The scheme and implementation of vessel hydrostatic test in cpr1000 nuclear power plant

Zhenguo Zhang ¹ and Huixing Feng
Suzhou Nuclear Power Research Institute Co., Ltd., Shenzhen, Guangdong, 518124, China.

¹ Email: zhangzhenguo@cgnpc.com.cn

Abstract. Nuclear vessels hydrostatic test involves many important systems and key equipment in CPR1000 models nuclear power plant. This paper introduces how to make the nuclear vessel hydrostatic test scheme and the implementation of vessel hydrostatic test. The scheme of nuclear vessel hydrostatic test contains hydrostatic test plan scheduling, hydrostatic test Isolation Boundary, cutting and welding of hydrostatic test aspect, The implementation of nuclear vessel hydrostatic test contains instrument of hydrostatic test, working file of hydrostatic test, manpower arrangement of hydrostatic test, actual execution of hydrostatic test and technical difficulties of vessel hydrostatic test. This paper mainly discusses the scheme and implementation of nuclear vessel hydrostatic test.

1. Introduction
Nuclear vessels hydrostatic test is a pressure test in order to test the seal and bearing capacity. It uses water as medium and the test pressure is above the design pressure. Nuclear vessels hydrostatic test is an important part of the nuclear power plant in service inspection. The CPR1000 models involving the need to implement nuclear vessel hydrostatic test system are: RCP/RCV/RIS/EAS/TEG/TEU/SAP/SAR/GCT/ASG/APG/LHQ/LHP and many other key systems. Its equipment including RCP002BA/RCV002BA/RCV001EX/RCV002RF/ RIS001BA/RIS002BA/RIS003BA/EAS001RF/EAS002RF/ASG001ZE/ASG003ZE and many other key equipment related to nuclear safety quality. At present there are about 100 nuclear vessels in one CPR1000 nuclear power plant need to implement the hydrostatic test in every 10 years, the prepared and implementation workload is large, how to make the nuclear vessel hydrostatic test scheme and the implementation of vessel hydrostatic test is a worthy of in-depth discussion topic. This paper mainly discusses the scheme and implementation of nuclear vessel hydrostatic test.

2. Nuclear vessel hydrostatic test scheme
The scheme of nuclear vessel hydrostatic test should consider the following aspects:

2.1. Hydrostatic test plan scheduling
The upstream relevant laws and regulations of hydrostatic test mainly includes: the RSE -M PWR nuclear equipment in service inspection rules[1], the RCC -M PWR nuclear machinery and equipment design and construction rules[2]. According to the request of RSE - M, the hydrostatic test interval of nuclear pressure vessel should not be more than ten years, unless there are special provisions. When making the plan scheduling of hydrostatic test in nuclear power plant, it should set aside one and a half
years margin before the expiration date. The length of the overhaul is also an important aspect, if the overhaul time in about 40 days, it can arrange around 18 vessel water pressure test, if the overhaul time in 30 days or so, it can arrange around 13 vessels of hydrostatic test, if the overhaul time in 26 days or so, it can arrange around 7 vessels of hydrostatic test. The high difficulty implementation vessel should be staggered arrangement in different rounds of overhaul as far as possible, such as the RCP002BA/RCV002BA/RCV001EX. Hydrostatic test involves some vessels which has the same function of redundancy design, such as EAS001/002RF, LHP250/251/252BA and LHQ250/251/252BA of diesel engine system, SAP001/002BA, ASG001/003ZE, APG001/002RF system, etc., considering its function to ensure the safety, it suggest that the same function of redundancy design vessel can be arranged in different rounds of overhaul in order to ensure the safety redundancy of nuclear equipment availability.

2.2. Hydrostatic test isolation boundary
The isolation boundary of the hydrostatic test is the most critical problem. It refers the flow chart of the main system. The isolation boundary must be completely, the valve and instrument parts need to consider its bearing capacity within the boundaries. It refers the EOMR, SDM of the valve and instrument. When found the valve and instrument bearing capacity is insufficient, it needs to be demolished, and extend the scope of its isolation boundary. Within the isolation boundary, the exhaust gas, filling water and drainage point is an important aspect, it generally chooses the top position of the vessel as the exhaust gas point, and it generally chooses the bottom position of the vessel as the filling water and drainage point. The exhaust gas, filling water and drainage point need to meet the visual principle and choose the low dose region. The drainage path planning should be short, and it should reduce the number of pipeline joints.

2.3. The cutting and welding of hydrostatic test
Most hydrostatic tests need to cut the pipeline of the system in order to weld the test instruments. The cutting and welding position is the important factor which needs to be considered. When choosing the cutting and welding position, the scene of the cutting and welding space is big enough, the size of the cutting and welding pipeline is small and, it should has the position of argon filling when pipeline welding needs argon filling weld.

