_{12} (kbar)	$V_L[110]$ (km/sec)	$V_{1S}[110]$ ξ along [001] (km/sec)	$V_{2S}[110]$ ξ along [1$\bar{1}$0] (km/sec)
Li^nH	0.776	9.06	7.40	6.34	636	424	150	10.55	7.62	5.77
								10.26*	7.40*	5.60*
Li^7H	.783	9.02	7.39	6.34	637	428	154	10.50	7.70	5.80
								10.25*	7.39*	5.56*
Li^7D	.890	8.38	6.81	6.02	626	419	171	-	-	-
								9.58*	6.81*	5.05*

*Calculated

TABLE IV

HUGONIOT DATA FOR Li^6D ($\bar{\rho}_0$ = 0.798 g/cm^3)

ρ_0 (g/cm^3)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm^3)	$U_{s\,calc}$ (km/sec)
0.792	7.39	0.69	0.040	0.874	5.96
.805	7.56	.91	.055	.915	6.17
.798	7.98	1.31	.083	.955	8.53
.799	8.48	1.71	.116	1.001	6.91
.798	9.15	2.43	.177	1.086	7.59
.800	9.44	2.66	.201	1.113	7.81
.798	9.67	2.80	.216	1.122	7.95
.799	10.00	3.12	.249	1.162	8.26
.799	10.21	3.28	.268	1.177	8.41
.798	10.37	3.47	.287	1.199	8.59
.798	10.63	3.79	.321	1.239	8.89
.798	10.79	3.79	.327	1.231	8.91
.797	11.04	4.06	.357	1.260	9.16
.798	11.22	4.21	.377	1.277	9.31
.798	11.24	4.39	.394	1.309	9.46
.798	11.18	4.40	.393	1.316	9.47
.797	11.73	4.61	.432	1.314	9.70
.794	11.84	4.70	.442	1.318	9.78
.797	11.71	4.71	.440	1.334	9.78

TABLE V

HUGONIOT DATA FOR Li^6D ($\bar{\rho}_0$ = 0.764 g/cm^3)

ρ_0 (g/cm^3)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm^3)	$U_{s\,calc}$ (km/sec)
0.767	6.14	0.70	0.033	0.866	5.94
.764	6.00	.72	.033	.868	5.95
.764	6.52	.98	.049	.899	6.18
.765	6.53	1.00	.050	.903	6.20
.761	7.19	1.36	.074	.938	6.54
.765	7.25	1.37	.076	.943	6.55
.768	7.23	1.39	.077	.950	6.57
.762	7.24	1.39	.077	.943	6.56
.764	7.10	1.39	.076	.951	6.56
.766	7.04	1.40	.075	.955	6.56
.760	7.65	1.71	.100	.979	6.86
.749	7.58	1.72	.098	.969	6.86
.767	7.75	1.74	.104	.990	6.90
.762	7.75	1.79	.106	.991	6.93
.764	7.70	1.80	.106	.996	6.94
.767	8.64	2.38	.157	1.058	7.49
.764	8.73	2.39	.160	1.052	7.51
.768	8.86	2.61	.177	1.089	7.71
.764	8.83	2.61	.176	1.085	7.71
.765	9.48	3.12	.226	1.140	8.91
.766	9.54	3.15	.230	1.143	8.22
.761	9.74	3.15	.233	1.124	8.23
.782	10.17	3.66	.284	1.191	8.71
.761	10.30	3.71	.290	1.188	8.75
.759	10.31	3.71	.290	1.184	8.75
.765	10.31	3.74	.295	1.200	8.79
.768	10.59	3.90	.317	1.215	8.95
.766	11.11	4.53	.385	1.293	9.54
.757	11.57	4.83	.423	1.299	9.82
.786	11.57	4.85	.430	1.319	9.86
.761	11.78	4.86	.436	1.297	9.88
.766	11.50	4.91	.433	1.337	9.90
.766	12.04	5.29	.488	1.367	10.28
.766	12.23	5.37	.503	1.366	10.36

TABLE VI

HUGONIOT DATA FOR Li^6D ($\bar{\rho}_0$ = 0.738 g/cm^3)

ρ_0 (g/cm^3)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm^3)	$U_{s\,calc}$ (km/sec)
0.736	5.35	0.75	0.030	0.857	5.96
.737	5.96	.98	.043	.882	6.17
.733	6.70	1.39	.068	.925	6.53
.731	7.38	1.80	.097	.987	6.91
.739	8.41	2.52	.157	1.055	7.59
.733	8.76	2.76	.177	1.071	7.81
.737	8.98	2.90	.192	1.088	7.95
.741	9.34	3.23	.224	1.133	8.28
.735	9.47	3.41	.237	1.149	8.41
.738	9.82	3.58	.259	1.162	8.59
.739	10.21	3.89	.294	1.195	8.89
.741	10.30	3.91	.298	1.194	8.91
.738	10.46	4.15	.320	1.223	9.12
.740	10.55	4.18	.328	1.226	9.16
.739	10.84	4.33	.347	1.230	9.31
.742	11.09	4.48	.369	1.245	9.46
.740	11.08	4.50	.368	1.247	9.47
.744	11.34	4.73	.399	1.276	9.70
.738	11.58	4.82	.411	1.265	9.78
.736	11.45	4.83	.407	1.274	9.78

TABLE VII

HUGONIOT DATA FOR Li^6D ($\bar{\rho}_0$ = 0.665 g/cm^3)

ρ_0 (g/cm^3)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm^3)	$U_{s\,calc}$ (km/sec)
0.668	3.66	0.81	0.020	0.858	5.96
.672	4.57	1.05	.032	.872	6.17
.680	5.49	1.47	.053	.902	6.53
.668	6.36	1.89	.080	.951	6.91
.670	7.71	2.63	.136	1.016	7.59
.669	8.07	2.87	.155	1.038	7.81
.677	8.34	3.00	.170	1.058	7.95
.667	8.64	3.37	.194	1.093	8.26
.664	8.98	3.53	.210	1.093	8.41
.662	9.23	3.72	.227	1.108	8.59
.675	9.86	4.01	.267	1.137	8.89
.656	9.90	4.05	.263	1.110	8.91
.666	9.95	4.29	.284	1.170	9.12
.676	10.23	4.30	.297	1.166	9.16
.676	10.51	4.45	.316	1.171	9.31
.664	10.59	4.65	.327	1.184	9.47
.637	10.34	4.71	.310	1.169	9.46
.638	10.75	4.96	.340	1.183	9.70
.673	11.06	4.97	.370	1.222	9.78
.665	11.09	4.98	.367	1.207	9.78

[redacted]

TABLE VIII

HUGONIOT DATA FOR Li^6D ($\bar{\rho}_0$ = 0.579 g/cm^3)

ρ_0 (g/cm^3)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm^3)	$U_{s,calc}$ (km/sec)
0.592	2.87	0.85	0.014	0.840	5.98
.571	3.39	1.12	.022	.85;	6.17
.572	4.40	1.56	.039	.885	6.53
.587	5.34	2.00	.061	.908	6.91
.571	6.81	2.77	.108	.962	7.59
.574	7.29	3.01	.128	.977	7.81
.572	7.49	3.17	.136	.991	7.95
.570	7.83	3.54	.158	1.039	8.26
.571	8.29	3.69	.175	1.029	8.41
.575	8.59	3.88	.191	1.048	8.59
.587	9.09	4.19	.224	1.089	8.89
.583	9.23	4.21	.227	1.072	8.91
.579	9.35	4.47	.242	1.109	9.12
.570	9.54	4.52	.257	1.083	9.16
.578	9.91	4.65	.266	1.089	9.31
.596	10.23	4.79	.292	1.121	9.47
.588	9.93	4.83	.282	1.145	9.48
.594	10.48	5.06	.315	1.148	9.70
.594	10.62	5.14	.325	1.152	9.78
.578	10.52	5.18	.315	1.138	9.78

TABLE IX

HUGONIOT DATA FOR Li^6D ($\bar{\rho}_0$ = 0.514 g/cm^3)

ρ_0 (g/cm^3)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm^3)	$U_{s,calc}$ (km/sec)
0.522	3.01	1.14	0.018	0.840	8.17
.526	4.08	1.59	.034	.861	6.53
.530	4.88	2.05	.053	.913	6.91
.532	6.35	2.83	.096	.961	7.59
.514	6.76	3.10	.108	.950	7.81
.527	7.12	3.24	.122	.968	7.95
.519	7.54	3.62	.142	.998	8.26
.521	7.98	3.78	.157	.988	8.41
.539	8.35	3.94	.177	1.021	8.59
.506	9.04	4.34	.198	.972	8.91
.499	8.70	4.35	.189	.999	8.89
.511	9.08	4.60	.213	1.035	9.12
.502	9.38	4.64	.218	.993	9.16
.508	9.72	4.78	.235	.996	9.31
.508	10.05	4.96	.253	1.003	9.47
.499	9.86	4.98	.245	1.009	9.46
.510	10.27	5.23	.274	1.038	9.70
.497	10.51	5.33	.279	1.010	9.78
.500	10.33	5.35	.276	1.035	9.78

TABLE X

HUGONIOT DATA FOR Li^6D ($\bar{\rho}_0$ = 0.448 g/cm^3)

ρ_0 (g/cm^3)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm^3)	$U_{s,calc}$ (km/sec)
0.456	2.60	1.18	0.014	0.825	6.17
.456	3.45	1.84	.026	.889	6.53
.450	4.34	2.12	.041	.879	6.91
.457	5.80	2.93	.078	.924	7.59
.482	6.25	3.19	.092	.942	7.81
.452	6.59	3.35	.100	.920	7.95
.448	7.05	3.73	.118	.953	8.28
.425	7.48	3.93	.125	.897	8.41
.458	7.83	4.09	.147	.959	8.59
.447	8.37	4.48	.167	.958	8.89
.441	8.42	4.48	.167	.944	8.91
.448	8.75	4.73	.185	.974	9.12
.451	9.09	4.75	.194	.943	9.16
.444	9.39	4.92	.205	.933	9.31
.446	9.71	5.09	.220	.937	9.46
.444	9.61	5.11	.218	.948	9.47
.450	10.04	5.36	.242	.965	9.70
.434	10.20	5.49	.243	.940	9.78
.442	10.02	5.49	.243	.977	9.78

TABLE XI

HUGONIOT DATA FOR Li^6H ($\bar{\rho}_0$ = 0.666 g/cm^3)

ρ_0 (g/cm^3)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm^3)	$U_{s,calc}$ (km/sec)
0.669	6.42	0.72	0.031	0.753	5.94
.661	6.38	.73	.031	.747	5.95
.664	6.31	.73	.031	.751	5.95
.666	6.86	1.00	.045	.779	8.18
.671	6.81	1.02	.046	.789	8.20
.881	7.49	1.42	.070	.816	6.57
.661	8.13	1.79	.096	.847	8.90
.662	9.02	2.43	.145	.907	7.49
.660	9.91	3.19	.209	.974	8.19
.666	10.71	3.74	.268	1.023	8.71
.671	10.97	3.99	.294	1.054	8.95
.664	11.71	4.63	.380	1.098	9.54
.664	12.31	4.95	.404	1.110	9.86
.664	12.41	4.99	.411	1.111	9.90
.664	12.73	5.40	.457	1.154	10.28
.664	12.93	5.48	.471	1.153	10.36

[redacted]

APPROVED FOR PUBLIC RELEASE

[redacted]

TABLE XII

HUGONIOT DATA FOR Li^nH AND Li^7H

($\bar{\rho}_0$ = 0.739 g/cm³)

