Design Features of a Spent Fuel Transfer Device between Spent Fuel Storage Pools in NPPs

Il-Seon Hwang [a*], Kwang-Jeok Ko [a], Min-Gyu Kim [a], Yeon-Ho Cho [a], Hyun-Min Kim [a]
[a]*NSSS Division, KEPCO Engineering & Construction Company, Inc., Daejeon, Korea*
[*]*Corresponding author: iseonh@kepco-enc.com*

1. Introduction

The spent fuel storage capacity for domestic nuclear power plants being under construction is planned to increase its storage capacity compared to those of previous APR1400 Nuclear Power Plants (NPPs). To accommodate the required storage capability, the spent fuel storage pools are comprised of the spent fuel storage pool "A" and pool "B" in the fuel handling area of auxiliary building. The spent fuel stored in the spent fuel storage pool "A" after being withdrawn from a reactor vessel is transferred to the spent fuel storage pool "B". To do this, it is necessary to develop a Spent Fuel Transfer Device (SFTD) for transferring spent fuel assemblies between spent fuel storage pools in the refueling canal.

This paper introduces the SFTD which will be newly applied in domestic nuclear power plants, and describes its design features including plant arrangement, component layout and sequences of fuel transfer.

2. Design Features

2.1 Location of the SFTD in Fuel Handling Area

The spent fuel storage pools in the fuel handling area of auxiliary building are composed of the spent fuel storage pool "A" and pool "B" as shown in Fig. 1. The Spent Fuel Handling Machine (SFHM) in each pool is provided for handling new or spent fuel. To allow the underwater transportation of spent fuel assemblies between spent fuel storage pools, the SFTD is arranged at the extended refueling canal of fuel handling area as shown in Fig. 1.

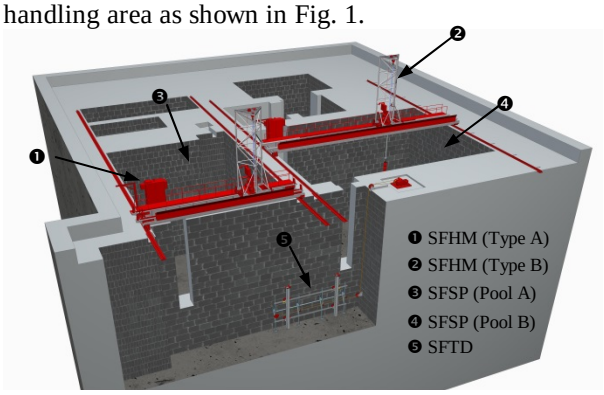

Fig. 1. Configuration of the SFTD between Spent Fuel Storage Pool "A" and Pool "B"

2.2 System Components

The SFTD is the equipment for transporting the spent fuel assembly within the extended refueling canal of the fuel handling area between spent fuel storage pools during plant operation or refueling operation. The major components of this transfer device consist of a support frame with guide rails, a fuel transfer cavity, a winch assembly and a control console as depicted in Fig. 2.

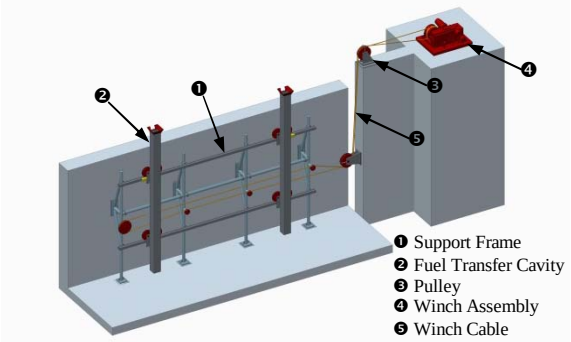

Fig. 2. Outline arrangement of the SFTD in FHA

A support frame provides the support for the fuel transfer cavity and contains two (upper & lower) guide rails on which the fuel transfer cavity guide wheels ride when moving the spent fuel assembly. A spent fuel assembly is inserted in or removed from the fuel transfer cavity in a vertical position by using the SFHM. The fuel transfer cavity is moved horizontally up to a designated location in a vertical position by means of a cable system which is driven by using winch assembly and control console located in the fuel handling area.

The configuration of the fuel transfer cavity is similar to that of fuel transfer system upper cavity of the previous APR1400 NPPs, and the fuel transfer cavity is designed to meet a criticality and cooling requirement.

The SFTD is controlled from its control console located on the operating floor adjacent to the refueling canal of fuel handling area, and can also be controlled from the SFHM control console.

