Rapid #: -22559363

CROSS REF ID:	**1356171**
LENDER:	**MVS (Millersville University) :: Main Library**
BORROWER:	**ORE (Oregon State University) :: Main Library**
TYPE:	Article CC:CCL
JOURNAL TITLE:	Transactions of the American Nuclear Society
USER JOURNAL TITLE:	Nuclear science and engineering : the journal of the American Nuclear Society.
ARTICLE TITLE:	The NCSU (North Carolina State Univ.) freon PWR (pressurized water reactor) loop
ARTICLE AUTHOR:	Caves, J.R.
VOLUME:	59
ISSUE:	
MONTH:	
YEAR:	1989
PAGES:	-
ISSN:	0003-018X
OCLC #:	

Processed by RapidX: 5/10/2024 9:12:54 AM

INNOVATIONS IN NUCLEAR ENGINEERING EDUCATION AND TRAINING

1. The NCSU Freon PWR Loop, *John R. Caves, J. Michael Doster, Garry D. Miller, Bernard W. Wehring, Paul J. Turinsky (NCSU)*

The nuclear engineering department at North Carolina State University has designed[1] and constructed an operating scale model of a pressurized water reactor (PWR) nuclear steam supply system (NSSS). This facility will be used for education, training, and research. The "loop" uses electric heaters to simulate the reactor core and Freon as the primary and secondary coolant. Viewing ports at various locations in the loop allow the students to visualize flow regimes in normal and off-normal operating conditions.

The loop provides the opportunity for students and power plant operations personnel to investigate and study overall system response during normal operation, small-break loss-of-coolant accidents, steam generator tube ruptures, main steam line breaks, and other events where the interaction between facility design and control systems determine the effect of a perturbation on the system. It provides a working understanding of NSSS operation to students in the undergraduate and graduate education programs and helps power plant personnel develop a better understanding of the thermal-hydraulic effects on system transient response. The loop complements simulator training by allowing visual observation of the fluid in the reactor, pressurizer, and steam generators.

The objective of the design effort was to scale the thermal-hydraulic characteristics of a two-loop Westinghouse NSSS. The primary design criteria were the following:

1. The loop must provide proper tracking of the parameters of interest on specific transient scenarios.

2. The proper sequence of automatic protective actions must be maintained except when intentionally overridden.

3. Observation of the scenarios of interest must lead to the proper conclusions concerning how the consequences of the transient are affected by operator actions.

The question of how well those objectives are met are being determined during the present testing phase, which will extend through December of 1989.

The scaling laws of Ishii and Kataoka[2] were used to scale the loop to the Prairie Island NSSS. This sets various ratios between model (loop) and prototype parameters to maintain similarity in thermal-hydraulic performance. Lengths are reduced by a factor of 9.6, and temperatures scale by a factor of 8.04. The cross-sectional flow area ratio was chosen to be 92, which provides geometric similarity between plant and model for simple components and a close approximation to geometric similarity for components such as the reactor and steam generator. Time characteristics have a scale ratio of 1, so time response on the loop is consistent with the plant. Refrigerant R-11 is the working fluid in both the primary and secondary systems.

Eight kilowatts is the nominal full power for the system, distributed uniformly among 106 heater rods, each 0.38 m long and a 1.0-cm diam. Nominal average loop temperature at full power is 95°C with a temperature rise across the core of 4.4°C. Normal operating system pressure is 760 kPa. The reactor vessel is 1.2 m tall and a 0.35-m diam, while the vapor generators are 2.1 m tall and a 0.35-m diam.

Provisions have been made for the simulation of various abnormal occurrences. Thermal-hydraulic scaling of natural circulation in both single- and two-phase regimes provide direct correlations between model and prototype operation. Factors affecting the development of natural circulation are studied in depth in a hands-on environment, which is very effective for instructional purposes. Loss-of-coolant accidents can be simulated by opening valves installed to vent the system to the dump condenser to model steam generator tube ruptures and small breaks.

The model is instrumented in much the same manner as the actual NSSS. Indications of all of the major operating parameters are continuously available on the control console. Control functions that affect plant response to the transients of interest are provided, including a point kinetics model for reactivity feedback to the core, vapor generator level control, and the reactor protection system.

This project represents a joint venture between North Carolina State University, Carolina Power and Light, Duke Power, and Virginia Power companies. The utilities provided construction costs in return for training time on the facility. Current plans include programs for reactor operator license candidates, licensed operators in requalification programs, and plant engineers. The project is an extension of current reactor operator training programs offered by the university to enhance understanding of basic principles of reactor physics, heat transfer, and fluid flow.

Current research projects using the loop include the development of adaptive expert systems to monitor the performance of the facility, diagnose mechanical faults, and to make recommendations to operators for mitigation of accidents. This involves having thermal-hydraulics and core-physics simulators running faster than real time on a minisupercomputer, with operating parameters updated by communication with the data acquisition and control computer. Further opportunities for research will be investigated as they arise.

The Freon loop is an innovative project with many potential benefactors. It is expected to be very valuable to students as they gain understanding of integrated system response, which makes them more valuable to future employers. Utility operators and engineers will have the opportunity to strengthen their understanding of thermal-hydraulic phenomena, which has implications for improving safety at operating plants. Researchers will have a test bed for investigation of advanced control algorithms, reactor thermal-hydraulic models, and expert system-based operator aids.

1. J. R. CAVES, B. W. WEHRING, J. M. DOSTER, P. J. TURINSKY, "PWR Thermal Hydraulics Training Facility for Engineers and Operators," *Trans. Am. Nucl. Soc.*, **52** (June 1986).

2. M. ISHII, I. KATAOKA, "Scaling Criteria for LWR's Under Single-Phase and Two-Phase Natural Circulation," ANL-83-32, NUREG/CR-3267, Argonne National Lab. (Mar. 1983).