Westinghouse Quiver – A simple and safe system for the complete handling and storing of failed BWR and PWR fuel rods and fragments – 17049

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ABSTRACT

Background

Extracted leaking fuel rods from fuel assemblies have been stored in the spent fuel pools at the Nuclear Power Plants for many years. Sending those fuel rods to an intermediate storage has been very difficult due to the uncertainty of the technical requirements.

The Westinghouse Quiver is a container that can be used from the first moment when the leaking fuel rod is extracted from the Fuel Assembly. The leaking fuel rod can be placed in the Westinghouse Quiver. When the Quiver is filled, it can be sealed and dried and then treated as a regular fuel assembly during intermediate storage and final repository.

Purpose of System

The purpose of the system is to store leaking fuel rods, broken rods and fuel rod fragments leak tight in the fuel pool and after vacuum drying and permanent sealing at an intermediate storage facility. The Quiver is designed to be fully compatible with a regular fuel assembly. That means all handling of the Quiver in a Nuclear Power Plant, during transportation or storage is also identical to that of a regular fuel assembly.

Fulfilling these criteria together with functional testing, the Quiver is considered acceptable for long time storage of leaking fuel rods, both in dry or wet condition. The Quiver has been qualified in Switzerland for use in the spent fuel pool, intermediate storage, and for a final repository. The system will be implemented as well in Sweden during 2016-2019.

INTRODUCTION

The Quiver is a multifunctional container with the following functions:

- Storage of failed fuel leak tight or gas tight in a spent fuel pool
- Transport encapsulation for failed fuel and high burn up fuel rods (transport from nuclear power plants to storage facilities or hot cell facilities)
- Storage of failed fuel in a wet intermediate storage facility
- Storage of failed fuel in a dry cask for intermediate storage
- Storage of failed fuel in a final repository

DESCRIPTION

General Design

The Quiver Container (Fig. 1) is manufactured in stainless steel. The materials are well suited for the environmental factors the Quiver is exposed to, like corrosion, heat, radiation and load. These materials have successfully been used in applications such as fuel elevators, scrap containers and fuel rod containers similar to the Quiver since beginning of the 70's.

The outer dimensions are adapted to commercial nuclear BWR and PWR fuel. This enables the Quiver to be handled according to fuel handling procedures for any applicable nuclear power plants and that the Quiver can be stored in fuel racks, fuel elevators or other fuel handling positions.

The Quiver house consists of 28 tubes (BWR design) and up to 85 tubes (PWR design) for failed fuel rods and/or fuel rod fragments and one tube for evacuation of water. The tubes are held together and supported by an upper and a lower gable, as well as 7 spacers. The lower gable is attached to the bottom part, which contains a filter unit. Upper and lower gable is interconnected by a corner bar in each corner. The spacers are connected to the corner bars to get a stable frame. For the handling of the Quiver in the fuel pool and for evacuation and vacuum drying procedure, some manual handling tools are necessary.

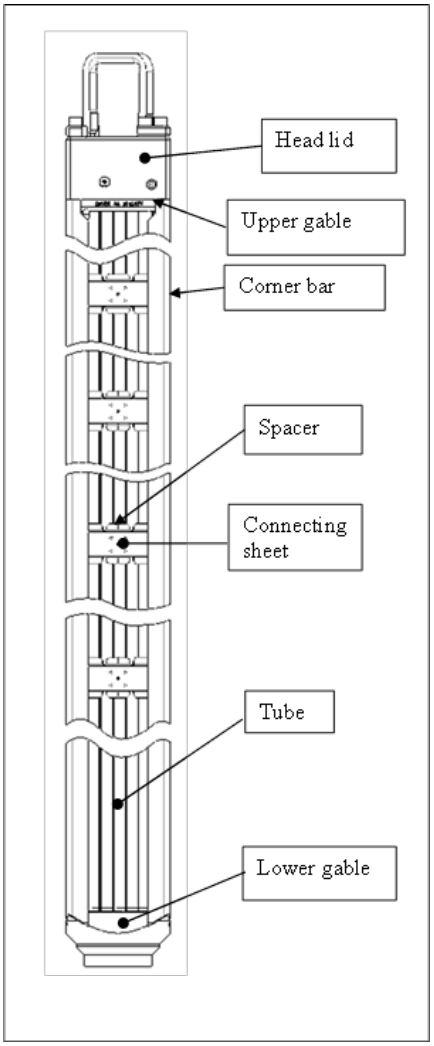

Fig. 1 – Example of BWR Quiver Design

Head Lids

The system has two different head lids. One of the head lids is used for handling in the fuel pool. The other head lid is used for permanent sealing and longtime storage in dry condition.

The head lid for handling in the fuel pool (see figure 2) has a pressure-discharge hole provided with a 200 μm filter.

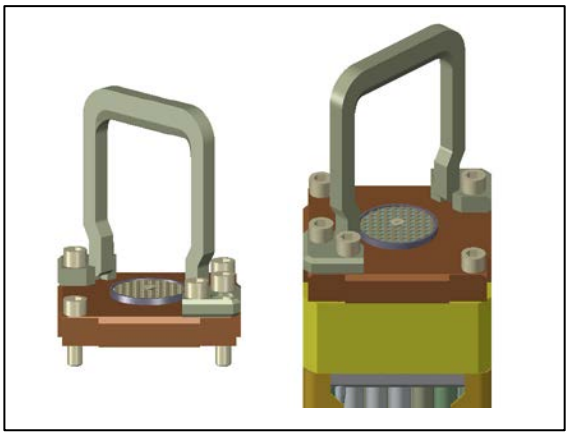

Fig. 2 – Example of BWR Quiver Head Design for handling in the Spent Fuel Pool

The long term storage head lid is sealed to the upper gable by a Helicoflex seal ring and an additional Helicoflex seal is used when performing leak detection. The grooves for the Helicoflex seals have connections where tightness check of the seal can be performed after vacuum drying and sealing.

