CONF-830609--27

ANALYSIS OF THE OPERA 15-PIN EXPERIMENT WITH SABRE-2P*

S. D. Rose J. J. Carbajo

CONF-830609--27

DE83 014037

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830

Summary Prepared for Submission to the
1983 ANS Annual Meeting

June 12-17, 1983

Detroit, Michigan

*This research is sponsored by the Office of Breeder Reactor Projects, U.S. Department of Energy under contract W-7405-eng-26 with the Union Carbide Corporation.

ANALYSIS OF THE OPERA 15-PIN EXPERIMENT WITH SABRE-2P

S. D. Rose J. J. Carbajo

SUMMARY

The OPERA (Out-of-Pile Expulsion and Reentry Apparatus) experiment [1] simulates the initial phase of a pump coastdown without scram of a liquid-metal fast breeder reactor, specifically the Fast Flux Test Facility. The test section is a 15-pin 60° triangular sector designed to simulate a full-size 61-pin hexagonal bundle. A previous study [2] indicates this to be an adequate simulation. In this paper, experimental results from the OPERA 15-pin experiment performed at ANL in 1982 are compared to analytical calculations obtained with the SABRE-2P code at ORNL.

The subchannel boiling code, SABRE-2P is a version of the single-phase transient code SABRE-2 [3] with a two-phase model included. Due to symmetry considerations, only half of the triangular sector has to be modeled with SABRE-2P. The loss-of-flow (LOF) transient was modeled with a pressure drop boundary condition consisting of two pressure ramps. The total pressure drop at steady-state (0 s) for the test bundle, including the inlet valve, was 435 kPa to yield the required initial inlet velocity of 4.28 m s^{-1}. This pressure drop was first decreased at a rate of 53 kPa s^{-1} to give the required velocity of 2.5 m s^{-1} at 5 s. After 5 s, a less steep pressure ramp of -14.8 kPa s^{-1} was used. The inlet valve was modeled as a $k\rho v^2$ resistance in the first axial node with a value for k of 15.24 based on a calculation of pressure drop at steady-state conditions. A linear power distribution in the axial direction was used; the pin power was 26.7 kW. The sodium inlet temperature was constant at 323°C. An adiabatic heat flux boundary condition was assumed for the outer surface of the duct wall. This is considered to be a reasonable assumption because heat

losses to the surrounding environment should be small during the rapid transient. The heat capacity of the duct wall is accounted for in the calculation.

Figure 1 shows the test section inlet velocity. Boiling is first detected at 9.6 s by the thermocouple in the wire-wrap on pin 1, located 12.7 mm upstream of the end of the heated section. The first indication of permanent dryout is at 14 s, but this is indicated by the thermocouple in the wire-wrap on pin 5 at the same axial location. After ∿10 s, the inlet flow rapidly drops reaching zero at 12 s followed by a series of oscillations with a frequency of about 2 Hz. Between 12 and 14 s, thermocouple data indicate possible intermittent dryout. Similar behavior has been observed for the in-core W-1 Sodium Loop Safety Facility experiment [4]. The SABRE-2P prediction of the OPERA experiment shows boiling initiation at 8 s in the hottest channel (apex of the triangular sector) at the end of the heated section. Dryout is predicted in this location at 12.2 s, and the calculation is terminated at this point. The predicted boiling time at the location of the pin 1 thermocouple is 9.4 s which compares well with the data.

Figure 2 shows the radial temperature profiles at 0 and 9.5 s into the LOF. At steady-state (0 s), the highest temperature is not at the pin 1 thermocouple but at the pin 9 thermocouple. This is a good indication of distortion occurring before the initiation of the LOF transient. At 9.5 s, the temperature is hottest at pin 1 indicating a change in the distortion of the pins. The SABRE-2P calculated radial temperature profile at 0 s shows the hot spot at the apex of the triangular sector and also indicates that the calculated radial temperature profile is steeper than measured experimentally. These calculations are only appropriate for an undistorted geometry and a more thorough analysis is not warranted.

In conclusion, the experimental data indicate that distortion occurred in the triangular bundle. Despite this problem, the comparison between analytical and experimental results is satisfactory. The SABRE-2P code is capable of predicting the transient thermal-hydraulic behavior from boiling to dryout adequately.

REFERENCES

1. T. J. Scale, "OPERA Fifteen-Pin Sodium Expulsion Test," *Trans. Amer. Nucl. Soc.* 43, 495 (1982).

2. J. J. Carbajo and S. D. Rose, "Study of the Applicability of Using a 15-Pin Triangular Sector as a Substitute for a 61-Pin Hexagonal Simulated LMFBR Fuel Assembly," *Trans. Amer. Nucl. Soc.* 43, 497 (1982).

