Docket No. 52-021
MHI Ref: UAP-HF-10060

Enclosure 3

UAP-HF-10060
Docket No. 52-021

US-APWR DNB TEST PLAN

March, 2010
(Non-Proprietary)

US-APWR

DNB TEST PLAN

NON-PROPRIETARY VERSION

March, 2010

MITSUBISHI HEAVY INDUSTRIES, LTD

Table of Contents

1. INTRODUCTION

MHI has been planning to carry out DNB tests for the US-APWR fuel design in order to respond to NRC's Request for Additional Information (RAI) on Topical Report, MUAP-07009-P Revision 0 "THERMAL DESIGN METHODOLOGY" (References 1, 5 and 6). The outline of the test plan has already been submitted to NRC via MHI's letter UAP-HF-09182 (Reference 2). This document completes the test plan for the DNB test.

2. TEST OBJECTIVE

The objective of the DNB test is to provide an additional confirmation of the applicability of WRB-1 and WRB-2 correlations for the US-APWR fuel design by obtaining DNB test data from the 14-ft test bundles representative of the US-APWR fuel design. In this planned test, the steady-state DNB heat fluxes are measured for the flow conditions which will bound limiting conditions for DNB analyses relevant to all the normal operation and anticipated operational occurrences of the US-APWR core.

3. TEST EQUIPMENT

3.1 Test Loop

The DNB test is conducted using a high pressure and high temperature water loop at KATHY (KArlstein Thermal Hydraulics facilitY) in Germany (References 3 and 4). The schematic apparatus of KATHY loop is shown in Figure 1. The facility is capable of conducting heat transfer tests for PWR and BWR fuel geometries and fluid conditions. For PWR condition, the system pressure and flow rate can be controlled up to 18.5MPa and 150m^3/h respectively and the test rod bundle is electrically heated by 15MW DC rectifier system. The loop capability can effectively bound the needed DNB test conditions for the US-APWR core.

3.2 Test Sections

Typical and thimble cell tests will be conducted. The specifications of the test rod bundle geometries are summarized in Table 1. The geometries are representative for the US-APWR fuel design using the same grid spacer type (Figure 2), grid spacing, and heated length. The configuration is also identical to the tests, which were conducted in the Heat Transfer Research Facility of Columbia University and are described in Appendix C of Topical Report MUAP-08009-P (Reference 1), [

].

The tests will be conducted using a 5x5 array of the electrically heated rods as shown in Figure 3 and 4, respectively. [

]. All the heater rods have a non-uniform axial power distribution as shown in Figure 5. The axial power distribution is simulated [
].
The axial geometry of test bundle is shown in Figure 6. [

]

4. TEST CONDITIONS

Test conditions will bound the DNB related safety analysis conditions for the WRB-2 correlation described in the US-APWR DCD chapter 15 (Reference 5) as shown in Table 2. Table 3 shows a preliminary test matrix based on pressure, mass velocity, and inlet temperature.

5. TEST PROCEDURES

5.1 Preliminary Checks

(1) Calibration of measurement devices
The measurement devices that detect parameters having impacts on DNB test results will be calibrated prior to the test. [
].

(2) Test bundle inspections
The dimensions of test bundle and the power distributions simulated [
] will be checked prior to the test.

(3) Heat balance check and pressure drop measurements
The heat balance, determined [
] The axial pressure drop across the test bundle will be measured and [ ]

5.2 DNB Test

DNB heat flux is measured for steady-state fluid conditions. After the fluid conditions, such as pressure, mass velocity, and inlet temperature, reach the specified conditions, the power of heater rod bundle is gradually increased until the thermocouples [
] detect DNB as a result of the rapid increasing in the heater rod temperature. DNB heat flux is determined from the heater rod power when DNB occurs. All the measured

data are logged during the power increasing process.

During the DNB test, [

].

5.3 Post-experiment Checks

After the completion of the DNB tests, test bundle inspections, heat balance check and pressure drop measurement as those conducted in the preliminary checks are performed to confirm the integrity of test bundle.

6. EVALUATIONS

The DNB tests will be conducted for each of the test conditions described in Table 3. For each test condition, pressure, mass velocity, inlet temperature and heat flux measured at DNB occurrence are measured.

Those measured parameters are used for the input of VIPRE-01M subchannel analysis code with WRB-1and WRB-2 correlations to predict the DNB heat flux. The measured to predicted DNB heat fluxes ratio (M/P) is obtained for each test point, and the M/P numbers are statistically analyzed by the same procedure described in Appendix C of MUAP-07009 (Reference 1).

The Limit DNBRs for the correlations, based on the present DNB test data, will be evaluated and consequently the validity of the US-APWR design is confirmed.

7. QUALITY ASSURANCE PROGRAM

This test will be performed under the quality assurance program of US-APWR (Reference 7) that satisfies 10 CFR Part50 Appendix-B, ASME NQA-1-1994 and 10 CFR Part21.

8. TENTATIVE TEST SCHEDULE

The currently planned schedule of the DNB test is shown in Table 4.

