CONF-9606116--3
BNL-62638

CURRENT AND PROSPECTIVE SAFETY ISSUES AT THE HFBR

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Introduction

The Brookhaven High Flux Beam Reactor (HFBR) was designed primarily to produce external neutron beams for experimental research. It is cooled, moderated and reflected by heavy water and uses MTR-ETR type fuel elements containing enriched uranium. The reactor power when operation began in 1965 was 40 MW, was raised to 60 MW in 1982 after a number of plant modifications, and operated at that level until 1989. Since that time safety questions have been raised which resulted in extended shutdowns and a reduction in operating power to 30 MW. This paper will discuss the principle safety issues, plans for their resolution and return to 60 MW operation. In addition, radiation embrittlement of the reactor vessel and thermal shield and its affect on the life of the facility will be briefly discussed.

Core Thermal Hydraulics Issue

During normal operation, the primary system is pressurized (200 psig) and the coolant flow direction is downward through the core (Figure 1). In a complete loss of coolant flow accident, the reactor is automatically shutdown and depressurized and the flow direction in the core changes from downflow to natural circulation upflow when decay heat increases the water temperature in the core and thermal buoyancy forces become dominant. The return path for the natural circulation flow around the core is provided by the opening of spring-loaded valves. Natural circulation is capable of providing an extended period of decay heat removal.

Since the transition from downflow to upflow involves an interval of stagnated flow, a key question is at what power level can this transition safely occur. While ex-reactor tests were done during the reactor design to demonstrate the feasibility of flow reversal, questions about the applicability and prototypicality of these tests were raised by external reviewers. This issue was one of the contributing factors to the 1989-1991 shutdown. Restart at a reduced power of 30 MW was based on the conservative assumption that heat removal was flooding limited.

Subsequently, an experimental and analytical program was initiated to obtain a more realistic and defensible estimate of the flow reversal power limit. Single channel tests were conducted and models of the test loop and the HFBR were developed using the thermal hydraulics code RELAP5. The code was benchmarked against the test results and the HFBR model was used to analyze loss of flow accidents and to determine the power limit. The report[1] of this work concluded that flow reversal would not be a limiting

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condition for operating power levels substantially above 60 MW. This report has received favorable third party review and is awaiting DOE review.

Seismic Vulnerabilities

Prior to the increase in power to 60 MW in 1982, the plants seismic resistance was upgraded to a DBE of 0.2 g. Flaws in the seismic analysis were identified in 1992 from a PRA that was being done for the reactor at that time. The vulnerable components included: (1) a tank containing a neutron poison which is added in emergencies; (2) the control room enclosure which is an unreinforced cinder block structure; and (3) certain non-critical components which would damage critical components in an earthquake.

Because of time constraints, interim fixes were implemented which were acceptable for 30 MW operation but questionable for higher powers. These were: (1) and alternative seismically qualified poison supply system; (2) an automatic scram at a specified ground motion; and (3) a detailed plan to bring personnel from off-site to replace personnel disabled in the Control Room and to perform required emergency operations. For operation up to 60 MW, additional measures including the strengthening of the Control Room and other structures will be required.

Reactor Life-Limiting Components

The reactor vessel beam tubes are potential life limiting components due to hardening caused by the thermal neutron induced transformation of aluminum to silicon. The beam tubes are welded to the vessel and replacement is a questionable option. While there is evidence from an on-going material surveillance program that the drop in ductility has stabilized at a safe level, there are long term concerns about the continued buildup of silicon. Vessel replacement within a decade is being studied.

The thermal shield is undergoing embrittlement by fast neutron irradiation. The nil-ductility transition (NDT) temperature in some shield locations has reached the shield operating temperature. Fortunately, the potential for crack propagation is small because of the low stress levels in these regions. A study is underway to better define the life of the thermal shield.

This Work was supported by the U.S. Department of Energy: Contract No. DE-AC02-76CH00016.

References:

[1] Lap Y. Cheng and Paul R. Tichler, "Flow Reversal Power Limit for the HFBR," BNL Report, October 1995.

