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MIXTURES AND THEIR RELATIONSHIPS TO REACTOR SAFETY"
(For Geneva Conference)

AUTHOR

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Contribution to the Report
"CRITICAL FLOW PHENOMENA IN TWO-PHASE MIXTURES AND
THEIR RELATIONSHIPS TO REACTOR SAFETY"

F. R. Zaloudek
January 23, 1964

Normally, in the flow of a flashing liquid through a pipe, it is assumed that the location of the choking phenomenon, if it exists, is at the exit of the pipe. Experiments have indicated that there are circumstances under which choking can occur at the entrance instead⁽¹⁾. These experiments were performed to study the flashing of initially-compressed water through short lengths of pipe with length/diameter ratios of up to 20. Entrance configurations considered included sharp and rounded transitions and conical passages of 20- and 45-degree tapers. Upstream pressures ranged from 115 to 1800 psia and in all instances, the upstream pressures were much greater than the saturation values. In most cases, choking of the flow was incurred when the liquid entering the pipe was required to depressurize to the saturation pressure (or below) when accelerating through the reduction at the entrance. Axial pressure surveys demonstrated that the pressure at the entrance of the pipe during choked conditions was the saturation pressure. It remained at the saturation value regardless of upstream pressure and the pressure distribution along the remainder of the pipe.

Visual observations through transparent viewing sections revealed that, during choking, vaporization was occurring in the slower moving fluid near the pipe wall; the core was a relatively clear and presumably metastable liquid. Flow rates associated with upstream choking were accurately

January 23, 1964

predictable by conventional nozzle equations using single-phase contraction coefficients and assuming the lower pressure to be the saturation value. The flow rates measured during upstream choking were much greater than values predicted by the Fauske or Levy theories on the basis of measured exit conditions.

For very short pipes ($L/D < 6$) with abrupt entrances, the flow patterns and critical flow rates were influenced by either a free or submerged discharge condition. With a submerged discharge, such pipes were observed to be subject only to the upstream choking mentioned above. With a free discharge, the hot water was observed separate from the wall of the pipe at the entrance and flow detached from the walls in a metastable stream to the low pressure region where complete relaxation to equilibrium conditions occurred. With such flow patterns, choking occurred at the exit of the pipe when the downstream pressure was low enough to cause sufficient vaporization in the nonequilibrium stream. Critical flow rates under these circumstances were predictable by the semi-empirical correlations of Burnell⁽²⁾, Kinderman and Wales⁽³⁾, and Bailey⁽⁴⁾.

Programs are under way to extend the available steam-water critical discharge data to higher temperatures and pressures than presently available in literature. In preliminary phases of this investigation⁽⁵⁾, experiments have been performed to determine the maximum discharge rates from a 1000-gallon, 2500-psi pressure vessel through one-half-inch diameter flow passages with water temperatures up to 550°F. Correspondence of the observed critical mass velocity with values predicted by the Fauske theory

January 23, 1964

has been observed at critical pressures as high as 600 psia. In this program, experiments are to be performed to determine the critical discharge characteristics of pipe sizes up to four inches and to investigate critical flow in various valves, elbows, and tees discharging directly to atmosphere.

January 23, 1964

- (1) F. R. Zaloudek, "The Critical Flow of Hot Water Through Short Tubes," HW-77594, May 1, 1962.
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