ρ_0 (g/cm³)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm³)	U_s est (km/sec)
0.743	6.11	0.71	0.032	0.841	5.91
.740	5.97	.73	.032	.842	5.95
.742	6.52	.98	.048	.874	6.18
.735	6.44	1.01	.048	.872	6.20
.736*	7.15	1.37	.072	.911	6.54
.729*	7.17	1.39	.072	.904	6.55
.741*	7.12	1.40	.074	.923	6.56
.741	7.15	1.40	.074	.922	8.57
.742*	6.90	1.41	.072	.933	6.56
.736*	6.92	1.41	.072	.925	6.56
.739*	7.57	1.73	.097	.957	6.86
.732*	7.63	1.73	.097	.946	6.86
.741	7.73	1.76	.101	.959	6.90
.741*	7.83	1.80	.104	.962	6.93
.749*	7.84	1.80	.106	.972	6.94
.742	8.66	2.39	.154	1.025	7.49
.733*	8.67	2.42	.154	1.017	7.51
.739*	8.62	2.45	.158	1.032	7.54
.737*	8.83	2.64	.171	1.050	7.71
.735*	8.76	2.64	.170	1.052	7.71
.742	9.46	3.14	.221	1.111	8.19
.740*	9.58	3.17	.225	1.105	8.22
.737*	9.58	3.18	.225	1.104	8.23
.741	10.25	3.68	.280	1.156	8.71
.740*	10.27	3.72	.283	1.160	8.75
.737*	10.24	3.73	.282	1.160	8.75
.740*	10.22	3.74	.283	1.167	8.75
.735*	10.19	3.75	.280	1.162	8.75
.735*	10.34	3.77	.287	1.157	8.79
.743	10.56	3.93	.307	1.183	8.95
.740*	11.22	4.52	.375	1.238	9.50
.741	11.30	4.55	.381	1.240	9.54
.741	11.45	4.57	.388	1.233	9.57
.734*	11.63	4.86	.414	1.260	9.82
.741	11.91	4.86	.429	1.251	9.86
.741	12.07	4.90	.438	1.247	9.90
.738*	11.80	4.90	.427	1.262	9.88
.741	12.16	5.32	.480	1.318	10.28
.741	12.15	5.42	.488	1.338	10.36
crystal data ($\bar{\rho}_0$ = 0.777 g/cm³)					
0.783*	7.59	0.96	0.057	0.896	6.20
.776*	7.67	1.20	.071	.920	6.42
.763*	7.50	1.30	.075	.924	6.50
.777*	9.13	2.58	.183	1.083	7.71
.783*	10.54	3.61	.298	1.190	8.71
.783*	11.71	4.49	.411	1.269	9.57
.778*	12.04	4.82	.450	1.293	9.88

*Li^7H

TABLE XIII

HUGONIOT DATA FOR Li^nD AND Li^7D

($\bar{\rho}_0$ = 0.840 g/cm³)

ρ_0 (g/cm³)	U_s (km/sec)	U_p (km/sec)	P (Mbar)	ρ (g/cm³)	U_s est (km/sec)
0.840	5.88	0.70	0.034	0.953	5.94
.839	5.79	.71	.035	.956	5.95
.840	6.30	.96	.051	.992	6.18
.839	6.33	.98	.052	.993	6.20
.840	7.50	1.72	.108	1.090	6.90
.839	8.29	2.35	.163	1.170	7.49
.844	9.11	3.07	.236	1.274	8.19
.838	9.86	3.61	.298	1.321	8.71
.840	10.21	3.84	.330	1.347	8.95
.842	10.97	4.48	.414	1.423	9.57
.841	11.03	4.59	.426	1.441	9.68
.840	11.24	4.78	.451	1.461	9.86
.841	11.56	4.80	.466	1.437	9.90
.840	11.85	5.20	.517	1.496	10.28
.840	11.85	5.29	.527	1.518	10.36
crystal data ($\bar{\rho}_0$ = 0.890 g/cm³)					
0.890*	7.13	0.94	0.060	1.025	6.20
.890*	10.01	3.54	.315	1.376	8.71
.890*	10.96	4.42	.431	1.491	9.57

*Li^7D

[redacted]

[redacted]

TABLE XIV

THERMODYNAMIC GRÜNEISEN γ AND $(\partial E/\partial P)_V$ FOR Li^6H, Li^6D, Li^nH, AND Li^nD

Mat	ρ_0 (g/cm^3)	V_0 (cm^3/g)	β (/°K)	C_0 (cm/sec)	c_p (cal/mol°K)	c_p (erg/g°K)	γ	$(\partial E/\partial P)_V$ (cm^3/g)
Li^6H	0.689	1.451	84.9×10^{-6}	6.72×10^5	6.682	3.953×10^7	0.970	1.496
Li^6D	.795	1.258	95.1	6.35	6.682	3.461	1.108	1.135
Li^nH	.776	1.289	93.0	6.34	6.682	3.518	1.063	1.213
Li^nD	.883	1.133	107.7	6.02	6.682	3.122	1.250	0.906

TABLE XV

SUMMARY OF CRYSTAL-DENSITY HUGONIOT COEFFICIENTS OF THE EQUATION $U_s = C_0 + SU_p$ FOR Li^6H, Li^6D, Li^nH, AND Li^nD FOR DATA HAVING $U_p > 0.9$ km/sec

Material	ρ_0 (g/cm^3)	C_0 (km/sec)	S
Li^6H	0.696	6.740	1.189
Li^6D	.802	6.464	1.130
Li^nH	.783	6.426	1.167
Li^nD	.890	6.138	1.151

[redacted]

TABLE XVI

EQUATION OF STATE OF Li^6H

COEFFICIENTS IN US•CO•S•UP•S2•UP••2•.... 6.740 1.189
OE/DPIV•1.496 CM••3/O OAMMA• .970
OEBYE PARAMETERS RHOO• .688 T• 293 THETA•1088 3NK• 7.058E•07 CV• 3.820E•07

	PARAMETERS ON THE HUGONIOT							RELEASE ISENTROPEIP•01			ZERO KELVIN		T 0 ISOTHERM	
P	RHO	T	S	E	C	US	UP	RHO	T	UFS	RHO	E	RHO	C
MB	O/CM••3	OEG-K	•	••	KM/SEC	KM/SEC	KM/SEC	O/CM••3	OEO-K	KM/SEC	G/CM••3	••	G/CM••3	KM/SEC
0.00	.696	293	20.78	.422	6.74	6.74	0.00	.696	293	0.00	.702	0.000	.70	6.74
.02	.737	310	20.90	.502	7.27	7.21	.40	.696	294	.80	.742	.074	.74	7.27
.04	.772	328	21.50	.706	7.70	7.64	.75	.696	298	1.51	.778	.255	.77	7.72
.08	.804	350	22.72	1.000	8.08	8.02	1.08	.695	307	2.15	.809	.506	.81	8.10
.08	.833	378	24.50	1.365	8.42	8.37	1.37	.694	321	2.75	.838	.805	.84	8.44
.10	.859	407	26.77	1.785	8.72	8.70	1.65	.693	338	3.30	.865	1.138	.86	8.75
.12	.883	441	29.40	2.251	9.00	9.01	1.91	.692	357	3.83	.891	1.497	.89	9.03
.14	.906	478	32.32	2.757	9.26	9.31	2.16	.690	379	4.33	.914	1.875	.91	9.30
.16	.928	517	35.42	3.295	9.50	9.59	2.40	.688	403	4.80	.937	2.268	.93	9.55
.18	.948	560	38.66	3.863	9.73	9.08	2.62	.686	428	5.26	.958	2.672	.96	9.79
.20	.968	604	41.97	4.456	9.94	10.12	2.84	.684	454	5.70	.978	3.084	.98	10.01
.22	.988	651	45.33	5.072	10.15	10.37	3.05	.682	481	6.13	.998	3.503	1.00	10.22
.24	1.004	699	48.70	5.708	10.34	10.61	3.25	.679	509	6.54	1.017	3.927	1.02	10.43
.26	1.021	749	52.05	6.362	10.53	10.84	3.45	.677	537	6.94	1.035	4.355	1.03	10.63
.28	1.037	801	55.39	7.033	10.71	11.06	3.64	.674	566	7.32	1.052	4.786	1.05	10.82
.30	1.052	854	58.68	7.720	10.89	11.28	3.82	.671	595	7.70	1.069	5.218	1.07	11.00
.32	1.067	909	61.92	8.421	11.06	11.50	4.00	.668	625	8.07	1.085	5.652	1.08	11.18
.34	1.082	965	65.:2	9.134	11.22	11.70	4.17	.664	654	8.43	1.:01	6.086	1.10	11.36
.38	1.096	1023	68.25	9.860	11.38	11.91	4.34	.661	684	8.79	1.116	6.521	1.11	11.53
.38	1.110	1081	71.32	10.596	11.53	12.10	4.51	.657	7:5	8.13	1.13:	6.955	1.13	11.69
.40	1.123	1142	74.33	11.344	11.68	12.30	4.67	.654	745	9.47	1.145	7.389	1.14	11.85
.42	1.136	1203	77.28	12.101	11.83	12.49	4.83	.650	775	9.81	1.159	7.822	1.16	12.0:
.44	1.148	1268	80.16	12.067	11.97	12.67	4.99	.646	806	10.14	1.173	8.254	1.17	12.17
.46	1.160	1329	82.98	13.642	12.11	12.85	5.14	.642	836	10.46	1.186	8.685	1.19	12.32
.48	1.172	1394	85.73	14.425	12.25	13.03	5.28	.638	886	10.78	1.199	9.115	1.20	12.47
.50	1.183	1460	88.43	15.215	12.38	13.21	5.44	.634	898	11.09	1.212	9.544	1.21	12.61

•• •••••10••10 EROS/O
• •••••10••6 EROS/O-DEO K

TABLE XVII

EQUATION OF STATE OF Li^6D

COEFFICIENTS IN US•CO•S•UP•S2•UP••2•... 6.464 1.130
OE/OPIV•1.135 CM••3/O GAMMA•1.108
DEBYE PARAMETERS RHOO• .795 T• 293 THETA•1095 3NK• 6.179E•07 CV• 3.322E•07

	PARAMETERS ON THE HUGONIOT							RELEASE ISENTROPE:P•01			ZERO KELVIN		T 0 ISOTHERM	
P	RHO	T	S	E	C	US	UP	RHO	T	UFS	RHO	E	RHO	C
MB	O/CM••3	OEO-K	•	••	KM/SEC	KM/SEC	KM/SEC	G/CM••3	OEG-K	KM/SEC	G/CM••3	••	G/CM••3	KM/SEC
0.00	.802	293	18.00	.368	6.46	6.48	0.00	.802	293	0.00	.810	0.000	.80	6.46
.02	.847	311	18.09	.432	6.90	6.87	.36	.802	294	.73	.854	.062	.85	6.91
.04	.886	331	18.55	.603	7.26	7.24	.69	.802	298	1.38	.893	.215	.89	7.27
.06	.922	353	19.49	.854	7.58	7.58	.99	.801	306	1.97	.929	.431	.93	7.59
.08	.955	380	20.89	1.165	7.85	7.89•	1.26	.800	318	2.53	.963	.691	.96	7.87
.10	.985	410	22.68	1.527	8.10	8.19	1.52	.799	333	3.05	.994	.983	.99	8.12
.12	1.014	444	24.79	1.930	8.33	8.46	1.77	.797	351	3.54	1.023	1.301	1.02	8.35
.14	1.041	481	27.14	2.368	8.54	8.72	2.00	.796	371	4.01	1.051	1.637	1.05	8.57
.16	1.066	521	29.67	2.837	8.73	8.98	2.22	.793	392	.46	1.078	1.988	1.08	8.77
.18	1.090	584	32.31	3.332	8.91	9.22	2.44	.791	415	4.89	1.103	2.351	1.10	8.96
.20	1.113	608	35.03	3.851	9.09	9.45	2.64	.789	439	5.3:	1.127	2.724	1.13	9.13
.22	1.135	655	37.80	4.390	9.25	9.67	2.84	.786	464	5.71	1.151	3.104	1.15	9.30
.24	1.156	704	40.59	4.949	9.40	9.88	3.03	.783	490	6.10	1.174	3.490	1.17	9.47
.26	1.176	754	43.37	5.524	9.55	10.09	3.21	.780	516	6.47	1.195	3.880	1.19	9.62
.28	1.196	806	46.15	6.116	9.69	10.30	3.39	.777	.542	8.84	1.217	4.274	1.22	9.77
.30	1.215	860	48.90	6.721	9.83	10.49	3.57	.773	569	7.20	1.237	4.671	1.24	9.92
.32	1.233	915	51.61	7.340	9.96	10.68	3.73	.770	596	7.55	1.257	5.070	1.26	10.06
.34	1.251	972	54.29	7.971	10.09	10.87	3.90	.766	623	7.89	1.277	5.471	1.28	10.19
.36	1.268	1030	56.92	8.613	10.21	11.05	4.06	.762	650	8.23	1.296	5.872	1.29	10.32
.38	1.284	1090	59.50	9.265	10.33	11.23	4.22	.759	677	8.56	1.314	6.275	1.31	10.45
.40	1.301	1151	62.04	9.928	10.45	11.41	4.37	.755	705	8.88	1.332	6.677	1.33	10.57
.42	1.316	1213	64.53	10.599	10.56	11.58	4.52	.750	732	9.20	1.350	7.080	1.35	10.69
.44	1.332	1276	66.96	11.280	10.67	11.74	4.67	.748	759	9.51	1.367	7.482	1.37	10.81
.48	1.347	1341	69.35	11.968	10.78	11.91	4.82	.742	787	9.82	1.384	7.884	1.38	10.93
.48	1.362	1407	71.68	12.664	10.88	12.07	4.96	.737	814	10.13	1.401	8.286	1.40	11.04
.50	1.376	1474	73.97	13.368	10.98	12.23	5.10	.733	840	10.43	1.417	8.687	1.42	11.15