3. J. D. MacDougall, *SABRE-2: A Computer Program for the Calculation of Transient Three-Dimensional Flows in Rod Clusters*, AEEW-R 1104, United Kingdom Atomic Energy Authority (1978).

4. J. F. Dearing and S. D. Rose, "Two-Dimensional Modeling of Sodium Boiling in the W-1 Sodium Loop Safety Facility Experiment," *Trans. Amer. Nucl. Soc.* 39, 1067 (1981).

FIGURE CAPTIONS

Fig. 1 Experimental and SABRE-2P Calculated Values for the Test Section Inlet Velocity of the OPERA 15-Pin Experiment

Fig. 2 Experimental and SABRE-2P Calculated Radial Temperature Profiles for OPERA 15-Pin Experiment at 0 s and 9.5 s

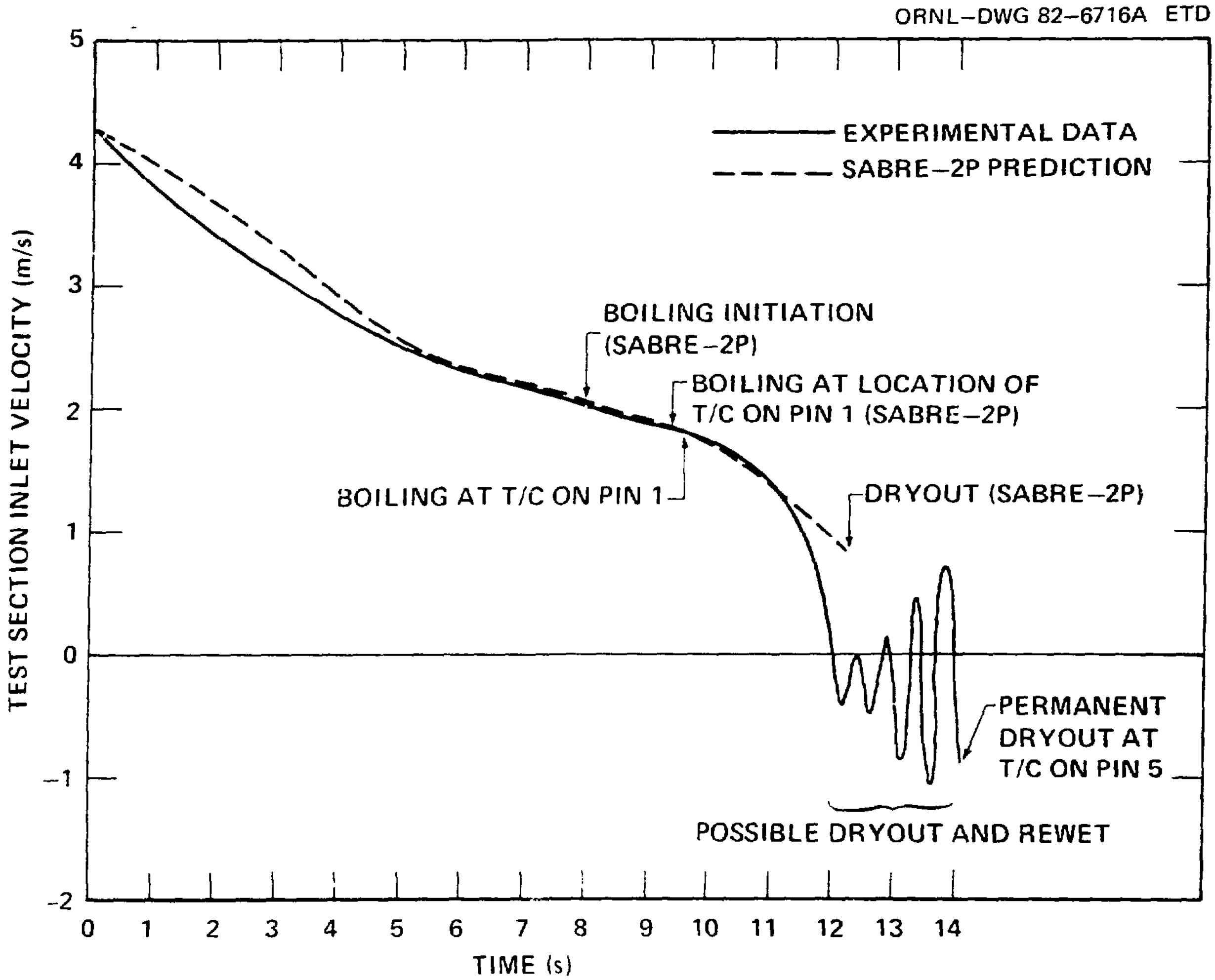

Fig. 1 Experimental and SABRE-2P Calculated Values for the Test Section Inlet Velocity of the OPERA 15-Pin Experiment

