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Overview of Commissioning Startup Test of RCPTF

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1. Introduction

A test facility called a reactor coolant pump test facility (RCPTF) was constructed within the KAERI site in 2012. The major components and systems are ready for a startup test, and various kinds of commissioning activities from loop cleanup to hot functional operation were performed for about 4 months, i.e., from Sep. 2012 until Dec. 2012.

RCPTF was built for functional and performance tests of reactor coolant pumps (RCPs), which will be installed from SUN 1 & 2, now called SHU 1 & 2. Every RCP can be installed on the pump casing of RCPTF for a functional performance test. Other systems, e.g., seal injection, component cooling, instruments, and electrical power, were also connected after the erection of RCP assembly.

2. Overview of RCPTF

RCPTF consists of main loop piping at a real plant scale, a charging/letdown system, a seal injection system, main loop cooling system, component cooling system, power supply system, DCS/DAS system, and other auxiliary systems. The main loop consists of pump casing, flow restriction orifice, flow control valves, and venturi flow meter. Fig. 1 shows the vertical arrangement of the RCPTF.

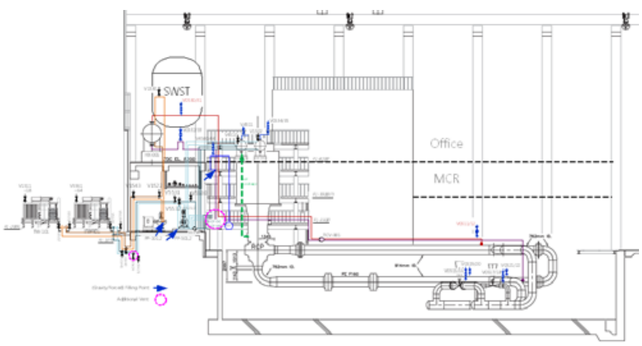

Fig. 1 Vertical arrangement of the RCPTF

During the operation of the RCPTF, all operational limits are monitored to satisfy the requirements of the pump vendor. Fig. 2 shows an example of the reproduced limit curves for pump operation. In a real plant, the RT_{NDT} limit is considered to be a critical parameter, but it is ignored in RCPTF (the reactor coolant pump of SHU 1 & 2 is a Doosan-Andritz type, which has an additional fourth stage standby still seal for resisting station blackout scenarios).

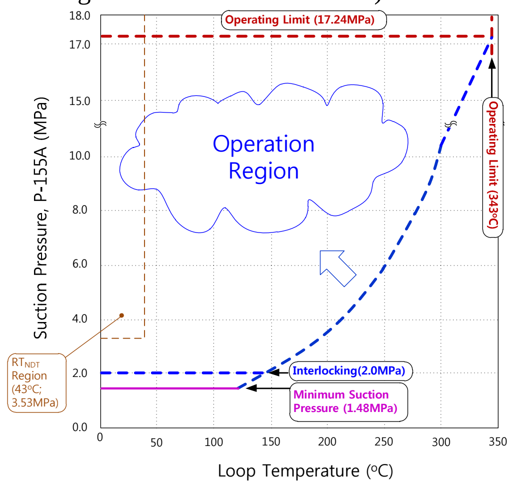

Fig. 2 P-T operation limit curves of the RCPTF

For reference, Fig. 3 shows the overall shape of the RCP of SHU 1 & 2.