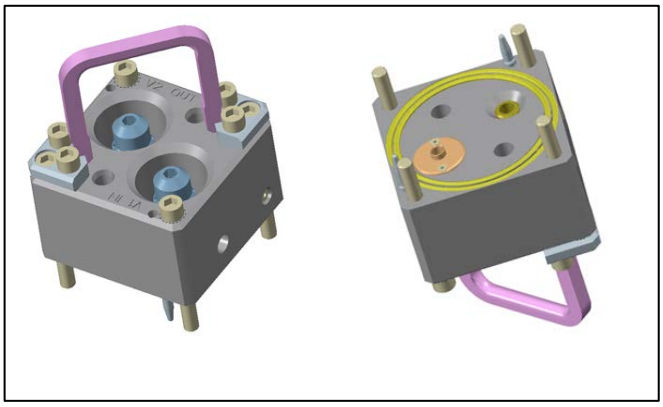

Fig. 3 – Example of BWR Quiver Permanent Sealing Head Design

Drying of Quiver and Quiver content

If the Quiver will be used as a storage container for failed fuel rods at an intermediate storage site, all leaking fuel rods are punctured in the plenum in order to optimize the drying process and to make sure that all failed fuel rods can communicate with the drying equipment.

The drying process is performed according to ASTM C1553 (Guide for Drying Behavior of Spent Nuclear Fuel). The Quiver design (see bottom of the Quiver, Fig. 4) allows the drying of all loaded leaking fuel rods at the same time since all leaking fuel rods and rod fragments can communicate with the drying equipment.

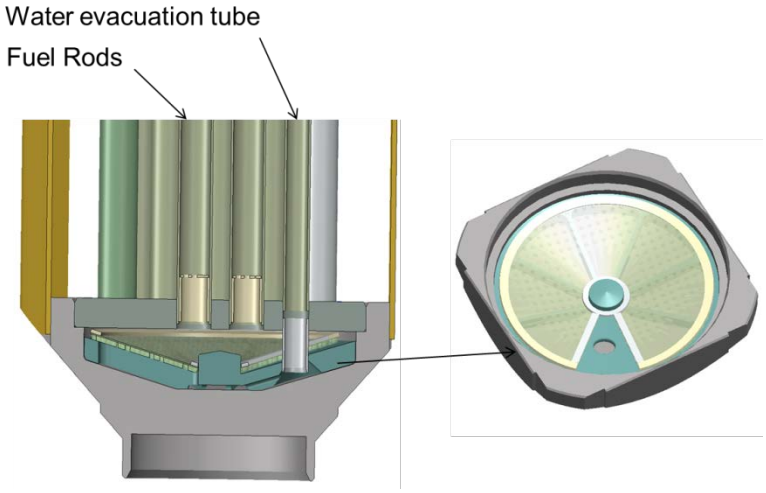

Fig. 4 – Design of bottom part of Quiver

For the evacuation of the water from the Quiver, special tools will be connected to the two valves (inlet for air, outlet for air and water) of the Quiver. The water will pass the filter in the bottom part of the Quiver, rise through the evacuation tube and the hose in the connection tool and out to the evacuation system. The water is removed in a couple of minutes and after the water has been removed from the Quiver, the vacuum drying system is connected. After the vacuum drying process, a helium leak tightness test of the head lid seal is performed.

Intermediate Storage and Final Repository

The Quiver can be qualified for all dry casks but also fuel transport containers on the market. In Switzerland there is an ongoing project to qualify the Quiver for an AREVA TN container as well as for the NCS-45 container from DAHER.

After storage of the Quiver in an intermediate storage, the Quiver is transferred to the final repository there it is treated as a regular fuel assembly. In Switzerland NAGRA (National Technical Competence Centre in the field of deep geological

disposal of radioactive waste) has approved the Quiver's suitability for the final repository in Switzerland.

CONCLUSION

The design of the Quiver is based on requirements from different customers and authorities in different countries collected over the years.

The philosophy of the Quiver system is to be a safe storage container for failed fuel rods and fuel rod fragments in a spent fuel pool, intermediate storage and final repository. A Quiver loaded with failed fuel rods in Helium tight condition according to qualified procedures transfers the failed fuel to a bundle that can be treated like a regular fuel assembly. This is achieved because

- the design criteria is matched with the design criteria of a fresh fuel assembly
- the fuel is dried according to standard procedures
- the proof of tightness can be shown
- the quiver content includes fewer fuel rods as a normal fuel assembly
- the leaking fuel rods will get a new capsulation (no scratches, not corroded, no Hydrogen uptake)
- the new capsulation has thicker dimensions (no fretting marks)
- in case of a crash, the quiver is more stable than a regular fuel assembly because of double encapsulation

This means that no special treatment of failed fuel rods or fuel rod fragments for intermediate storage or final repository is necessary.