

STATUS OF THE CLINCH RIVER BREEDER REACTOR PLANT
NUCLEAR STEAM SUPPLY SYSTEM

by

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The Clinch River Breeder Reactor Project progress and accomplishments on the Nuclear Steam Supply Systems (NSSS), during the last year will be highlighted in this presentation.

A year ago the Project's first year's accomplishments were presented. The work performed in 1973 and 1974 by the CRBRP participants included completion of a plant system design review and agreement on key reference design decisions with PNC/AEC on March 1, 1974. During this review period the project guidelines were re-assessed and many simplifications were made in the system design. Key plant parameters are listed in Table 1. The reference design for the Clinch River Breeder Reactor Plant was established and has been published including a description of all systems, key drawings, flow diagrams, conceptual general arrangement drawings, an equipment list and the project schedules.

TABLE 1
PLANT PARAMETERS

Thermal Power, MW	975
Gross Electrical Power, MW	380
Net Electrical Power, MW	350
Gross Efficiency, %	39
Net Electrical Efficiency, %	36
Design Life, Years	30
Refueling Interval, Months	12
Reactor Inlet Temperature, °F	730
Reactor Mixed Mean Outlet Temperature, °F	995
Primary Pump Flow Rate, gpm	33,700

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Primary Pump Developed Heat, Ft. Na	450
Hot Leg Temperature, °F	936
Cold Leg Temperature, °F	651
Intermediate Pump Flow Rate, gpm	29,500
Intermediate Pump Developed Heat, Ft. Na	410
Steam Pressure at Turbine Throttle, psi	1,450
Steam Temperature at Turbine Throttle, °F	900
Feedwater Temperature, °F	450

Much has been accomplished in the past year as the project has progressed into detailed design efforts and procurement activities. A number of key areas of our NSSS efforts have been selected for this ANS status presentation.

- Heat Transport and Power Generation
- Heat Transport System Arrangement
- Intermediate Heat Exchanger
- Plant Control
- Reactor
- Reactor Vessel Head
- Reactor Control and Shutdown
- Prototypicality
- Project status

Heat Transport and Power Generation

A system of three identical piped circuits transport heat from the reactor, through primary and intermediate sodium loops, to steam generator modules which produce steam for the turbine. The primary heat transport loops operate at a maximum pressure of about 175 psig. The primary components have guard vessels surrounding them to contain sodium in the event of a leak in the coolant boundary.

The temperatures chosen were based on optimization studies which considered fuel life, piping and component reliability, and plant efficiency. The temperature differences were selected after studying the duty cycles expected in thirty years of plant service. If plant components meet nominal performance estimates the plant will be capable of operating at 115% of rated power.

Heat Transport System Arrangement

The reactor containment building houses the radioactive primary and auxiliary sodium systems. The use of identical loop configurations minimizes containment size and engineering cost. Conservatively arranged piping layouts achieve sufficiently low thermal stress levels to insure high reliability in the primary loop piping which occupies a major portion of the containment building plan. Design studies have shown this loop layout to be extrapolatable to commercially sized plants.

Maintenance and in-service inspection considerations have also resulted in the provision of a three-foot space around all primary and intermediate loop sodium piping. Eighteen-inch straight sections have been provided to affix welding equipment at all locations where need might arise to cut or weld the pipe. Longitudinally welded pipe has been specified where stress conditions permit.

A minimum number of inerted cells, twelve in the reactor containment building and four in the reactor service building, are utilized to house the radioactive sodium systems. These sixteen cells provide isolation of key components and improve availability by permitting on-line maintenance of key components.

Intermediate Heat Exchanger

The intermediate heat exchanger, being designed by Foster Wheeler, is a counterflow shell and tube design with the primary sodium on the shell side. The primary sodium flows downward and the intermediate (heated) fluid moves upward to enhance natural circulation for reactor decay heat removal. Major features of the Clinch River intermediate heat exchanger design are:

- Straight tubes and a flexible downcomer which uses a bellows for flexibility.
- Only front face tube sheet welds for improved fabrication and inspection.

- Tube bundles designed for in-place plugging of tubes.
- Tube bundles which are removeable and replaceable.

The intermediate heat exchanger equipment specification has been completed and long lead materials are on order.

Plant Control

The plant control system provides both manual and automatic controls for startup, load changing, rated power, standby and shutdown conditions. Automatic control of power, sodium and steam temperatures, and water flows is provided for load changing and power operation. Two modes of automatic control are provided:

- Reactor follow mode in which the plant is operated based on a reactor power level established by the plant operators.
- Load follow mode in which the plant responds to the electrical load demand from the utility automatic load dispatch system.

The plant can accommodate 10 percent step changes in load and three percent per minute ramp load changes.

Reactor

Modularized design concepts have been developed for both the lower core support structure and the upper internals. The main lower support structure contains 61 inlet modules each of which positions and directs flow to seven core assemblies. The upper internals structural members have a low thermal inertia and can withstand thermal transients yet have sufficient rigidity to prevent vibration.

Design margins and design features have been provided in the reactor system to enhance plant safety and maintainability:

- Essentially all of the reactor internals are removable.
- A negative reactivity feedback coefficient for all operating conditions.
- Inspection capability using the space between the reactor vessels and guard vessel.

- Design margin requirements for vessel loads and nozzle loads.
- Multiple flow paths to prevent flow blockage.
- Failed fuel detection and location capability.
- In-vessel post accident heat removal capability.

Reactor Vessel Head

A triple rotating plug head design was adopted to implement through the head refueling with a straight pull refueling machine.

The head design contains margin to accommodate hypothetical core disruptive accidents. A pressure pulse on the lower surface of the head sufficient to lift the rotating plugs would be transferred directly to the base of the outer plug after a relatively small amount of vertical motion. Holddown bolts are sized to accommodate this type of load.

Reactor Control and Shutdown

Two independent, diverse shutdown systems are provided. The primary system (15 rods) uses a fully developed electro-mechanical control rod drive mechanism design. The secondary system (4 rods) utilizes a diverse hydraulically assisted design. Either control rod system can shut the plant down with its highest worth control rod stuck in the all out position. A major reliability testing and analysis program is underway to establish the reliability of the shutdown systems. Extensive prototype testing of the Westinghouse designed primary shutdown system and the General Electric designed secondary shutdown system is scheduled. The project intent is to show that failure to scram is of such a low probability that accidents stemming from this action need not be considered as a design basis.

Prototypicality

The Clinch River Breeder Reactor Plant design evolved from a prudent application of the Project Management Corporation's Demonstration Plant Guidelines. Emphasis has been placed on safety and reliability. The objective of commercialization has been satisfied by designing for prototypicality in major systems and components. Prospect for economy will be demonstrated by

achieving capital costs extrapolatable to economically competitive commercial plants and through demonstration of fuel cycle performance. Most parameters of the plant are the same as those proposed for a commercial LMFBR.

Project Status

Major accomplishments have been achieved by the Project. Supporting the major milestones, system design descriptions and equipment specifications have been completed by the reactor manufacturers and architect engineer. Major milestone events, such as preparation of the Environmental Report and the Preliminary Safety Analysis Report, have been completed.

Supporting development programs in the national LMFBR program are being restructured as required to provide necessary data to the CRBRP design.