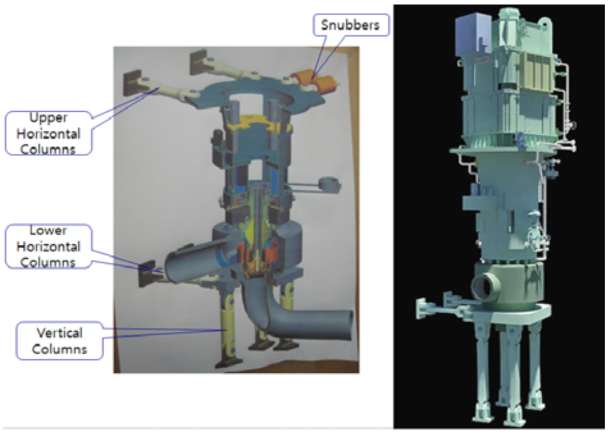

Fig. 3 Shape of RCP (Type-A)

The RCP seal consists of four stages of seals, e.g., hydro-dynamic seals for first three stages, and a standby still seal for the fourth stage, as shown in Fig. 4. As can be seen in the figure, the fourth stage seal is operated using nitrogen gas (for normal operation, the fourth seal should be open). During an accident, e.g., a station blackout or loss of component cooling water, there can be a failure of the first three seals, and the reactor coolant boundary will be sustained by the standby still seal. This prevents seal leakage into the containment from a failure of the first three seals.

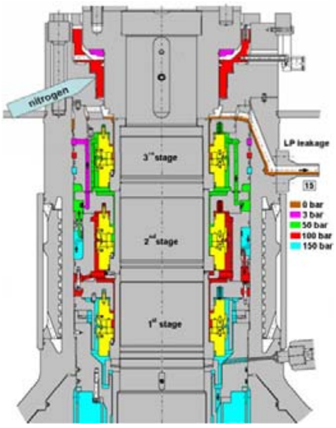

Fig. 4 Seal package of RCP

3. Commissioning Activities

After completion of the loop cleaning activity, various kinds of stand-alone functional tests for all pumps, fans, and motor-operated valves were performed. The key points for these components are the rotational directions fitted to their performance. In the case of high-voltage pumps, e.g., the main loop cooling pumps, a rotational check was performed under the system's filling conditions. For the RCP, the motor was disconnected from the pump, and a no-load test was performed. After fixing the rotational direction during the no-load test, the motor was connected with the RCP using a curved teeth coupling.

The following activities were filling each system with venting, which consists of static and dynamic venting. Dynamic venting was performed several times to minimize air bubbles in each system. For the main loop venting, the RCP was used for dynamic venting under 3.0 MPa. In this case, a pressure under-shoot at the pump suction is a good parameter for a prediction of air bubbles in the system.

After venting, leakage tests were performed according to the design requirements of each system. Based on the leakage test, the hydraulic integrities of each system can be confirmed, which means 'ready for operation'.

Normal startup procedures for the main loop are summarized as follows:

- Check seal injection line alignment
- Start seal injection
- Pressurize to 4.0Mpa using charging/letdown
- Start component cooling water system
- Start main loop cooling system
- Check initial condition of main loop
- Align seal injection line
- Check RCP enable 'ON' condition
- Start RCP
- Start heatup operation

During the operation, RCP is monitored according to the vendor requirements, as shown in Fig. 5.

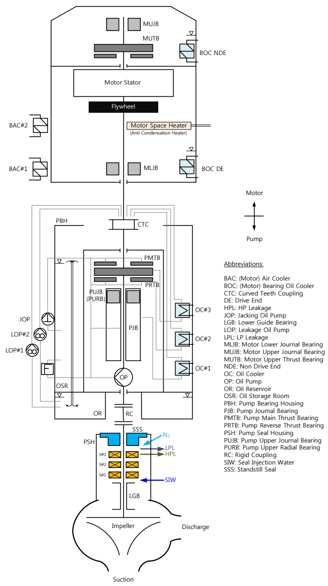

Fig. 5 Monitoring parameters for RCP operation

Several trials for heatup/cooldown operations were performed repeatedly by checking the structural integrity of the main loop. After fixing the problems found in the trial operations, a final heatup/cooldown operation was performed at the end of 2012.

4. Conclusions

A startup commissioning test was performed for RCPTF operation at the end of 2012. Major activities related to commissioning were summarized in this paper. Using the RCPTF, all RCPs installed in future nuclear power plants from SHU 1 & 2 will be tested before site installation.