3. Implementation of vessel hydrostatic test
The implementation of nuclear vessel hydrostatic test is different from the main primary system hydrostatic test[3,4], it should consider the following aspects:

3.1. Instrument of hydrostatic test
The instrument of hydrostatic test contains test pump, pressure gauge, high pressure hose, feed water device, exhaust device, and blind flange, etc. Hydrostatic test pump can be divided into manual pump and pneumatic pump. The advantage of the manual pump is the volume is small and convenient to use, it generally applies to the small volume vessel pressure test. Such as nuclear island fire protection fire water tank, etc. The advantage of pneumatic pump is the pressure rise rate is fast, it generally applies to the volume larger vessel pressure test. When choosing the hydrostatic test pressure gauge, the range of pressure gauges is 1.5 to 3 times of the test pressure, and the accuracy is 1.0 magnitude at least in order to ensure the reliability of hydrostatic test result data. High pressure hose should have the enough bearing capacity in order to meet the requirements of the test. The size of feed water device, exhaust device, and blind flange is determined according to field device size.

3.2. Working file of hydrostatic test
Hydrostatic test working file mainly includes the repair order ticket, welding quality files etc., these files are work technical documents. Hydrostatic test working ticket is roughly divided into several categories. If the installation of instrument of hydrostatic test takes a long time, the PW ticket is
suitable for the installation of instrument of hydrostatic test before hydrostatic test. If the installation of instrument of hydrostatic test takes a short time, general this part of the work uses the radiographic test permit ticket. The source of the water and air used test permit ticket.

3.3. Manpower arrangement of hydrostatic test
Due to the outage time is tight, if the hydrostatic test vessel number is more than 16 in one outage, the manpower arrangement of hydrostatic test needs 12 people, if the hydrostatic test vessel number is less than 12 in one outage, the manpower arrangement of hydrostatic test needs 9 people, if the hydrostatic test vessel number is less than 8 in one outage, the manpower arrangement of hydrostatic test needs 6 people. The hydrostatic test team generally consists of three members, each person has the corresponding responsibilities, there is one person responsible for the pressure gauge readings, one person is responsible for water switch, one person responsible for the operation on the pump.

3.4. Actual execution of hydrostatic test
The main steps of actual execution of hydrostatic test are as follows,

3.4.1. A System early stage of state verification and validation of the isolation boundary. The prerequisites should be confirmed before carrying out hydrostatic test, including the container internal and external visual check results qualified, the disassembling the relief valve (if required), the dismantling of non-return valve (if required), scaffold system (if needed), the removal of heat preservation (if needed), increase the manhole torque value (if needed), water quality requirements, validation of the isolation boundary.

3.4.2. Installing hydrostatic test instrument. After confirmed the prerequisites of hydrostatic test, the next step is installing the hydrostatic test instrument, the hydrostatic test instrument mainly relates to the work of cutting, grinding and welding. The worker should focus on the hydrostatic test instrument installation quality to avoid the leakage. The hydrostatic test instrument installation is vulnerable to field space constraints. When the scene space is large enough, the hydrostatic test instrument installation is relatively easy to operate. When the scene space is limited, the pipeline cutting work is very difficult to implement, it need to adjust the position of cutting point to a better space.

3.4.3. Water filling and hydrostatic test. When the hydrostatic test equipment has been installed, the water filling operation can start. In the process of water filling it needs to focus on whether there is a leak in the water filling path. When the vessel is full of water, the gas entrapped in the pressure vessel has been cleaned, it can use the test pump to rise the pressure. The rise and depressurization rate is not more than 10 bar/min. During this stage, it should be checked whether the vessel has deformation or leak. If not, the test result is qualified. If the test result is qualified, the test pressure can decrease to atmospheric pressure.

3.4.4. System recovery after hydrostatic test. After finishing the hydraulic pressure test work, the water inside the vessel should be drained out, then the hydrostatic test instrument can be dismantled, the valve needs to be install back, the cutting pipeline need to be welded back.

3.5. Technical difficulties of vessel hydrostatic test
The technical difficulties of nuclear vessel hydrostatic test contains of determine the leak point of hydrostatic test and the level judgment of vessel. In the process of hydrostatic test, if the pressure is unable to hold, there may be a leak point within the isolation boundary, how to accurately find possible leak point is difficulty in the hydrostatic test. If the leakage is outside of the vessel or isolation valve, it can be found by visual inspection, if the leakage is internal leakage valve, then it can be divided into the following several ways, one situation is that if the valves downstream has an empty
line or visual windows which can find leakage, it can be found by visual inspection. If there is no visual window, it can listen to the downstream piping sound of valve during the holding pressure platform. Because most of the vessel does not have the water level gauge or the water level gauge has been isolated, so it is difficult to judge the water level of vessel in the process of filling water, so the common practice is through according to the water filling time to approximately determining the water level of vessel.

4. Summary
As the amount of nuclear vessels is growing quickly with the construction of nuclear power station in China, hydrostatic test work is becoming more and more important. This paper introduces how to make the nuclear vessel hydrostatic test scheme and the implementation of vessel hydrostatic test. It has a significance reference for the engineer who needs to implement the hydrostatic test.

References
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