•• -••••10••10 ERGS/O
• •••••10••6 ERGS/O-OEG K

[redacted]

[redacted]

TABLE XVIII

EQUATION OF STATE OF Li^nH

COEFFICIENTS IN US=CO+S*UP+S2*UP**2+... 6.428 1.167
DE/DP)V=1.212 CM**3/G GAMMA=1.063
DEBYE PARAMETERS RHOO= .778 T= 293 THETA=1092 3NK= 6.278E+07 CV= 3.384E+07

	PARAMETERS ON THE HUGONIOT							RELEASE ISENTROPE(P=0)			ZERO KELVIN		T 0 ISOTHERM	
P MB	RHO G/CM**3	T DEG-K	S *	E **	C KM/SEC	US KM/SEC	UP KM/SEC	RHO G/CM**3	T DEG-K	UFS KM/SEC	RHO G/CM**3	E **	RHO G/CM**3	C KM/SEC
0.00	.783	293	18.36	.374	6.43	6.43	0.00	.783	293	0.00	.790	0.000	.78	6.43
.02	.828	311	18.46	.443	6.80	6.86	.37	.783	294	.74	.835	.065	.83	6.91
.04	.867	330	18.97	.622	7.30	7.25	.70	.783	298	1.41	.874	.224	.87	7.31
.06	.903	353	20.00	.882	7.64	7.60	1.01	.782	307	2.02	.910	.446	.91	7.65
.08	.935	380	21.52	1.204	7.94	7.93	1.29	.781	319	2.58	.942	.712	.94	7.96
.10	.965	411	23.45	1.578	8.21	8.24	1.55	.780	336	3.10	.973	1.010	.97	8.23
.12	.992	445	25.71	1.990	8.46	8.52	1.80	.778	354	3.60	1.001	1.332	1.00	8.49
.14	1.018	483	28.20	2.439	8.69	8.80	2.03	.776	375	4.07	1.028	1.671	1.03	8.72
.16	1.043	524	30.87	2.916	8.90	9.06	2.28	.774	398	4.52	1.054	2.025	1.05	8.95
.18	1.068	568	33.66	3.423	9.10	9.31	2.47	.772	422	4.98	1.078	2.389	1.08	9.15
.20	1.088	612	36.52	3.952	9.29	9.55	2.68	.769	447	5.37	1.101	2.762	1.10	9.35
.22	1.109	659	39.41	4.501	9.47	9.78	2.87	.767	473	5.78	1.124	3.141	1.12	9.54
.24	1.129	708	42.33	5.069	9.65	10.00	3.06	.764	499	6.17	1.145	3.525	1.14	9.72
.26	1.148	759	45.23	5.654	9.81	10.22	3.25	.761	526	6.55	1.166	3.914	1.16	9.90
.28	1.167	811	48.12	6.253	9.97	10.43	3.43	.757	554	6.92	1.188	4.305	1.18	10.06
.30	1.185	865	50.97	6.867	10.12	10.63	3.60	.754	581	7.28	1.205	4.698	1.20	10.23
.32	1.202	921	53.79	7.494	10.27	10.83	3.77	.750	609	7.63	1.224	5.093	1.22	10.38
.34	1.218	978	56.56	8.132	10.41	11.02	3.94	.747	637	7.97	1.242	5.489	1.24	10.54
.36	1.235	1038	59.28	8.782	10.55	11.21	4.10	.743	666	8.31	1.260	5.886	1.26	10.69
.38	1.250	1098	61.95	9.442	10.69	11.40	4.26	.739	694	8.64	1.277	6.283	1.28	10.83
.40	1.265	1157	64.57	10.111	10.82	11.58	4.41	.735	722	8.96	1.294	6.679	1.29	10.97
.42	1.280	1219	67.14	10.789	10.95	11.75	4.56	.731	751	9.28	1.310	7.075	1.31	11.11
.44	1.295	1283	69.65	11.478	11.07	11.93	4.71	.728	779	9.59	1.326	7.471	1.33	11.24
.46	1.309	1347	72.11	12.171	11.19	12.09	4.86	.722	807	9.90	1.342	7.865	1.34	11.36
.48	1.322	1413	74.51	12.873	11.31	12.28	5.00	.717	835	10.21	1.357	8.259	1.36	11.51
.50	1.335	1480	78.86	13.582	11.43	12.42	5.14	.713	863	10.51	1.372	8.652	1.37	11.63

** -----10**10 ERGS/G
* -----10**6 ERGS/G-DEG K

TABLE XIX

EQUATION OF STATE OF Li^nD.

COEFFICIENTS IN US=CO+S*UP+S2*UP**2+... 6.138 1.151
DE/DP)V= .906 CM**3/G GAMMA=1.250
DEBYE PARAMETERS RHOO= .883 T= 293 THETA=1103 3NK= 5.571E+07 CV= 2.971E+07

	PARAMETERS ON THE HUGONIOT							RELEASE ISENTROPE(P=0)			ZERO KELVIN		T 0 ISOTHERM	
P MB	RHO G/CM**3	T DEG-K	S *	E **	C KM/SEC	US KM/SEC	UP KM/SEC	RHO G/CM**3	T DEG-K	UFS KM/SEC	RHO G/CM**3	E **	RHO G/CM**3	C KM/SEC
0.00	.890	293	18.01	.327	6.14	6.14	0.00	.890	293	0.00	.900	0.000	.89	6.14
.02	.939	314	16.08	.388	6.56	6.53	.34	.890	294	.69	.948	.055	.94	6.57
.04	.983	335	16.50	.540	6.92	6.89	.65	.890	298	1.31	.992	.193	.99	6.93
.06	1.022	359	17.34	.763	7.22	7.21	.93	.889	306	1.87	1.032	.385	1.03	7.24
.08	1.058	388	18.59	1.042	7.49	7.51	1.20	.888	317	2.40	1.068	.617	1.06	7.51
.10	1.092	420	20.17	1.365	7.73	7.90	1.44	.886	332	2.89	1.102	.878	1.10	7.75
.12	1.123	456	22.03	1.725	7.95	8.06	1.67	.884	350	3.35	1.135	1.161	1.13	7.99
.14	1.152	495	24.09	2.118	8.15	8.32	1.89	.882	369	3.80	1.165	1.462	1.16	8.18
.16	1.180	536	26.30	2.534	8.34	8.56	2.10	.880	390	4.22	1.194	1.775	1.19	8.38
.18	1.206	580	28.62	2.975	8.51	8.79	2.30	.877	412	4.63	1.222	2.099	1.22	8.56
.20	1.231	627	30.99	3.438	8.68	9.01	2.49	.874	434	5.02	1.249	2.431	1.25	8.73
.22	1.255	675	33.41	3.818	8.84	9.22	2.68	.871	458	5.40	1.275	2.770	1.27	8.89
.24	1.277	725	35.84	4.416	8.99	9.43	2.86	.867	482	5.77	1.299	3.115	1.30	9.05
.26	1.299	777	38.27	4.928	9.13	9.63	3.03	.863	506	6.13	1.323	3.463	1.32	9.20
.28	1.320	831	40.68	5.454	9.27	9.82	3.20	.860	531	6.47	1.347	3.815	1.34	9.35
.30	1.341	888	43.07	5.993	9.40	10.01	3.37	.856	555	6.81	1.369	4.169	1.37	9.49
.32	1.360	943	45.44	6.544	9.52	10.20	3.53	.851	580	7.15	1.391	4.525	1.39	9.62
.34	1.380	1001	47.77	7.105	9.65	10.38	3.68	.847	605	7.47	1.412	4.883	1.41	9.75
.36	1.398	1080	50.06	7.676	9.77	10.55	3.83	.843	630	7.79	1.433	5.242	1.43	9.89
.38	1.416	1121	52.31	8.256	9.88	10.72	3.98	.838	655	8.10	1.453	5.601	1.45	10.00
.40	1.433	1183	54.52	8.845	9.99	10.89	4.13	.833	680	8.41	1.473	5.960	1.47	10.12
.42	1.450	1247	56.68	9.442	10.10	11.05	4.27	.829	704	8.71	1.492	6.320	1.49	10.24
.44	1.467	1311	58.80	10.047	10.21	11.21	4.41	.824	729	9.01	1.511	6.679	1.51	10.36
.46	1.483	1377	60.88	10.659	10.31	11.37	4.55	.819	753	9.30	1.530	7.038	1.53	10.47
.48	1.499	1444	62.92	11.277	10.41	11.52	4.68	.813	777	9.59	1.547	7.396	1.55	10.58
.50	1.514	1512	64.91	11.902	10.51	11.68	4.81	.808	800	9.87	1.565	7.755	1.56	10.68

** -----10**10 ERGS/G
* -----10**6 ERGS/G-DEG K

[redacted]

[redacted]