2.3 Design Considerations

The following design considerations are incorporated into design of the SFTD.

- Guide rails are installed in the upper and lower parts of support frame to be applicable to the horizontal movement of fuel transfer cavity, and guide wheels are also provided in both sides of the fuel transfer cavity to facilitate the horizontal movement in a vertical position.
- A bumper is provided at the upper part of the fuel transfer cavity to prevent the criticality due to inadvertent handling of the spent fuel.
- The minimum clearance between the bottom of the fuel transfer cavity and the floor of the refueling canal is secured so as not to interfere with the fuel transfer cavity while the fuel transfer cavity is moving horizontally in a vertical position.
- The structural integrity of support frame is ensured by installing the embedments at the wall as well as the floor of the refueling canal.
- In order for fuel transfer cavity to be moved in the horizontal direction stably, the installation position of the pulley fixed at the wall would be considered for the fuel transfer cavity to be pulled at the center of gravity.
- The dedicated drive winch and control console are provided for the SFTD, and the location of all cablings including power supplies is arranged so as not to interfere with the movement of fuel handling equipment.
- The bracket for support frame at wall and floor is designed to facilitate its removal with special wrenching tool to the operating floor in the event that active components (e.g., guide wheels, position measuring devices, limit switches) installed at the SFTD are inoperable.

2.4 Interlocks

The SFTD includes interlocks to prevent damages to spent fuel assemblies or equipment. The interlock system has two systems, which are composed of winch overload interlock and translation interlock. If the load of winch drive cable increases above the overload setpoint, the transfer operation of the SFTD is interrupted by the winch overload interlock system [1], and when the spent fuel handling machine is at the refueling canal of the fuel handling area, the transfer operation of the SFTD is denied by the translation interlock system.

2.5 Sequences of Fuel Transfer

Fig. 3 shows the transfer path of spent fuel between spent fuel storage pool “A” and pool “B” by using the SFHM (Type A & B) and the SFTD. The spent fuel stored in the spent fuel storage pool “A” after being withdrawn from a reactor vessel is transferred into the fuel transfer cavity of SFTD with the SFHM (Type A).

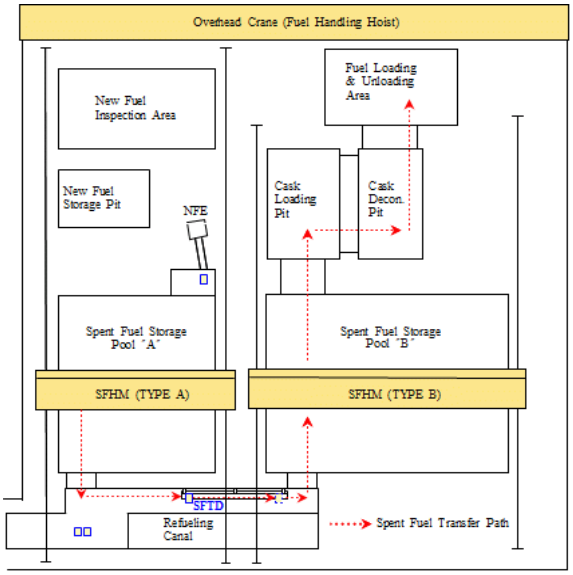

Fig. 3. Transfer path of spent fuel in FHA

The fuel transfer cavity, powered by a winch cable, is moved to the spent fuel storage pool “B” side. During the movement of the cavity, the SFHM (Type A & B) shall not be approached to the SFTD’s operating zone. The SFHM (Type A & B) can only access the transfer cavity when the fuel transfer cavity is at predetermined location. The spent fuel is transferred and stored in a designated location of the spent fuel storage pool “B” with the SFHM (Type B). The SFTD operation is implemented when the refueling canal is filled with spent fuel storage pool water to allow underwater transportation of the spent fuel.

The transfer distance of the SFTD is minimized to ensure that the spent fuel is handled in a safe and reliable manner by maximizing the operating zone of SFHM (Type A & B).

3. Conclusions

As described above, the SFTD is developed to allow the underwater transportation of spent fuel assemblies between spent fuel storage pools, and is also planned to be applied for domestic nuclear power plants being under construction. Through the SFTD, the spent fuel can be transferred easily and stably to a designated location while maintaining its vertical position within the refueling canal. It is expected that the SFTD can be useful equipment for transferring the spent fuel between spent fuel storage pools.

REFERENCES

[1] ANSI/ANS-57.1, Design Requirements for Light Water Reactor Fuel Handling Systems, 1992 (Reaffirmed 2005).