

Enclosure 1

Docket No. PROJ 0782

KHNP Response to RAI 3-7443 on Topical Report
“KCE-1 Critical Heat Flux Correlation for PLUS7 Thermal Design”
APR1400-F-C-TR-12002-P, Rev. 0

April 2014

Non-Proprietary Version

RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION 3-7443

Date of RAI Issued: 03/25/2014

Response Date: 04/23/2014

Question 2

The topical report described that the CHF point was confirmed when increasing the total power led to a temperature excursion of 10 to 30°F inside the heater rods. When the temperature indication was minimal, confirmation of the validity of a CHF point was obtained by observing a characteristic temperature decay with power reduction, as the CHF zone was rewetted. The applicant is asked to justify the above-mentioned CHF point confirmation technique, possibly by including a citation in the report that corroborates it.

Response

The CHF identification criteria described in Topical Report (APR1400-F-C-TR-12002-P) have been used and accepted in past application as described since early phase of HTRF operation (Ref. EPRI-NP 2609 vol. 1, Sep. 1982). Typical shape of characteristic temperature decay can be identified in Figure 2-1 (biggest red circle in right-side, but temperature excursion of this case is sufficient: time flows from top to bottom of the plot). This is due to the retarded recovery of heat transfer after CHF occurred ($D \Rightarrow D'$) from post-dryout film boiling to transition boiling ($D' \Rightarrow E \Rightarrow D$) or subcooled boiling ($D' \Rightarrow E \Rightarrow E'$), similar to hysteresis, inferred from typical boiling curve as shown in Figure 2-2 and heat transfer mechanism in corresponding boiling regime.

A citation to the reference used as the basis, if necessary, will be added to the "A" version of the topical report upon approval.