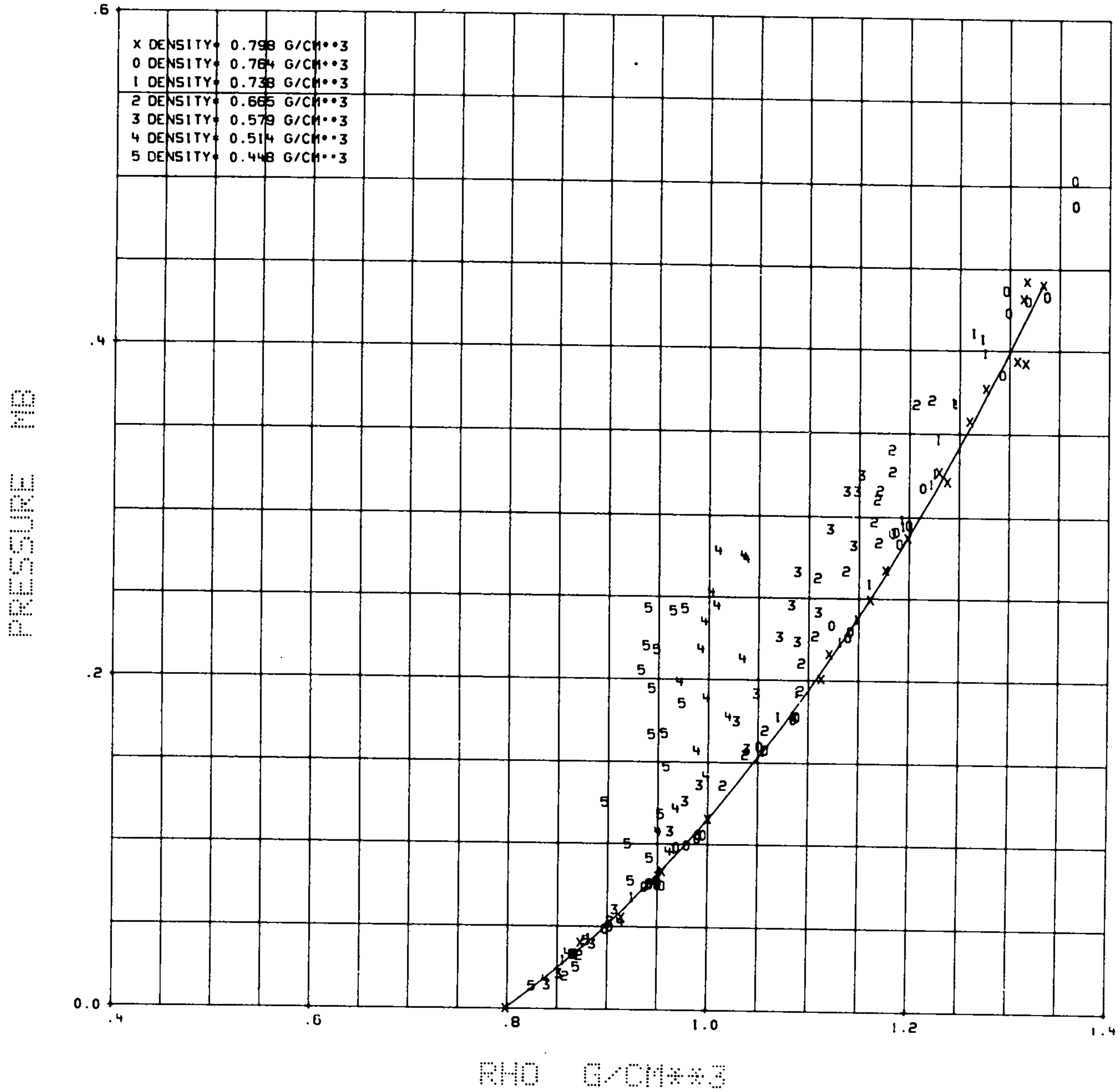

Fig. 1. Experimental pressure-density Hugoniot data for Li^6D at seven different porosities. The curve is the fit shown in Fig. 2.

[redacted]

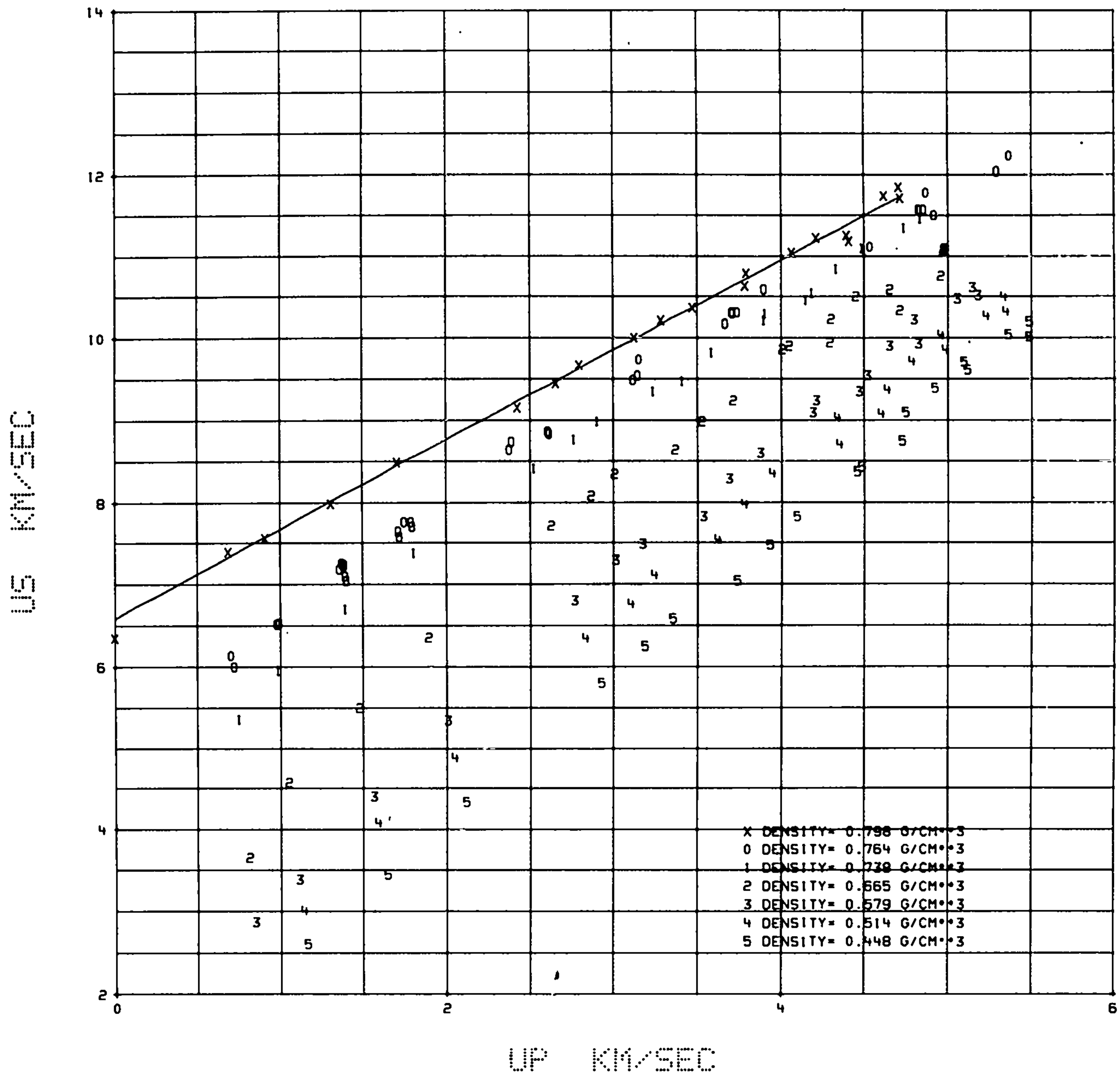

Fig. 2. Experimental shock velocity - particle velocity Hugoniot for Li^6D at seven different porosities. The linear least-squares fit of the data (excluding the bulk sound velocity) of the lowest porosity material is shown. The average density at each porosity is indicated in the legend. The Hugoniots of the porous samples curve downward in a manner predictable by calculations.

[redacted]

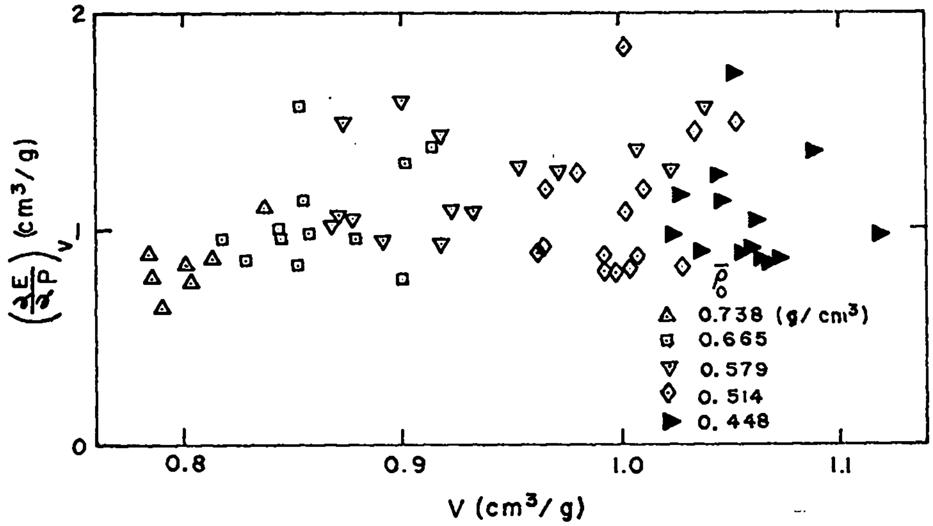

Fig. 3. $(\partial E/\partial P)_v$ vs specific volume for Li^6D for all data having $\Delta P > 15$ kbar.

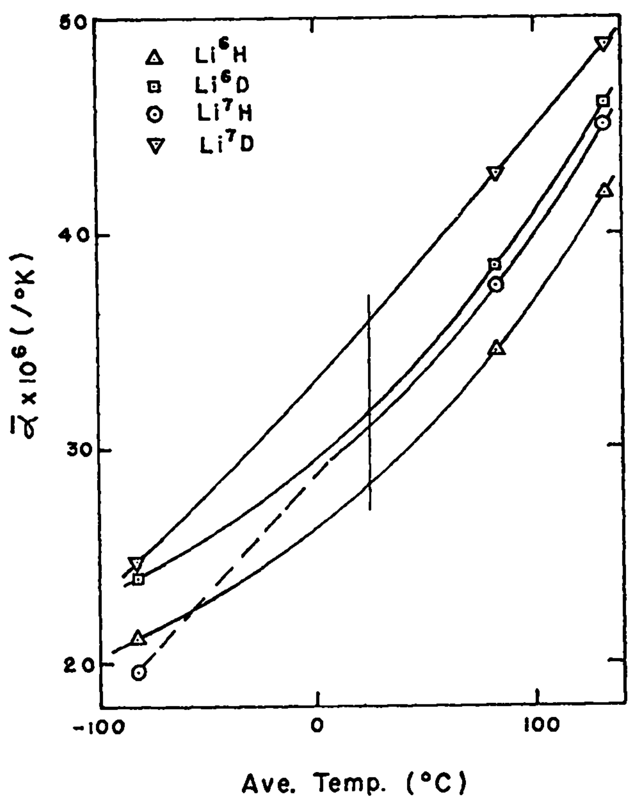

Fig. 4. Average coefficients of linear thermal expansion for Li^6H, Li^6D, Li^7H, and Li^7D over the interval T to 25°C using the data of Anderson et al.[7] The dashed line connects the unexplained low value of Li^7H at low temperature. The $\bar{\alpha}$ values at 25°C are identical to the instantaneous α values at that temperature.

