Research of in-service sipping test device*

Deng Jun-Xian, Zhao Xi-Juan, Ye Xiao-Li, Zhao Hong, Zhang Han, Zhang En-Hai, Gao Yan-Gang, Liu Ying-Lin, Song Ruo, Li Yong-Yuan, Liu Ai-Jun, Zhao Ping-Jun
(*Beijing Institute of Nuclear Engineering, Beijing 100840*)
Xu Yu-Ming
(*China National Nuclear Corporation, Beijing 100822*)

Abstract Sipping test device is used to identify the tightness of the irradiated fuel assembly during refuelling campaign. The gas is selected as the medium and the xenon-133 as the indicating nuclide. The device consists of the gas system, the γ-activity detection and measurement system, the power supply and signal system, the mechanical components and parts. The device has satisfactory functions, e.g. easy operation, indication in instrumentation, chart record and acoustic alarm, which can meet the operation demand of the nuclear reactor.
Keywords Sipping test, ^{133}Xe

1 Introduction

Sipping technique is used to identify the tightness of the fuel. By isolating the fuel assembly to be tested and increasing the pressure inside the fuel (by heating) or decreasing the pressure outside the fuel, the fission products released from the defective fuel will be accelerated. The tightness of the fuel can be identified by detecting the fission products.

The sipping technique has been developed since the 1960's. Up to date, there are the sipping taking the water as the medium, iodine and cesium isotopes as the indicating nuclides; the sipping taking the gas as the medium, krypton and xenon as the indicating nuclides; the poolside sipping using the sipping cell as the isolator; and the in-mast sipping using the mast of the refuelling manipulator as the isolator.

The objective of this subject is to set up a detection device to identify the tightness of the irradiated assembly for Qinshan phase two NPP. The device should be more sensitive and easier to be operated.

2 Optimum selection

It was learnt from the literature[1,2] that the escape factors of fission gas krypton and xenon from the defective fuel into the coolant are about five times of the factors of soluble fission products iodine and cesium, the activities of ^{85}Kr and ^{133}Xe in the coolant are higher than those of ^{131}I and ^{137}Cs, and the activity of ^{133}Xe in the coolant is about 150 times of that of ^{85}Kr, the ^{133}Xe has the much portion of γ activity with high peak which is easier to be detected, ^{133}Xe with a shorter half life can be detected during refuelling operation. Therefore, the ^{133}Xe is the best indicating nuclide for the sensitivity of device.

The in-service sipping using the mast as the isolator is simpler than the sipping with the special sipping cell and it is easy to be operated, only a bit more operation time is necessary without special operator. Then, the in-service sipping with gas medium and ^{133}Xe, the indicating nuclide were selected.

3 In-service sipping test device

As the fuel assembly griped by the gripper is raised inside the mast of the refuelling manipulator from the reactor core to the top gripper position for about 9 m, the ^{133}Xe release through the defective cladding of the fuel will be accelerated. The compressed air injected into the mast at the bottom rising around the fuel rods will carry the ^{133}Xe. The air will be attracted from the top of the mast to the counting chamber where the γ activity of the air will be detected and measured by the γ activity detection and measurement system to identify the tightness of the fuel assembly.

The sipping device consists of the gas sys-

*The Project Supported by National Eighth Five-Year Plan, 85-213-01-07 special subject
Manuscript received date: 97-10-01

tem, the γ activity detection and measurement system, the power supply and signal system, and the mechanical components and parts.

3.1 Gas system

The gas system is used for the compressed air supply, the air injection and the air attraction to the counting chamber.

The compressed air flow is divided into two ways, one is to supply the injection air at certain pressure and flow rate to the bottom of the mast, the other is to supply the air at certain pressure to a vacuum generator to attract the air from the mast through the counting chamber in certain flow rate.

The calibration of the gas system includes two steps: the tightness test of the whole circuit section by section; adjusting pressure and flow rate to the values.

3.2 The γ activity detection and measurement system

The γ system is used for detection, measurement and record of the γ activity of the gas inside the counting chamber, and consists of a series of Nuclear Instrument Module (NIM) units, the detector and the recorder.

The calibration of this system is done in three more steps: the adjustment of the NIM; the drawing of a curve in cps-threshold with a standard solid γ source; the setting of the threshold corresponding to the cps peak of the indicating nuclide.

3.3 Power supply and signal system

The power supply and signal system is used for supplying the power to the NIM rack, the recorder and the signal light. The system consists of the breaker, the timer, D.C. power source and signal light.

3.4 Mechanical components and parts

The mechanical components and parts include: the counting chamber, the lead cask, the source holder and the cabinet. All of these matters are out of vendor catalog. The design, manufacture and quality assurance should be done specially.

3.5 The key behaviour of the device

The following characteristics of the device were carefully measured: the sensitivity of the γ system, the tightness and attraction ability of the gas system, the calibration parameters of the systems in the device, the indication and record functions of the device.

3.6 The approach to the goal

The subject was successfully completed step by step as the following :

(I) The investigation done by consulting the information about existing sipping device worldwide from the experts and literature. (II) The optimum selection based on the investigation. (III) The engineering work. (IV) The procurement of the standard parts within the vendor catalog (for example, Breaker, Timer, Recorder, NIM). (V) The manufacture of the special parts (for example, lead cask, counting chamber, cabinet). (VI) The assembling and calibration of individual system outside the cabinet separately. (VII) The assembling and calibration of whole device inside the cabinet. (VIII) The evaluation of the key behaviour and the acceptance of the device.

3.7 The performance of the device

The device has satisfactory functions, e.g. easy operation, indication in the instrumentation, chart record and digital indication, and acoustic alarm. The calibration parameters are as they should be.

References

1 Bordy M, Parrat D. On line sipping system, IAEA-TECDOC-692. 1992, 15

2 IAEA, Guidebook on non-destructive examination of water reactor fuel, TRS No.332, 1991

Deng Jun-Xian: Professorship Senior Engineer, graduated from Department of Engineering Physics, Tsinghua University in 1962, engaged in National High Technology "863" Plan (614 special subject) in 1989-1991 and the engineering work for nuclear project. As Chinese experts he participated in IAEA Technical Committee Meeting in Vienna in 1986 and served as the chief scientific investigator of the research projects supported by IAEA in 1995. He was awarded three ministerial class prizes, published 14 articles including three papers in international conferences. He is the chief editor of two monographs with Huang Yi-Da and Xu Ji-Ming, respectively.