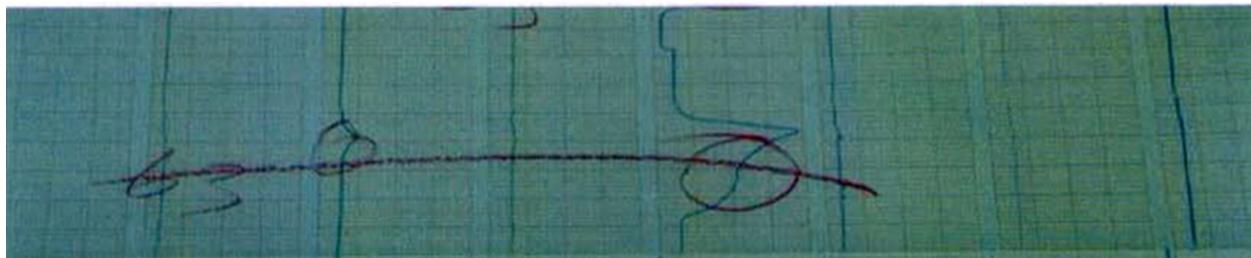


Figure 2-1 Typical Example of Characteristic Temperature Decay

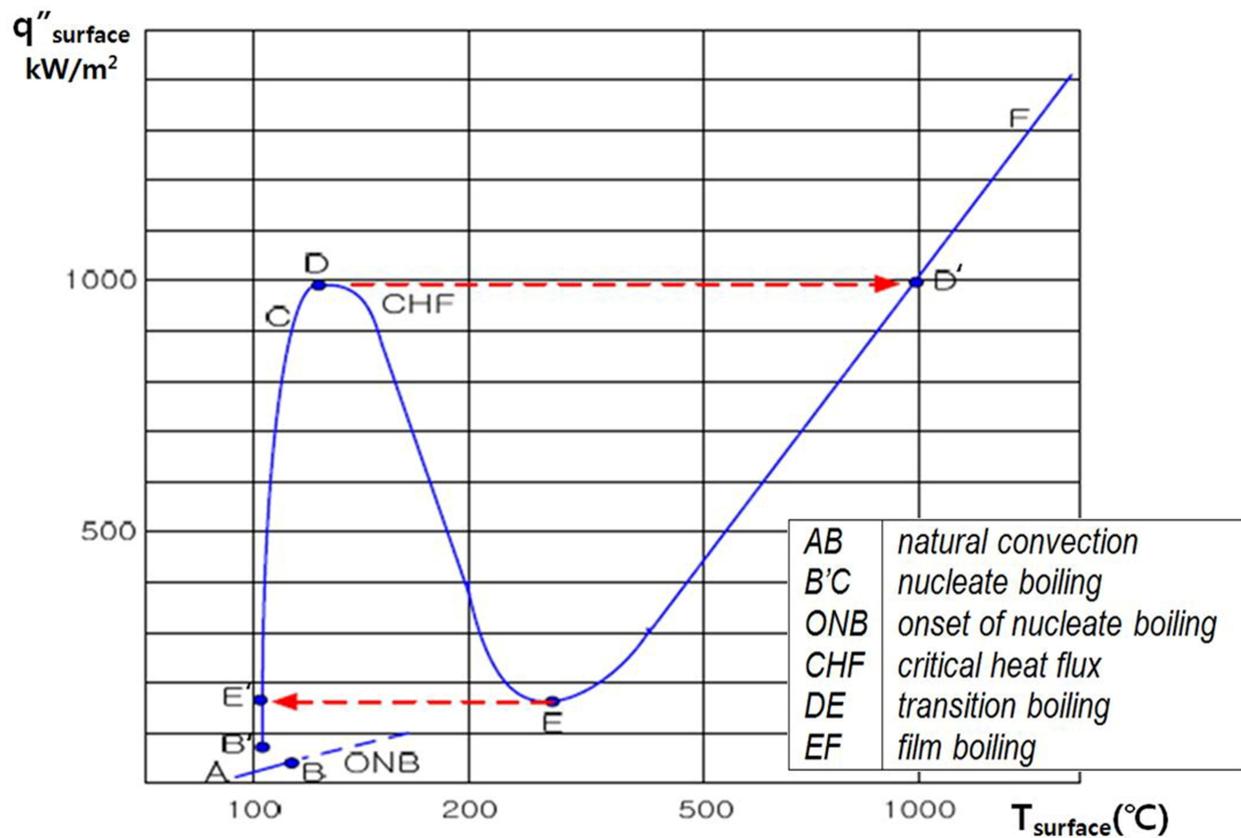


Figure 2-2 Typical Boiling Curve of the Water

Question 3

Figure 2-9 depicts seven thermocouples installed axially to measure the wall temperature of the heater rods. However, the thermocouple grid is asymmetrical between the BOHL (Beginning of Heated Length) and EOHL (End of Heated Length). Justify the temperature measurements made by using the asymmetrical thermocouples grid to be conservative with reference to the overall data reduction to compute CHF.

Response

With axially non-uniform axial power distribution, the locations of CHF indication are the downstream of peak power for the test section with uniformly arranged spacer grids. The spacer grids of PLUS7 CHF test section were uniformly arranged except the upstream grid from EOHL.

For the cosine power distribution (peak at middle of heated length and symmetry) applied to PLUS7 CHF test (as given in Figure 2-8 of topical report), possible location of CHF would be thermocouple (T/C) ID of 1 through 5.

According to the actual test data for PLUS7, the CHF elevations are limited to T/C ID of 2 through 5 as given in Appendix A-1 of topical report (column of 'TC' with format of XX.x, where XX: rod identification number per Figures 2-5 to and 2-7 and x : T/C identification number per Figure 2-9 of topical report) and summarized in Figure 3-1. No CHF was indicated at the other location including BOHL and EOHL.

Therefore, no impact on CHF measurement and data reduction due to axial T/C configuration is applied to PLUS7 CHF test.

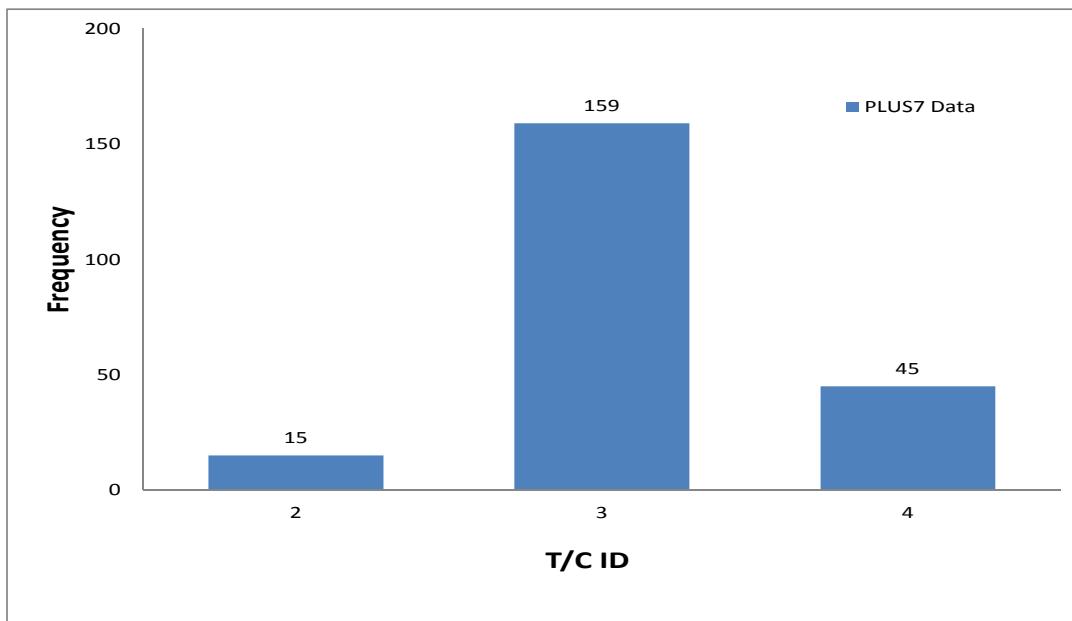


Figure 3-1 As-measured CHF elevations for PLUS7 CHF test

Question 5

Please describe how the overall bundle power was measured or calculated? It is not clear from the topical report.

Response

Overall bundle power (DC) was measured by means of voltage (V) and current (I) readings, as

$$\text{Power} = V * I.$$

Current metering/readout for protection/control/test operation was provided by switchboard shunts and recorded by the data acquisition system. Measurement of voltages was made at the generator terminals and at the test section inlet and outlet bus. These voltages were conditioned through precision resistor divider networks and amplifiers for entry into the data acquisition system and readout in the control room.

*HTRF maximum value of overall bundle power was 12 MW (= 240 Volt * 50,000 Ampere).*