[redacted]

[redacted]

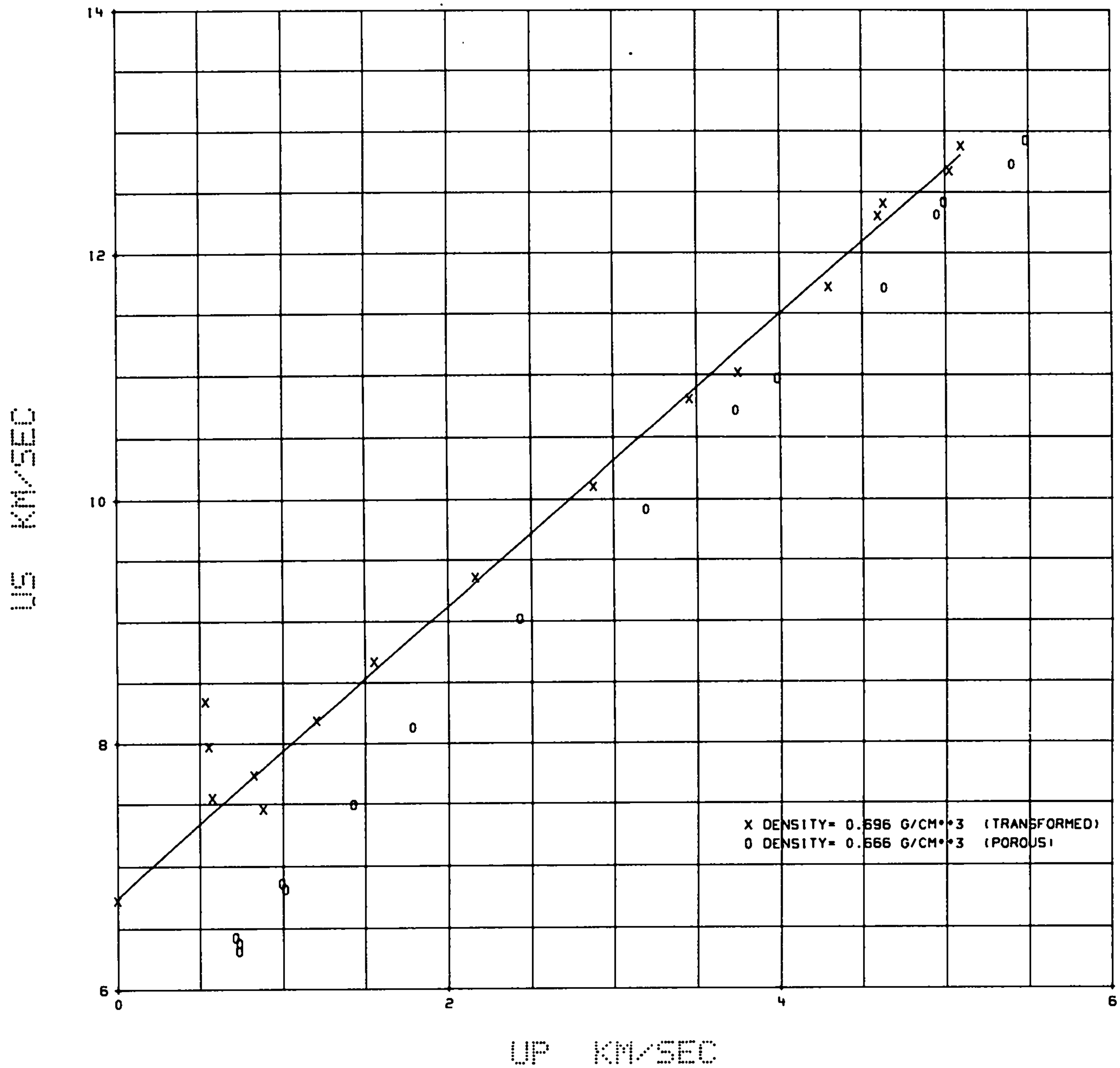

Fig. 5. Shock velocity - particle velocity Hugoniot data for Li^6H. Experimental porous Hugoniot data and transformed crystal-density Hugoniot points are shown. A linear least-squares fit of the transformed crystal-density points is shown for points having $U_p > 0.9$ km/sec.

[redacted]

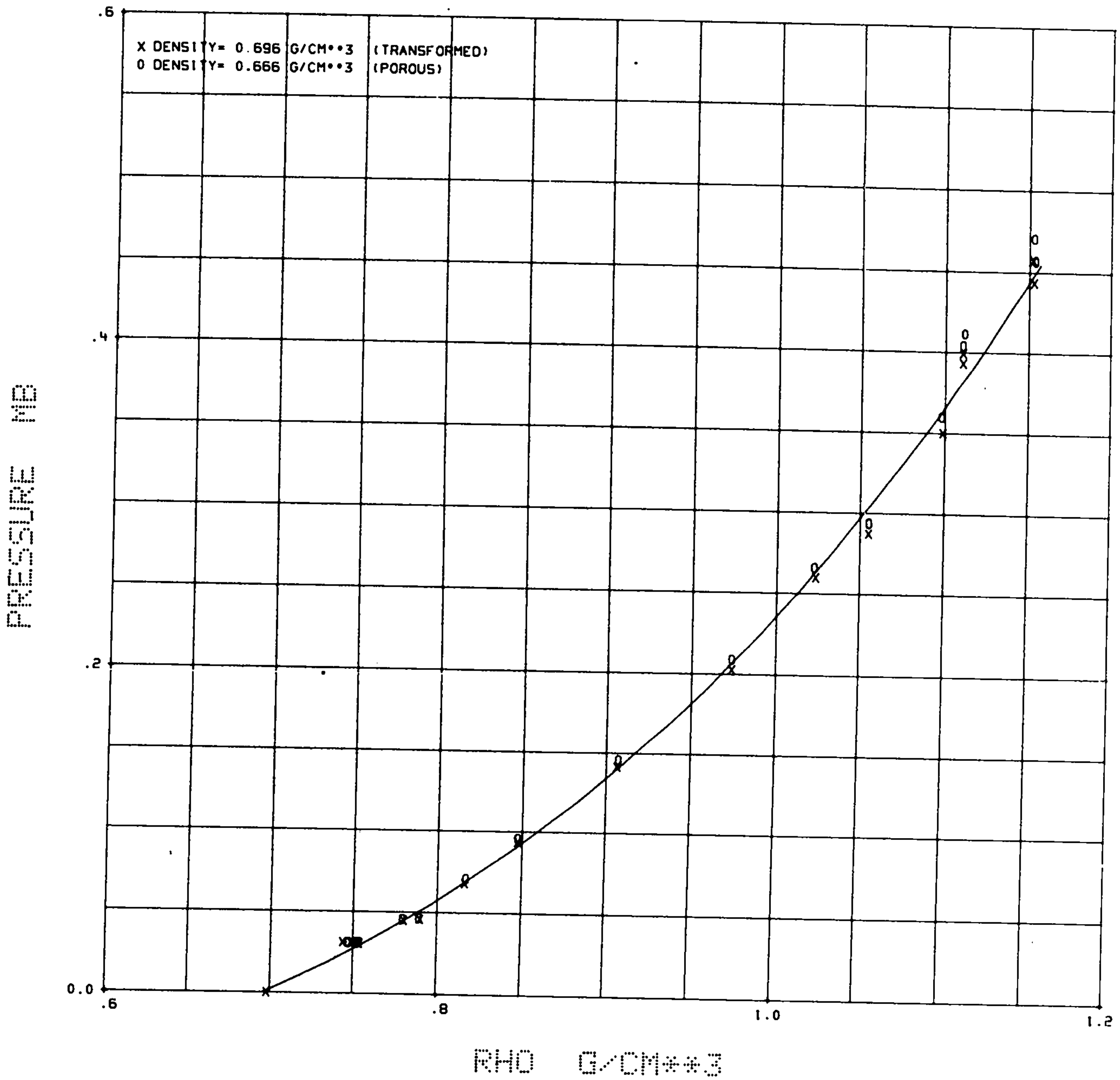

Fig. 6. Pressure-density Hugoniot data for Li^6H. Experimental porous Hugoniot data and transformed crystal-density Hugoniot points are shown. The curve is the fit shown in Fig. 5.

[redacted]

[redacted]

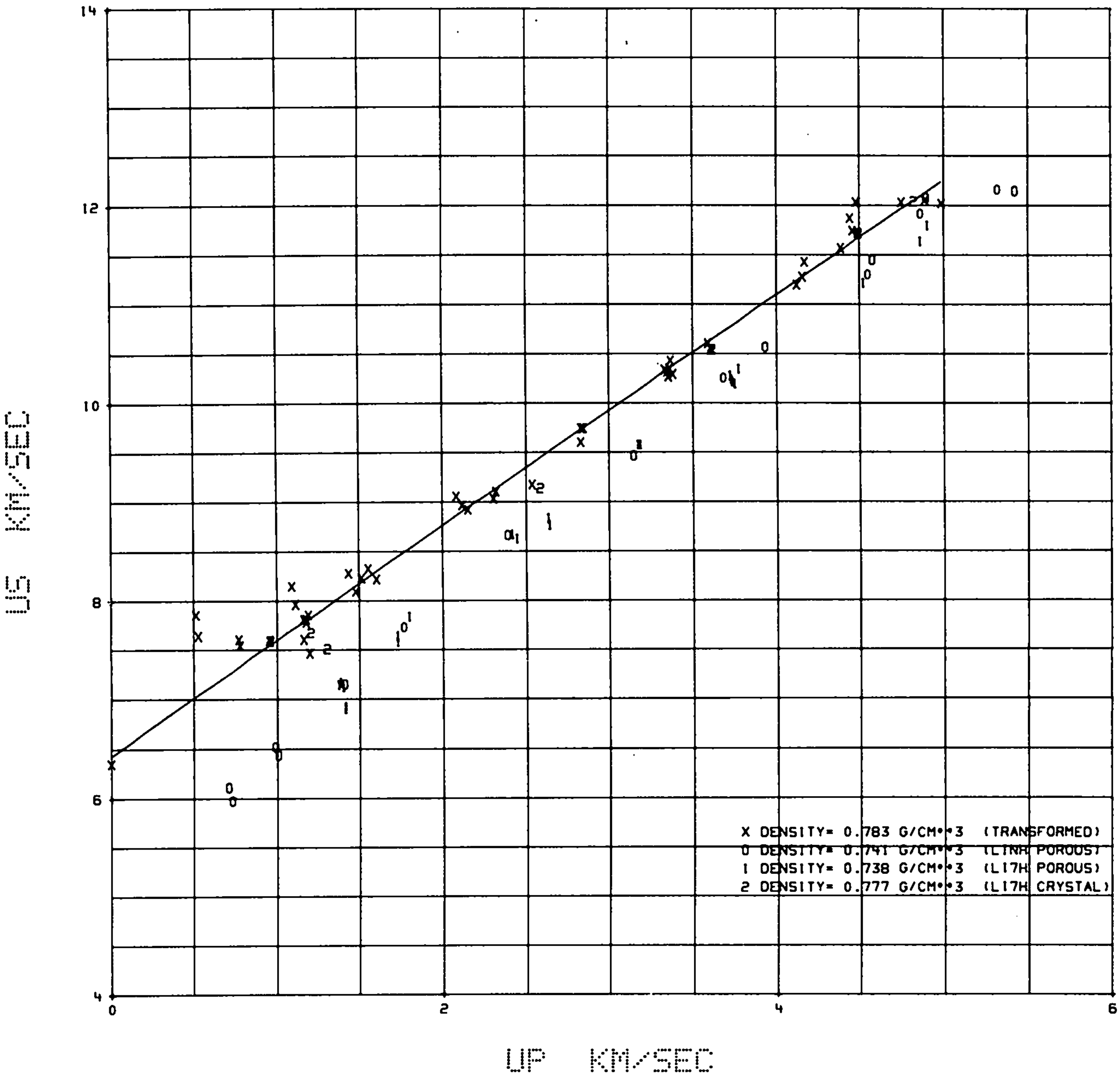

Fig. 7. Shock velocity - particle velocity Hugoniot data for Li^nH and Li^7H. Experimental porous Hugoniot data for Li^nH and Li^7H are shown along with single-crystal Li^7H data and transformed crystal-density points of all the data. A linear least-squares fit of the transformed crystal-density points is shown for points having $U_p > 0.9$ km/sec. No difference between the Li^nH and Li^7H Hugoniot data is resolved.

