INSPECTION PROCEDURE 61706

CORE THERMAL POWER EVALUATION

PROGRAM APPLICABILITY: 2515 (SUPPLEMENTAL), 2525

61706-01 INSPECTION OBJECTIVE

To verify that the calculation of core thermal power is correct and that the procedure used is technically adequate.

61706-02 INSPECTION REQUIREMENTS

02.01 Review the licensee's core thermal power evaluation procedure for boiling-water reactors (BWRs), pressurized-water reactors (PWRs), and high-temperature gas-cooled reactor (HTGR) at >50% power for the following:

a. Examine the "Core Performance Evaluation" data sheet, or equivalent, and verify that data are reasonable, consistent with previous data, and properly recorded.

b. Review the procedure for initial conditions and prerequisites.

c. Verify that the test and plant instruments used to obtain data are properly calibrated.

d. Review the licensee's core thermal power calculations to verify that they are correct.

e. Verify that the power range nuclear instruments are properly adjusted to agree with the results of the heat balance.

f. Verify that the procedure specifies the condition of the steam generator blowdown system during the core thermal power evaluation (PWR only).

02.02 Verify, by a 1-month sample, that the frequency of evaluations is as prescribed by the Plant's Technical Specifications (TS).

02.03 Independently calculate the core thermal power using the licensee's procedure for manual calculations or an NRC-developed calculation such as TPDWR1.

02.04 Verify that the core thermal power evaluation results were reviewed, approved, and documented in accordance with the licensee's administrative control procedures.

General Guidance. The thermal power of the BWR, PWR, and the HTGR is determined by a heat balance on the reactor system using operating data. Under steady-state conditions, the reactor heat output is obtained as the difference between the total heat removed from the reactor system and the total heat added in the flow streams returning to the reactor. A core heat balance in the power range is made to ensure that the core is operated at all times within the required thermal limits and/or fuel warranty requirements. Thermal power calculation is performed either by the plant's computer or by a manual method. The latter is normally required when the computer program is not working or to double check results obtained from the computer.

03.01 Specific Guidance

a. Inspection Requirement 02.01b. Typical initial conditions and prerequisites for a core thermal power determination are as follows:

   1. At the desired power level, the plant is operated for a sufficient length of time to show that steady-state operating conditions have been attained.

   2. Feedwater flow, water levels, and all controllable temperatures and pressures are maintained as nearly as possible, unchanged throughout the data acquisition period.

b. Inspection Requirement 02.01c. Although some of the instruments and most of the computer points may not be safety related, they must be calibrated in a traceable manner if they are used to verify operation within the licensed power limit. In many situations, problems with input data are far more common findings than findings of inadequate heat balance equations or poor arithmetic.

c. Inspection Requirement 02.01d. The thermal power is equal to the rate of heat transfer to the steam system plus certain heat losses, less the power contributed by the main coolant pumps (recirculating pumps in BWRs). The heat transfer to the system is equal to the enthalpy difference between the feedwater and the steam, multiplied by the mass flow of the feedwater. For PWRs this quantity must be calculated for each steam generator and summed. The minor heat losses are added. These include heat losses through the thermal insulation and the net loss between the letdown and the makeup to and from the reactor water cleanup system (or gas cleanup system for gas cooled reactors). The loss from steam generator blowdown is also added, if this is present. The heat added by the large reactor coolant pumps is subtracted.

d. Inspection Requirement 02.01e. For BWRs the gain of each average power range monitor (APRM) amplifier should be adjusted so that each APRM, following determination of the heat balance, is adjusted or verified to read the APRM value

required by plant procedures and/or TS. Likewise, for PWRs and HTGRs, the power range instruments are adjusted to the reactor power indicated by the heat balance.

Core thermal power evaluation is performed on a daily basis for both PWRs and BWRs. The specific requirements can be found in the plant's TS although the plant may follow more stringent guidelines as recommended by the manufacturer. Refer to Inspection Procedure 61705, "Calibration of Nuclear Instrumentation Systems," if calibration is required. In addition, the inspector should check that the average power level over any 8-hour shift did not exceed the "full steady-state licensed power level" (and similarly worded terms). The exact 8-hour periods defined as "shifts" are up to the plant, but should not be varied from day to day (the easiest definition is a normal shift manned by a particular "crew").

It is permissible to briefly exceed the "full, steady-state licensed power level" by as much as 2% for as long as 15 minutes. In no case should 102% power be exceeded, but lesser power "excursions" for longer periods should be allowed, with the above as guidance. For example, 1% excess for 30 minutes and 1/2% for 1 hour should be allowed. There are no limits on the number of times these "excursions" may occur, or the time interval that must separate such "excursions." The above requirement regarding the 8-hour average power will prevent abuse of this allowance.

e. Inspection Requirement 02.01f. The steam generator blowdown system is designed to remove dissolved solids and other impurities from the steam generator. If the blowdown is in progress during the core thermal power evaluation, consideration of the mass flow and enthalpy of this blowdown should be based on a review of the licensee's calculations and assumptions.

f. Inspection Requirement 02.03. Manual calculation is intended as a backup for the computer-calculated thermal power in case the computer is not operating. Manual calculation is inherently not as accurate as the computer-calculated thermal power. However, despite its accuracy limitations, the manual calculation should agree within ±5% of the computer-calculated thermal power (MWe). Even though the ±5% tolerance is not a requirement, a difference of >5% between the computer calculation and manual calculation indicates in all likelihood that an error in either the computer calculation or the manual calculation has been made. Most manual calculations performed utilizing data from the computer are within 1% of the computer-calculated thermal power.

An NRC program for Westinghouse PWRs entitled "TPDWR2: Thermal Power Determination for Westinghouse Reactors, Version 2", is available from the Engineering and Generic Communications Branch for use on the IBM PC. Users of this program should refer to the user's guide, NUREG-1167. A similar program for use on Combustion Engineering's reactors

entitled "TPDCER2: Thermal Power Determination for Combustion Engineering Reactors, Version 2", and the users guide for this program is also available from the Generic Communications Branch.

END