The state of the boundary region of contact between a heavy liquid metal coolant (lead, lead–bismuth and lead-lithium eutectics, gallium) and a structural material (steel, vanadium and beryllium alloys) largely determines the heat transfer between the solid and liquid metals, the stability of the structural materials, and the radiation conditions. Ultrasonic studies of the characteristics of this region have been performed at the Nizhnii Novgorod Technical University for 12Kh18N10T steel in contact with lead–bismuth coolant. Acoustic probing was done with a signal generation frequency 8 MHz. The delay time between two ultrasonic pulses was 2 msec (1/500 Hz). The acoustic signals through the volume studied and the boundary regions propagated along a waveguide system connected with the electric circuit generating and receiving the signal. The waveguides consisted of 12Kh18N10T steel rods with cross section $3 \times 3$ mm. The ultrasonic pulse propagating along the waveguide was reflected at the structural material–coolant interface according to Snell’s law [1], passed through two boundary regions and the coolant layer, and was once again reflected at the similar boundary of the second waveguide and then acted on the detector (Fig. 1). The measured amplitude of the pulses was determined by the phase state of the medium in the volume being monitored. The presence of a gas phase or a layer of impurity deposits with density less than the coolant density caused damping of the ultrasound.

In the course of this work, the dependences of the change in the amplitude of the ultrasonic signal on the wetting of solid metal by a liquid with argon and hydrogen bubbled through a layer of liquid metal were investigated. The changes in the amplitude of the acoustic signal as a function of the excess gas pressure (0.01–5 MPa) or vacuum in the gas volume above the free coolant level were investigated. These experimental investigations were performed in different temperature ranges.

Initially, at the first immersion of the waveguides into lead–bismuth eutectic at temperature 135°C, a signal equal to 4.8 V was recorded; 15 min later the signal decreased smoothly to 2.8 V, and after 5 min it increased to 5.3 V and once again decreased to 2.5 V, after which the sensor was removed from the alloy. When the waveguides were subsequently put into the alloy, the signal was 0.8–0.9 V and did not rise above these values.

The state of the boundary layer was changed by reducing oxide coatings. When hydrogen is introduced under the active part of the waveguides through the lead–bismuth eutectic at temperature 135°C, a signal equal to 0.35–0.6 V (Fig. 2). The sensor for thermodynamic activity of oxygen showed that a rapid decrease of oxygen content in the volume occurred in the first 3–4 h with hydrogen being fed continuously into the loop. After this series of experiments was completed, all structural components including the bubbler tube and the waveguides lying below the eutectic level were found to be wetted with the eutectic.

The investigations of the temperature dependence of the amplitude of the ultrasonic signal passing through the waveguides and the volume of the lead–bismuth eutectic confirmed that the signal is extinguished as a result of an increase in damping with increasing temperature [2] and intensification of physicochemical processes in the boundary layer on the
Fig. 1. Propagation of ultrasonic waves: 1) waveguide; 2) heavy liquid metal coolant; 3) oxide coating.

Fig. 2. Amplitude of ultrasonic signal (○) and emf (×) versus the hydrogen feed time at 500°C: ●, ■) start and end of hydrogen feed.

Fig. 3. Time dependence of the amplitude of the signal at temperature 200 (1), 300 (2), and 500°C (3) and atmospheric pressure (4), 5 (5), 3 (6), 2 (7), 1 MPa (8).