[redacted]

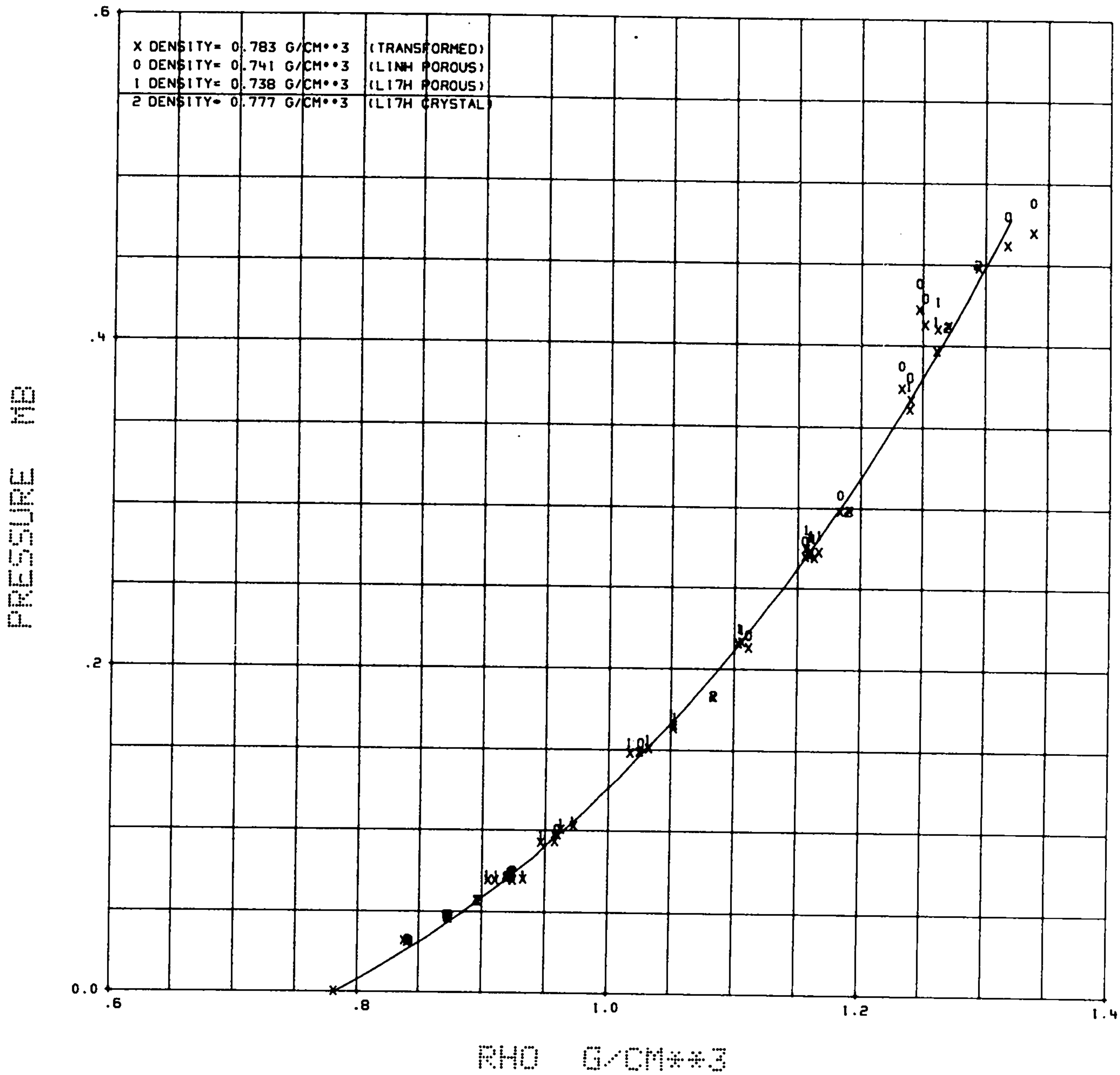

Fig. 8. Pressure-density Hugoniot data for $Li^{n}H$ and $Li^{7}H$. Experimental porous Hugoniot data for $Li^{n}H$ and $Li^{7}H$ are shown along with experimental single-crystal $Li^{7}H$ data and transformed crystal-density points for all the data. The curve is the fit shown in Fig. 7.

[redacted]

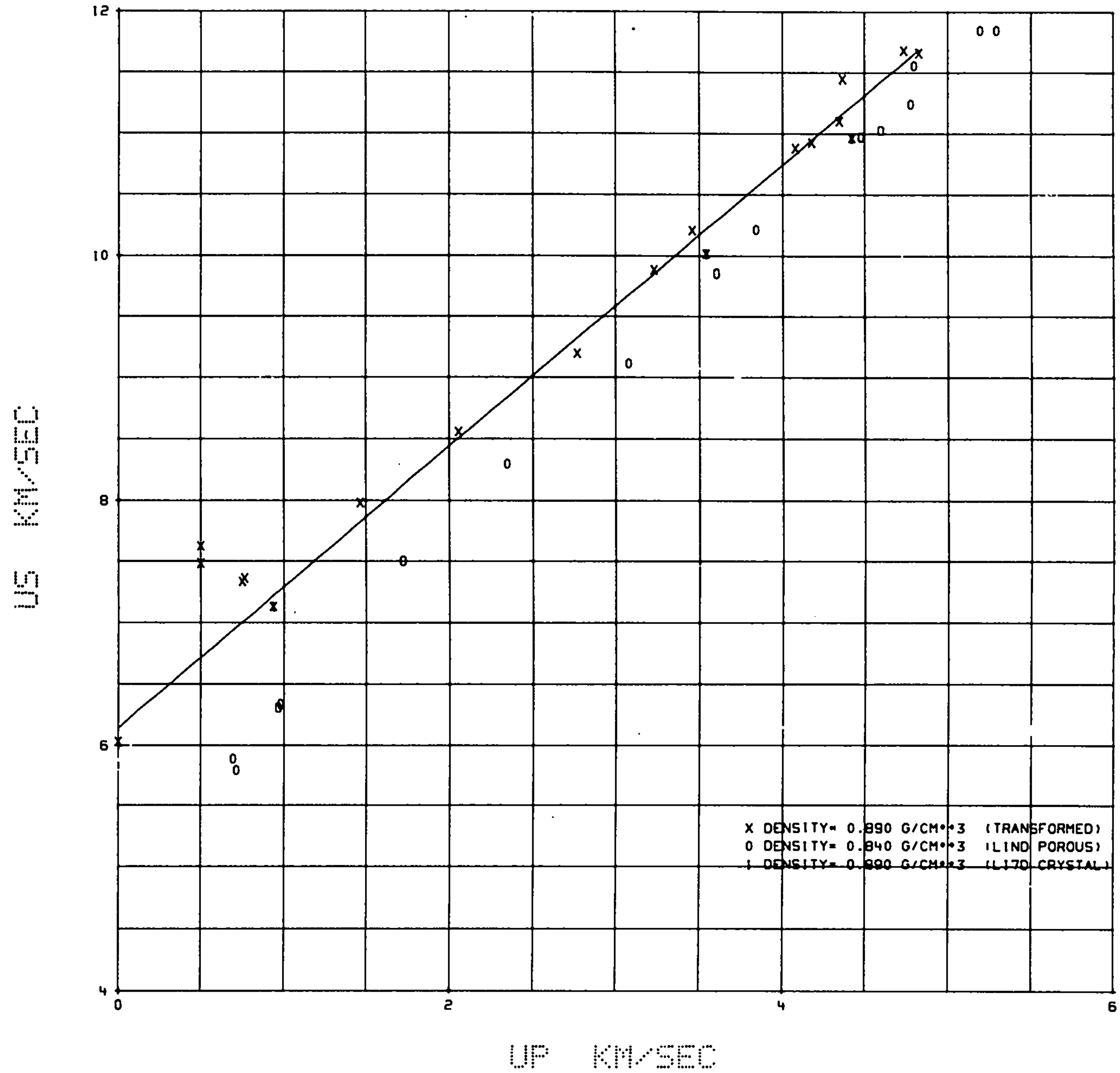

Fig. 9. Shock velocity - particle velocity Hugoniot data for Li^{n}D and Li^{7}D. Porous Hugoniot data for Li^{n}D and experimental single-crystal data for Li^{7}D are shown along with transformed crystal-density points. A linear least-squares fit of the experimental and transformed crystal-density points is shown for points having $U_p > 0.9$ km/sec. The three single-crystal data points lie below the fit. The reason for this difference is not known.

[redacted]

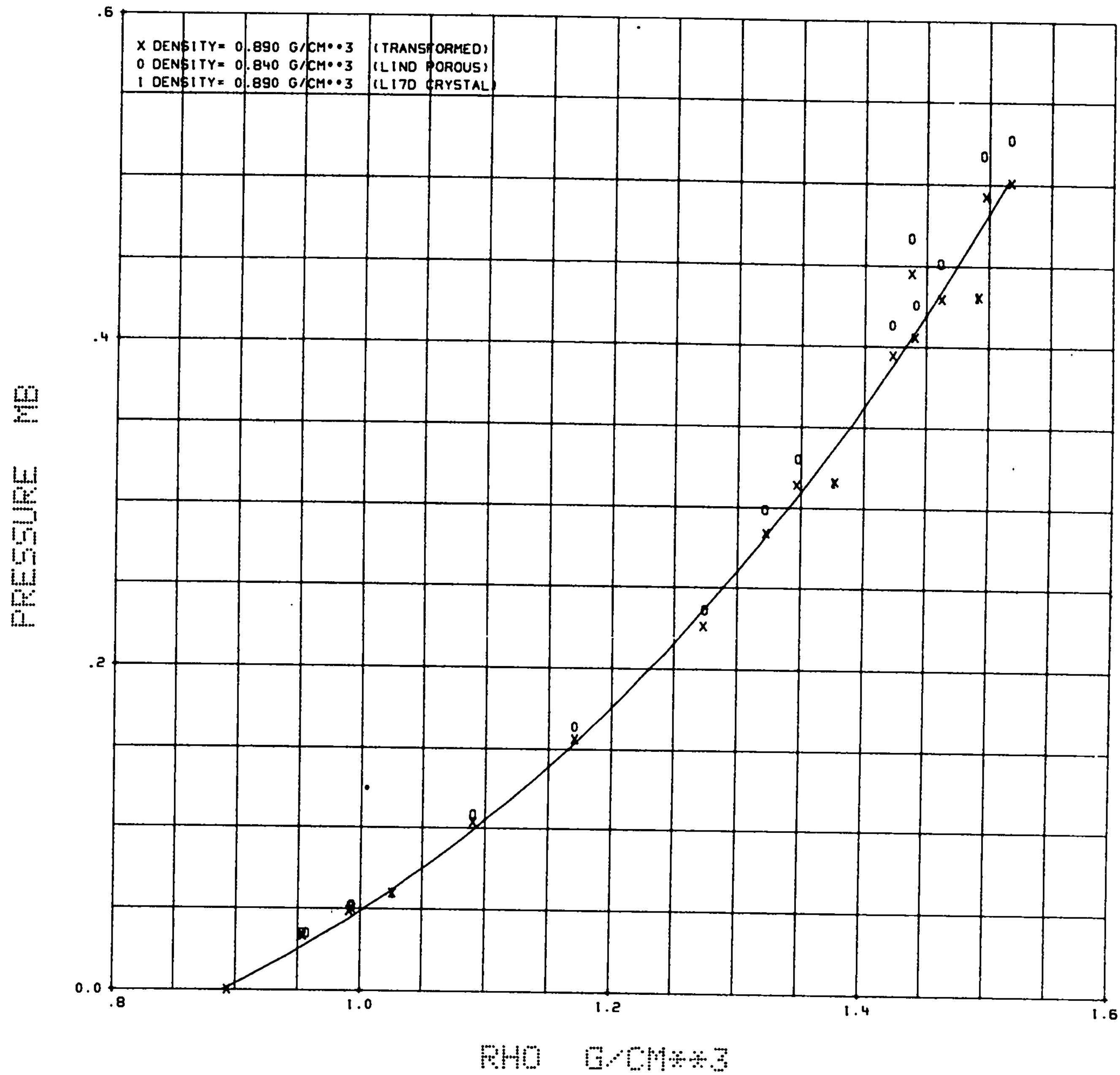

Fig. 10. Pressure-density Hugoniot data for Li^nD and Li^7D. Porous Hugoniot data for Li^nD and experimental single-crystal data for Li^7D are shown along with transformed crystal-density points. The curve is the fit shown in Fig. 9.