REFERENCES

1. Topical Report "THERMAL DESIGN METHODOLOGY", MUAP-07009-P Revision 0, May 2009
2. Letter from MHI to NRC, "Supplemental Information on UAP-HF-09093, MHI's Response to the NRC's Request for Additional Information related with Topical Report MUAP-07009-P Revision 0, THERMAL DESIGN METHODOLOGY", UAP-HF-09182,

dated on April 28, 2009
3. D. Kreuter, et al., "KATHY: FRAMATOME ANP's Thermal Hydraulic Test Loop", Proc. the 6th Int. Conf. on Nuclear Thermal Hydraulics, Operations and Safety (NUTHOS-6), N6P203, 2004
4. C. Herer, et al., "COMPARISON OF PWR FUEL ASSEMBLY CHF TESTS OBTAINED AT THREE DIFFERENT TEST FACILITIES", Proc. the 11th Int. Topical Meeting on Nuclear Reactor Thermal-Hydraulics (NURETH-11), 117, 2005
5. Letter from MHI to NRC, "Response to NRC's Request for Additional Information on US-APWR Topical Report MUAP-07009-P, Thermal Design Methodology", UAP-HF-08067, dated on April 4, 2008
6. Letter from MHI to NRC, "MHI's Response to the NRC's Request for Additional Information on Topical Report MUAP-07009-P, Revision 0, THERMAL DESIGN METHODOLOGY", UAP-HF-09093, dated on March 13, 2009
7. PQD-HD-19005-R3 "Quality Assurance Program (QAP) Description for Design Certification of the US-APWR", 2009

TABLE 1 TEST ROD BUNDLE GEOMETRIES

TABLE 2 TEST CONDITIONS FOR MHI DNB TESTS

TABLE 3 PLANED TEST MATRIX FOR MHI DNB TEST

TABLE 4 SCHEDULE OF DNB TEST

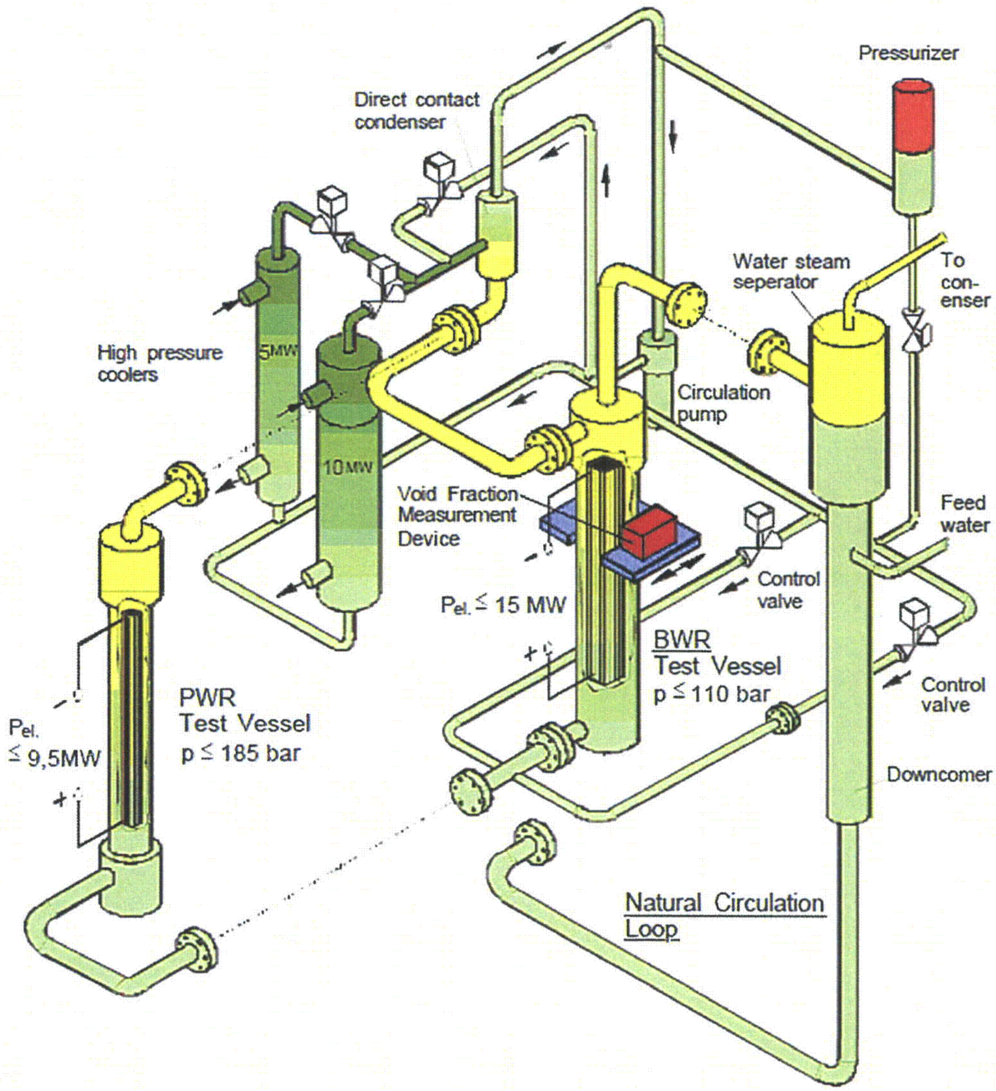

Figure 1 SCHEMATIC APPARATUS OF KATHY LOOP

Figure 2 MITSUBISHI GRID SPACER (Z3)

FIGURE 3 RADIAL GEOMETRY FOR TYPICAL CELL TEST

FIGURE 4 RADIAL GEOMETRY FOR THIMBLE CELL TEST

FIGURE 5 AXIAL POWER PROFILE OF HETAR RODS

FIGURE 6 AXIAL GEOMETRY FOR TYPICAL AND THIMBLE CELL TESTS