

Blow-down Tests in a Sodium-heated Steam Generator Tube

by

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U.S.A.****INTRODUCTION**

The design of steam generators for liquid metal fast breeder reactor (LMFBR) electric power plants is based on both normal load operation and plant transient conditions. Perhaps the most severe transient to which an LMFBR steam generator may be subjected is known as the "water-side isolation and dump" transient, often called the "blow-down" transient. It is intended to be a transient that is deliberately initiated by the power plant operator if it is deemed necessary to quickly isolate a steam generator from the remainder of the water system. Included in the isolation transient is the reduction of the water pressure from full operational pressure to near atmospheric pressure, and the dumping of the isolated water to an auxiliary vessel. This sequence of events is designed to occur in a time period in the range of 10 to 30 s, and as noted in Ref. 1, LMFBR steam generators must be designed to accommodate a small but finite number of the blow-down transients. The purpose of this investigation was to perform a blow-down experiment in a well instrumented, full scale, single tube model of an LMFBR steam generator. The data may be used directly in steam generator design and as a validation point for steam generator mathematical models in plant transient computer codes like the one used in Ref. 1.

EXPERIMENTAL PROCEDURE

A blow-down experiment was performed in the Steam Generator Test facility (Ref. 2-3) at Argonne National Laboratory, in a single-tube test section, vertically mounted, with a heated length of 13.1 m and an inside diameter of

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10 mm. Subcooled water entered the bottom of the tube and exited superheated at the top as it was heated by sodium flowing counter current in a surrounding annulus. Initial steady state operation was indicative of LMFBR steam generators. The water parameters were: mass flux = $436 \text{ kg/m}^2 \text{ s}$, pressure = 16.0 MPa, inlet subcooling = 213°C , and outlet superheat = 80°C . The sodium parameters were: mass flowrate = 0.353 kg/s , inlet temperature = 487°C , and test section temperature change = 192°C . The transient was then initiated by closing water isolation valves at the inlet and outlet of the test section and opening two water blow-down valves located at the test section inlet and outlet inside of the isolated region. The water exited the blow-down valves to the atmosphere. The valves were preprogramed such that the two blow-down valves opened in the time period between the initial movement of the inlet isolation valve and the complete isolation of the test section which was accomplished in approximately 4 s. The transient was allowed to continue for nearly 30 s at which time the water pressure was slowly approaching atmospheric. The sodium flowrate and inlet temperature were essentially unchanged during the entire test.

RESULTS AND CONCLUSION

The water mass flux is shown as a function of time in Fig. 1 as measured between the test section inlet and the inlet blow-down valve. Point "A" marks the initial movement of the inlet isolation valve which was completely closed at point "B". After point B was reached, with no feedwater flow, the water mass flux dropped quickly toward zero. The water flowmeter was out of its calibrated range in the dashed portion of the curve near zero flow, and during this time both blow-down valves began and completed their opening movements. The result seen in Fig. 1 was to produce downward (negative) water flow out of the test section inlet through the inlet blow-down valve. The water outlet isolation valve began its movement after the blow-down valves were completely open and was completely closed at point "E" marking complete test section isolation. Beyond point E, water continued to flow out of the bottom (water inlet) of the test section gradually approaching zero flow. The outlet water pressure decline was also moderate beyond point E as shown in Fig. 1. It declined at a rate of 0.7 MPa/s , but a sharp pressure spike occurred at point C when the outlet blow-down valve was opened. These results show that the

largest gradients in pressure and flow occurred when the isolation and blow-down valves changed position, and this part of the blow-down event must be included in system transient analyses as well as the more moderate part of the transient after the steam generator is isolated, i.e., after point E in Fig. 1.

REFERENCES

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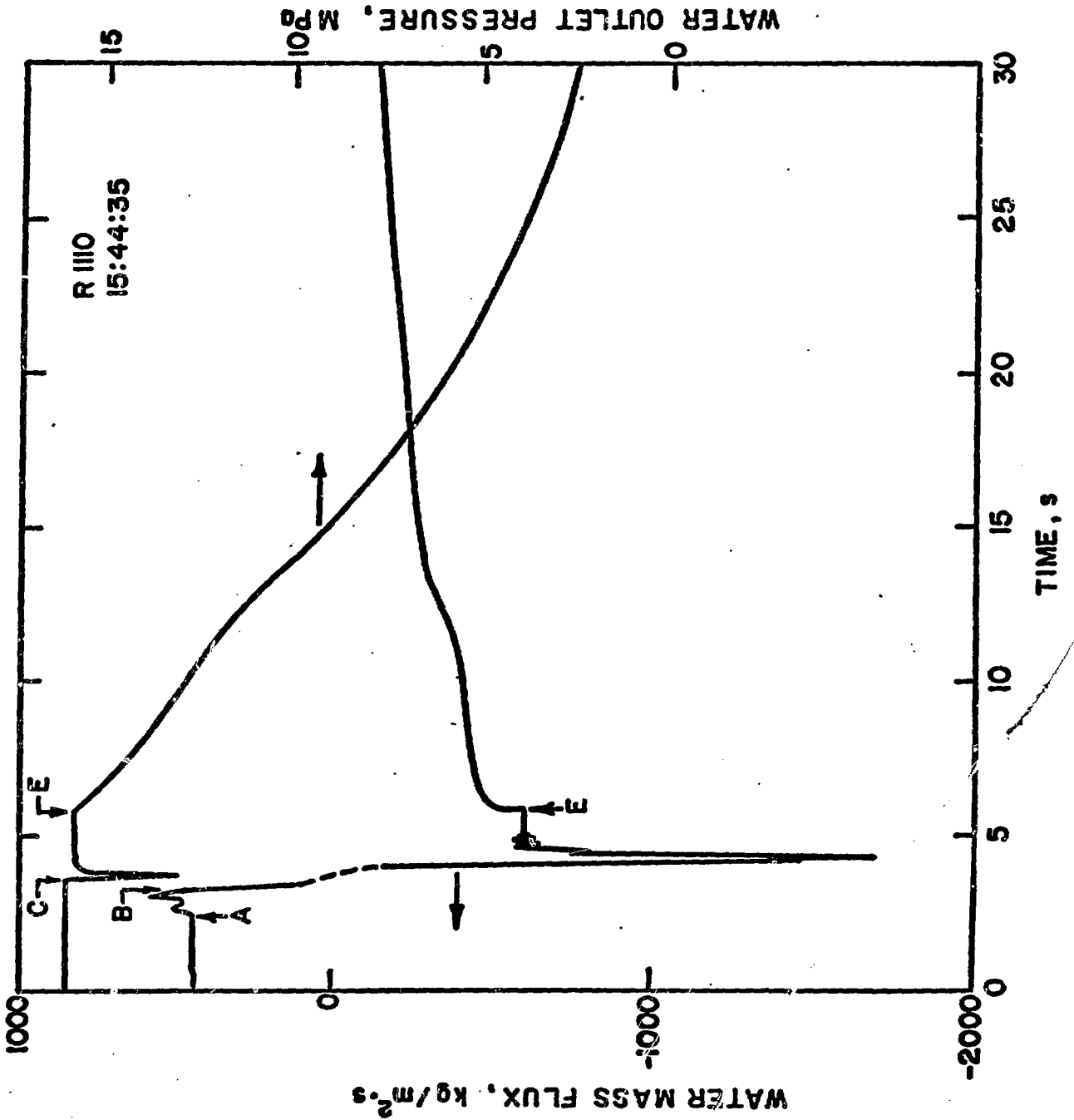


Figure 1. Flow and Pressure Responses During Blow-Down Transient