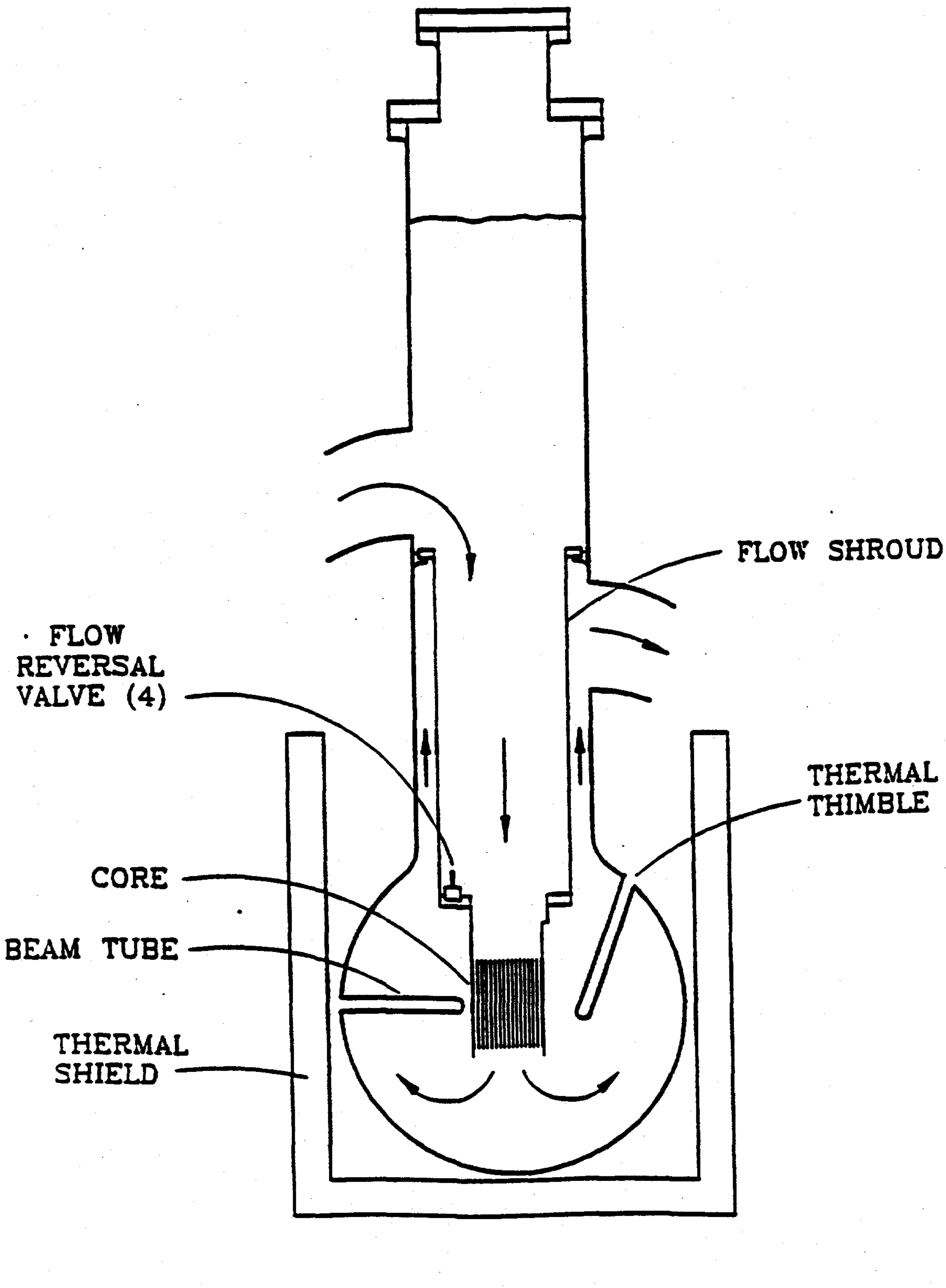

Figure 1 HFBR Vessel Showing Normal Flow Direction