ORNL–DWG 82–6889 ETD

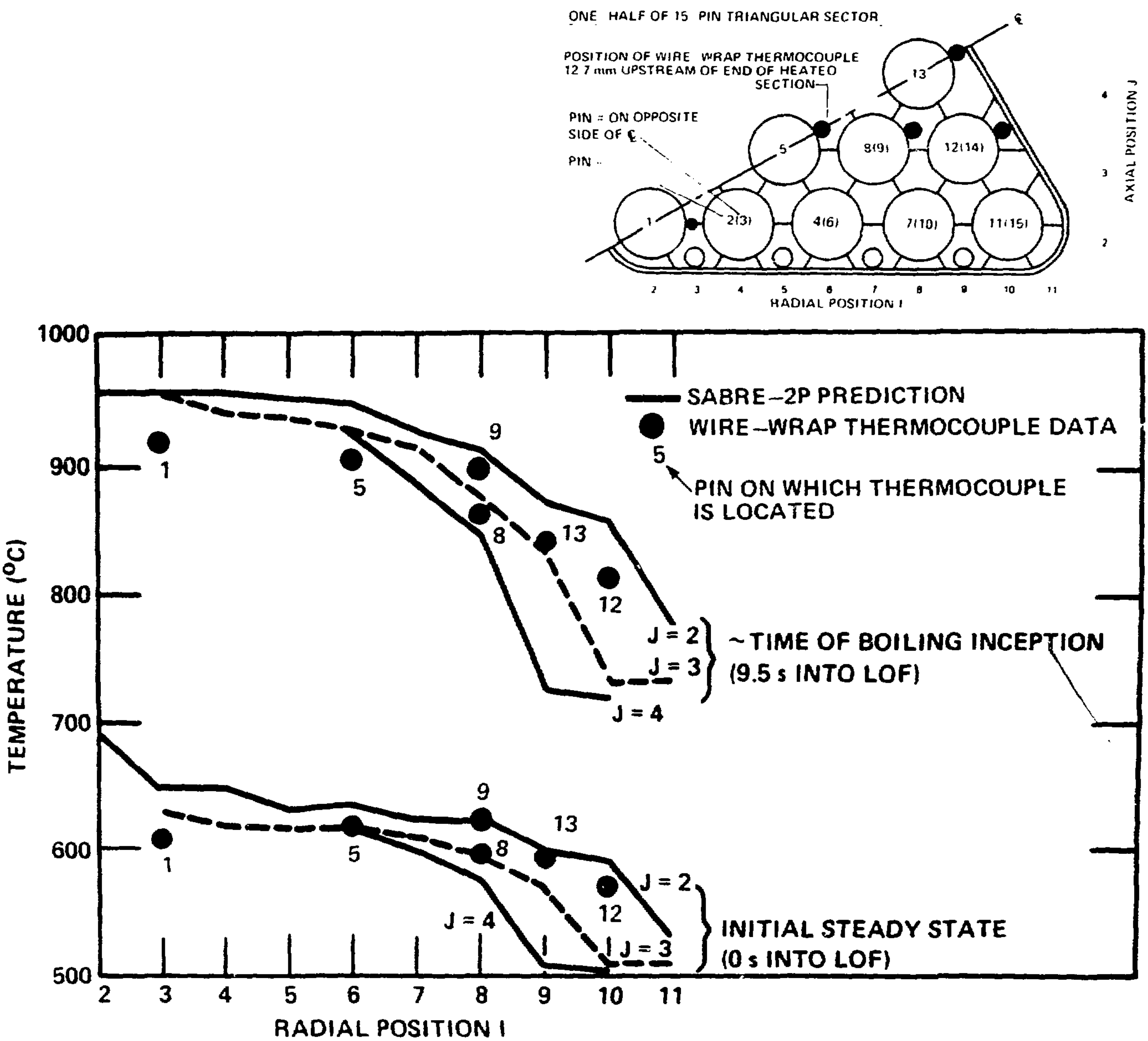

Fig. 2 Experimental and SABRE-2P Calculated Radial Temperature Profiles for OPERA 15-Pin Experiment at 0 s and 9.5 s