[redacted]

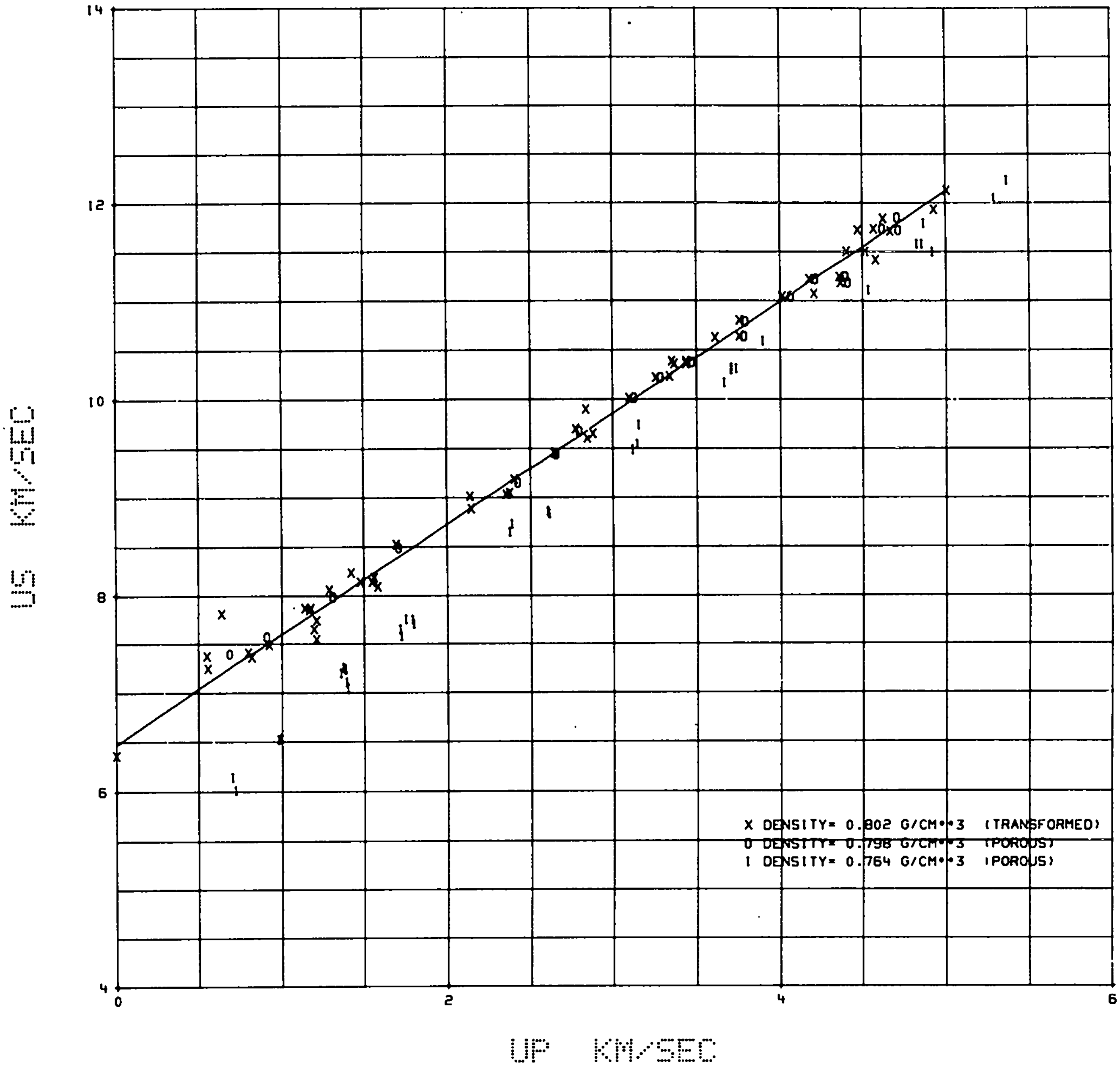

Fig. 11. Shock velocity - particle velocity Hugoniot data for Li^6D. Experimental porous Hugoniot data ($\bar{\rho}_0$ = 0.798 and 0.764 g/cm^3) and transformed crystal-density Hugoniot points are shown. A linear least-squares fit of the transformed crystal-density points is shown for points having $U_p > 0.9$ km/sec.

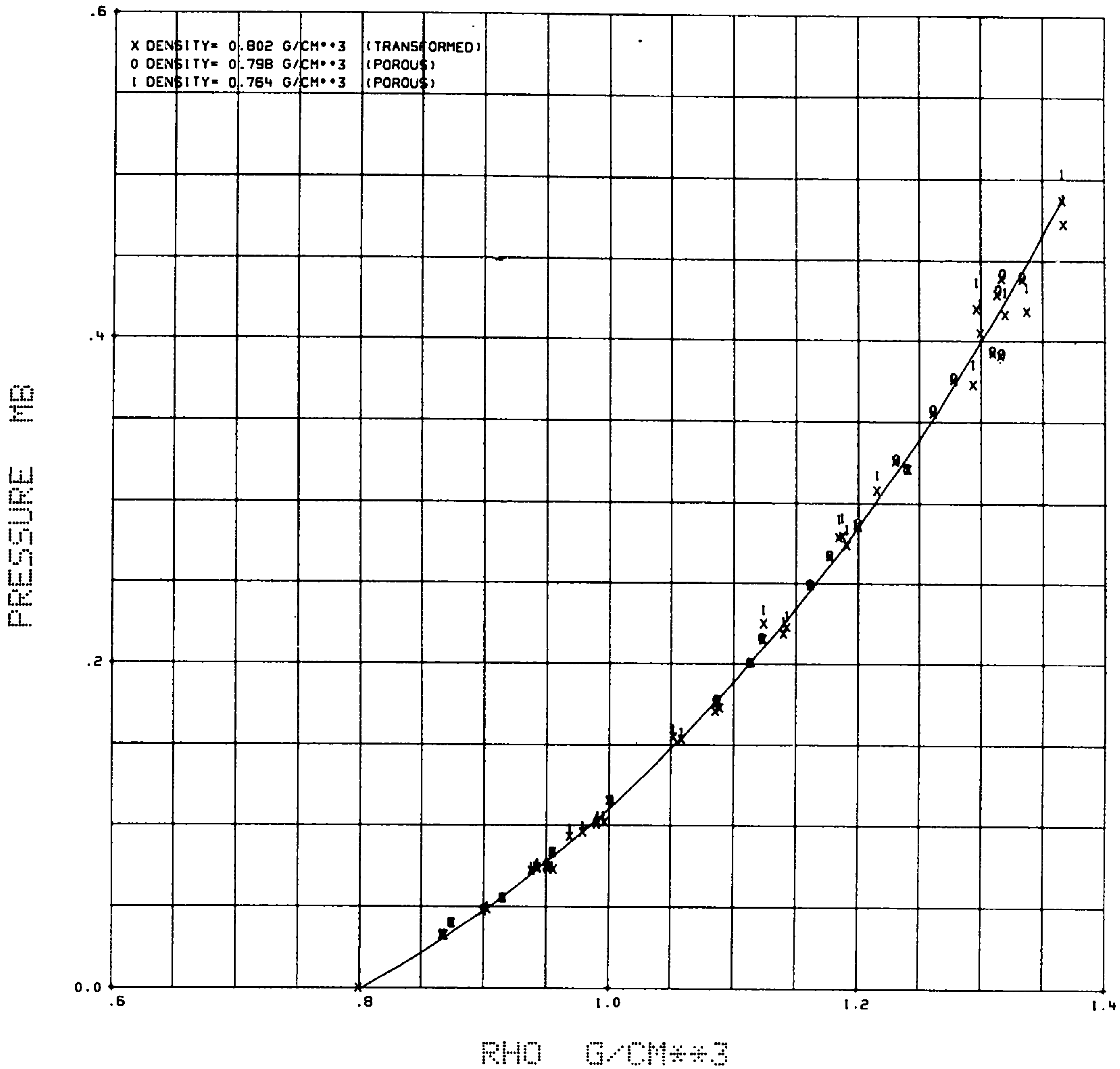

Fig. 12. Pressure-density Hugoniot data for Li^6D. Experimental porous Hugoniot data ($\bar{\rho}_0$ = 0.798 and 0.764 g/cm^3) and transformed crystal-density Hugoniot points are shown. The curve is the fit shown in Fig. 11.

[redacted]

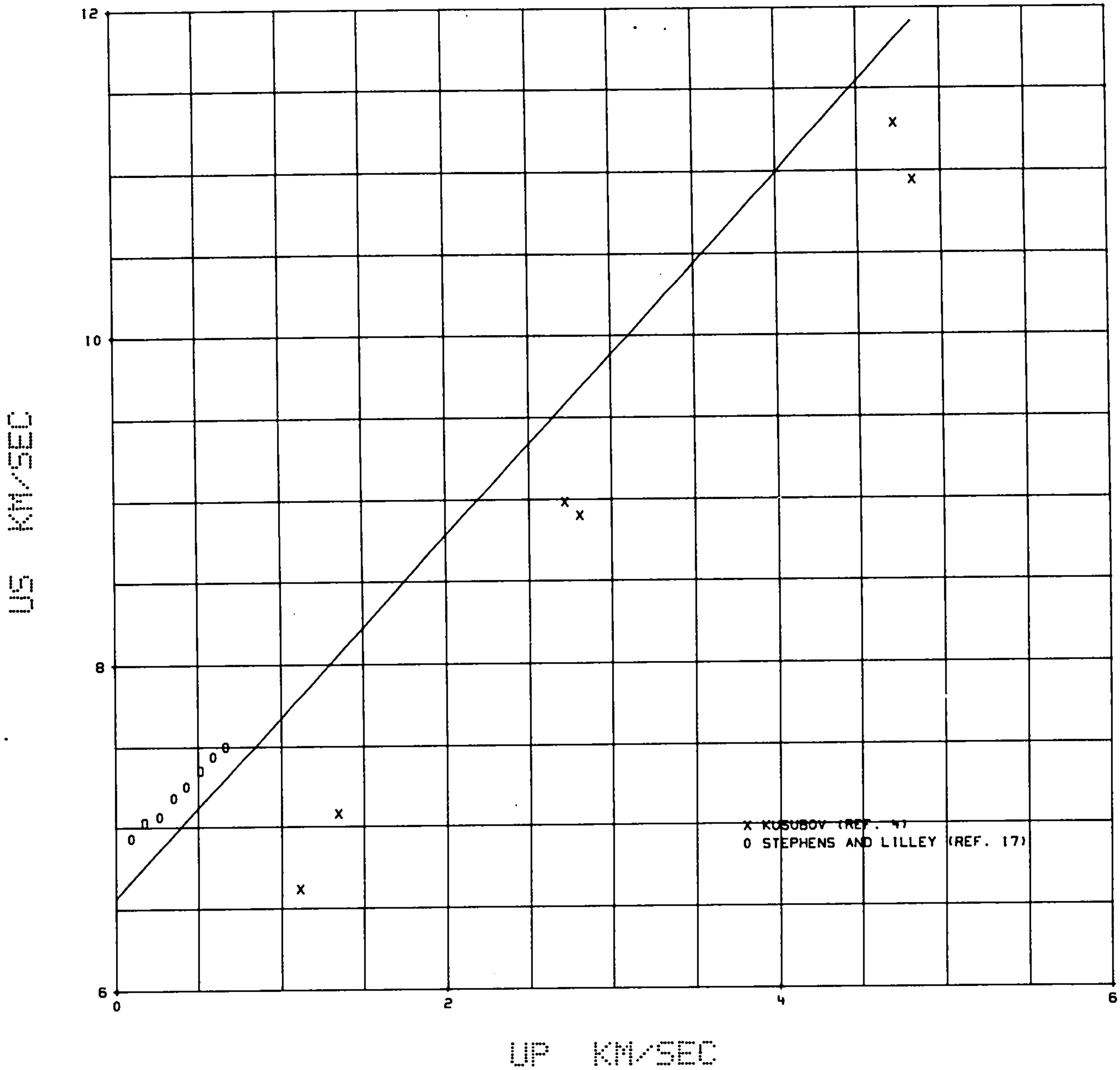

Fig. 13. Summary of other investigators' Li^6H Hugoniot data. The straight line shows the fit reported in Table XV.

