# CORRESPONDING STATES IN SHOCK COMPRESSION OF METALS

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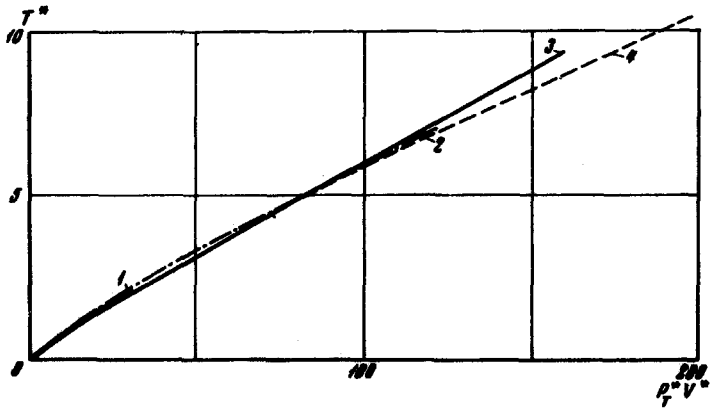
The law of corresponding states, well known for gases and liquids and used to solve a large number of problems, is valid at densities that are smaller by about one order of magnitude than the density of matter in the condensed state under normal conditions. It has been reported that the law of corresponding states is valid for argon and xenon in the condensed state under both static pressure [1] and under shock compression to 200 katm [2].

The state of a solid subjected to shock compression should apparently differ from the crystalline state. To describe such a state, one introduces the concepts of melting in the shock wave [3] and of the transformation of the substance into a gas of high density [4]. In addition, shock compression is accompanied by exceedingly strong heating of the substance. We can therefore attempt to apply the law of corresponding states to a description of the states realized in shock compression of solids, particularly metals. However, the equations of state of a metal under shock compression at pressures up to 10 million atm and temperatures up to several tens of thousand degrees cannot be represented in reduced form in terms of the reduced temperature $T^* = T/T_{cr}$, reduced pressure $P^* = P/P_{cr}$, and reduced volume $V^* = V/V_{cr}$ (all three of which equal unity at the critical point), and containing no quantities characterizing the concrete substance. That is to say, the law of corresponding states in pure form does not hold in this case. We shall show that this principle can be applied in a somewhat different form. We construct for the metal the reduced temperature $T^* = T/T_{cr}$ as a function of the reduced pressure of the thermal part of the pressure by the reduced volume, $P^*V^* = P_TV/P_{cr}V_{cr}$. Unfortunately, there are no experimentally measured critical parameters $T_{cr}$, $P_{cr}$, or $V_{cr}$ for metals. All that we have are values calculated for these quantities in one manner or another (cf.,e.g., [5, 6]). However, as a rule, values of $V_{cr}$ and $T_{cr}$ are cited in such papers. The author is aware of complete sets of critical-point parameters $T_{cr}$, $P_{cr}$, $V_{cr}$ only for the alkali metals K, Na, Li, Rb, and Cs [5] and for tin [6]. On the other hand, equations describing shock-wave compression are known for four of these metals: Li, Na, K [7] and Sn [8].

On the basis of the results of the cited papers, we plotted $T^* = T^*(P^*_TV^*)$ for K, Na, Li, and Sn (see the figure). Up to $\sim 10^4$ °K, the curves for all four metals practically coincide. The curves for Na and K begin to differ above $\sim 10^4$ °K, where the thermal excitation of the electrons comes into play. This difference can be attributed to an inaccurate choice, on the part of the authors of [7], of the corresponding coefficients in the electronic components of the energy and pressure in the equations of state for these metals. Thus, at least for these four metals, we can speak of corresponding states




Reduced temperature $T^* = T/T_{cr}$ vs. the reduced product $P_T^*V^* = P_TV/P_{cr}V_{cr}$ for metals in the shock-compression state. $P_{cr}$, $T_{cr}$, $V_{cr}$ - pressure, temperature, and specific volume at the critical point. 1 - Li, 2 - Sn, 3 - Na, 4 - K.

under shock compression, bearing in mind that if the reduced products $P^*_TV^* = P_TV/P_{cr}V_{cr}$ are equal for two states, the reduced temperature $T^* = T/T_{cr}$ will also be equal.

Unfortunately, it is impossible to verify the validity of this premise for other metals for which there are no complete sets of data, both with respect to the parameters of the state at the critical point, on the one hand, and with respect to the parameters of the state of shock compression, on the other. It is evidently highly desirable to obtain such data either by calculation or by experiment.

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## EMISSION STIMULATED BY EXPLOSION OF $HN_3$ IN $CO_2$

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The possibility of obtaining inverted population by transfer of energy from "hot" molecules to cold ones was discussed in [1, 2]. It was noted in [1] that "hot" molecules can be obtained during the course of chemical exothermal reactions. The molecule pair ($N_2$, $CO_2$) is one of the best for the realization of this idea, since the effective transfer of excitation from the vibrationally excited $N_2$ to the $CO_2$ has been demonstrated by the development of a powerful high-efficiency laser excited by a discharge in an $N_2 + CO_2$ mixture [3]. To obtain "hot" molecules, we used the exothermal reaction of decomposition of the molecule $HN_3$, in which nitrogen molecules are produced in excited vibrational states [4]. The decomposition (explosion) of $HN_3$ was effected in an $HN_3 + CO_2$