[redacted]

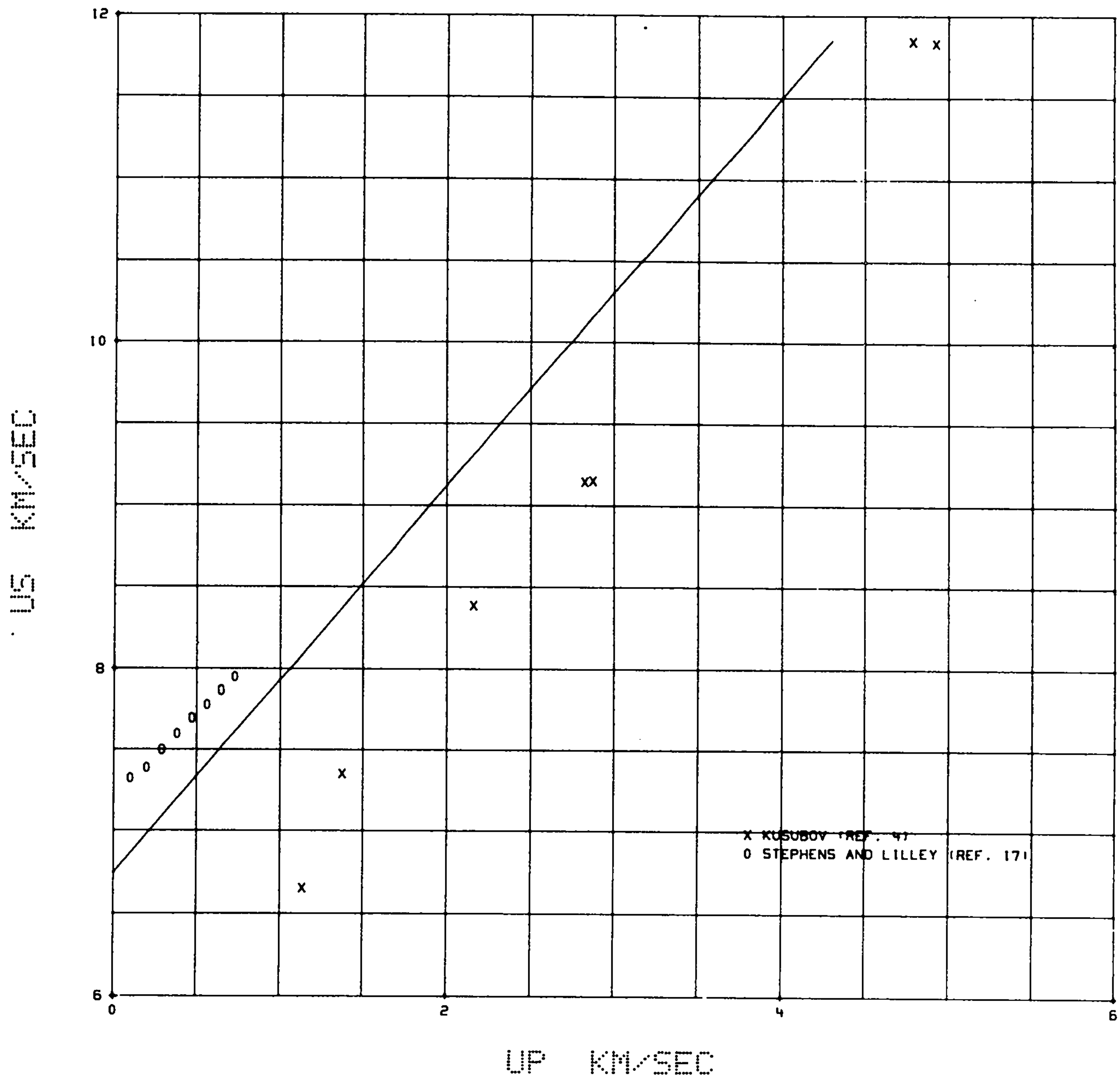

Fig. 14. Summary of other investigators' Li^6D Hugoniot data. The straight line shows the fit reported in Table XV.

[redacted]

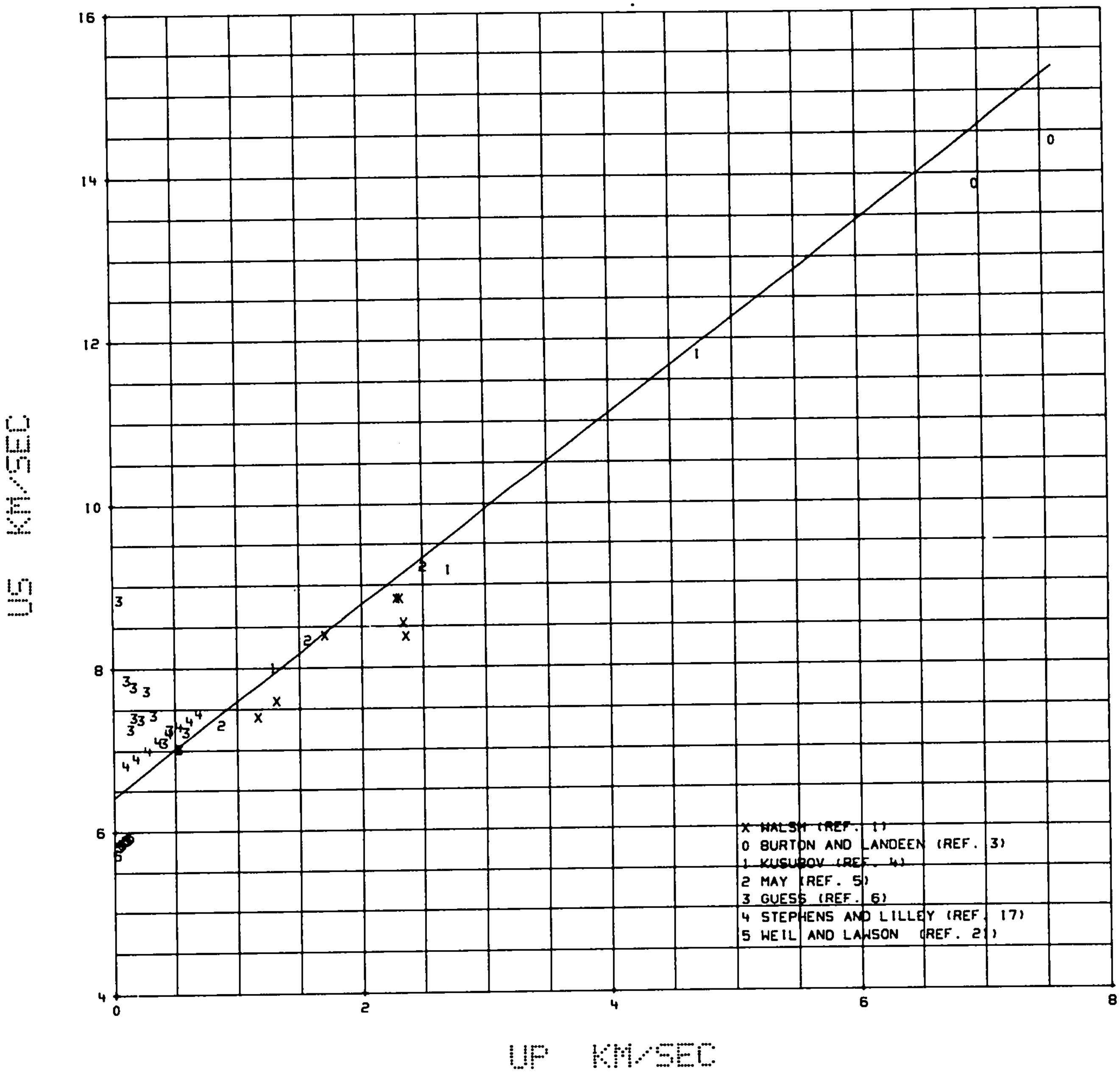

Fig. 15. Summary of other investigators' Li^{n}H Hugoniot data. The straight line shows the fit reported in Table XV.

[redacted]

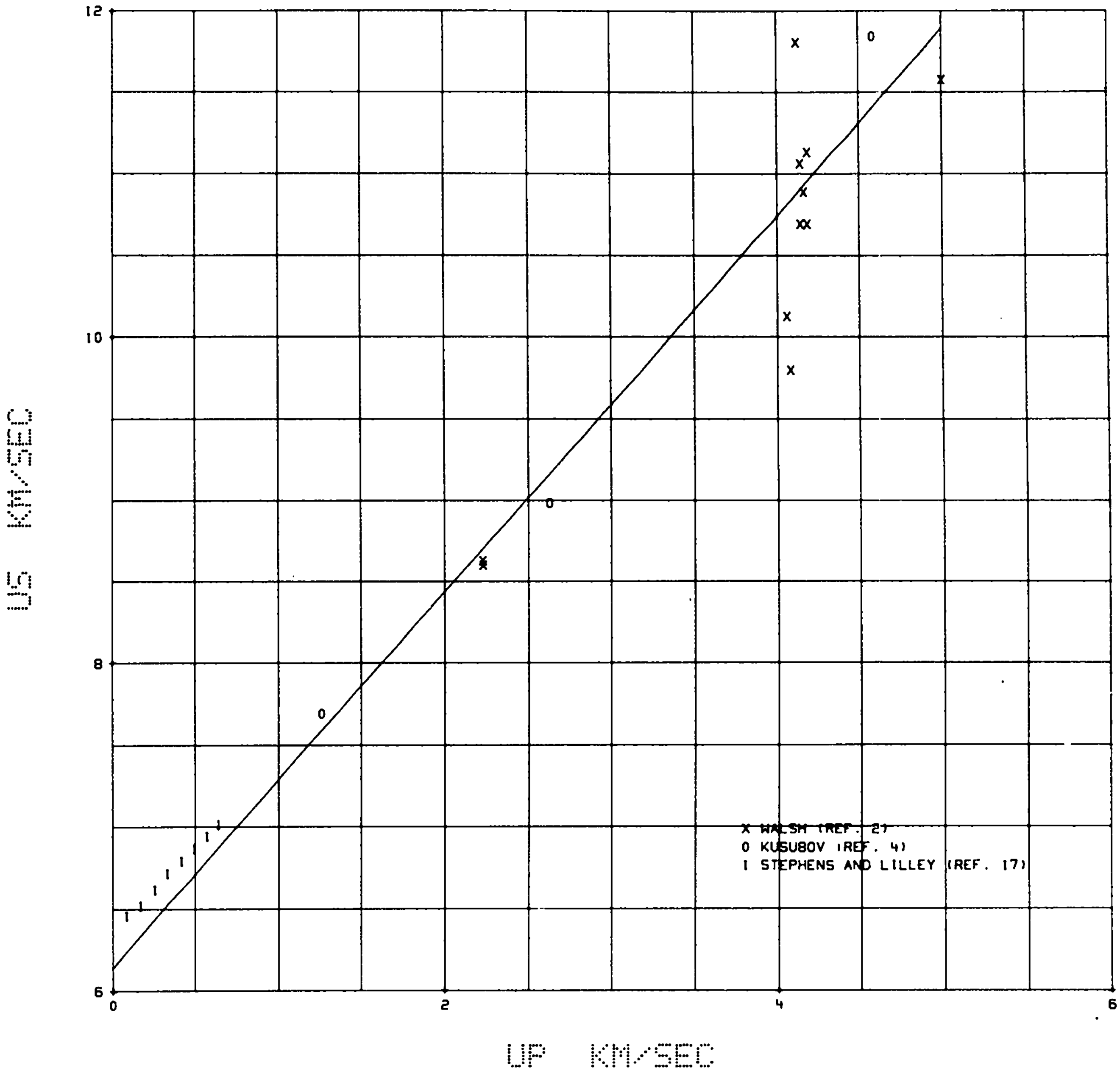

Fig. 16. Summary of other investigators' Li^{n}D Hugoniot data. The straight line shows the fit reported in Table XV.

KT/rd: 40

[redacted]

[redacted]

APPROVED FOR PUBLIC RELEASE