# THE EXPERIENCIES FROM THE INTERIM SPENT FUEL STORAGE OPERATION WITH CASTOR 440/84 CASKS IN DUKOVANY NPP

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**ABSTRACT**

Our company „CEZ Prague„ decided on a new technology in the storage of spent nuclear fuel in the year 1991. The main feature is due dual purpose metal cask CASTOR® 440/84 for 84 assemblies of the type VVER 440. The first stage of building was designed for 60 casks, currently 40 casks are stored. The CASTOR® 440/84 is a dual-purpose cask and provides dry storage in a 100 % helium atmosphere. The cask is monitored according to the design by a system which measures the pressure in the gap between the primary and secondary lid. Another monitoring system is the measurement of surface temperature.

For shipment, the cask is transported on a special railway wagon designed only for this reason. For application of the new technology, we had to provide many requirements. The most important were the reracking of storage pools, new universal nests in the loading pit, new service places in the reactor hall, shock absorbers, etc.

In December 1995, the first CASTOR® cask was placed into the storage hall. Until then we performed „trial„ operation for a duration of 14 months. The most important requirement of the State Office for Nuclear Safety was the necessity of special equipment for back cooling of the cask.

Dukovany's fuel was stored in the former Czechoslovakia in the Slovak power station of Bohunice. A total of 9 CASTOR® casks were transported between both republics. By the last transport, special procedures for back cooling of the cask were performed, and the last cask was completed in the Dukovany NPP area.

Main conclusions: In 6-years of safe operation, 40 casks have been placed in the ISFSF; the storage operation belongs to the best practices in the Dukovany NPP.

Perspectives: A second stage ISFSF is under preparation now; our company had chosen the winner of the competition - the advanced CASTOR® 440/84M cask. The next building will be more than two times bigger than the current ISFSF. The proposed life time is approximately 60 years.

## INTRODUCTION

It was evident at the end of the eighties that the original concept of return Transport of Spent Fuel to the former Soviet Union was a mere vision. Therefore the development began on our own system appropriate for spent fuel storage at NPP in the Czech Republic. In the competition of tenders which was published in 1991, a set of systems appropriate for interim storage of spent fuel was investigated. Finally, the system of GNB from Germany was chosen with the main feature the storage of spent fuel in CASTOR® casks. This decision regarding the storage facility was made also for political reasons. The storage facility which was designed within an area of Dukovany NPP, with limited capacity for 600 metric tonnes of HM (Heavy Metal) and the technology should make possible an easy transport of the SF (Spent Fuel) to another locality.

## THE PRINCIPLES OF THE CASTOR® 440/84 DESIGN

The CASTOR® 440/84 is a dual-purpose cask allowing both the long-term storage of SF and its transport. The main subsupplier is Czech Skoda, Pilsen. Spent fuel in amount of 84 fuel assemblies of the VVER 440 type is stored in the cask under 100 % helium atmosphere. Leak-tightness of the cask is provided by the system of two lids made from stainless steel, each with metal seals. Pressure in the space between lids is monitored by an appropriate system, and in such way also the leak-tightness of both lids is controlled. In addition protection against external events is provided by a third lid. The cask is provided in the two pairs of trunnions which allow its transport and storage into horizontal position on the transport vehicle. Protection of cask body on the internal surface is provided by nickel coating, the external surface is coated by an epoxy resin coating. The bottom of the cask is protected with an aluminium layer.

The cask is transported on a special railway wagon designed only for this reason. The overall length is 33 m and loading weight approximately 240 metric tonnes. The view on the 12-axle wagon is very interesting.

The system of working with the cask in NPP Dukovany is as follows:

The cask is shipped from the manufacturer's facility by railway to the corridor of the reactor building. Following rotation from horizontal to vertical position, it is lifted up to the reactor hall to its service (repository) place using a special lifting beam. There the operations from disassembly of the lids up to the check of cleanness are performed. Subsequently the cask is transported again using a lifting beam into the loading pit near the reactor and the storage pool. Then the cask is loaded by the refuelling machine with 84 fuel assemblies, there inspections including inspection with participation of IAEA inspectors are carried out and the cask is covered under water level with its primary lid. Then follows lifting of the cask from the pit and full decontamination of its surface. The cask is transported back to the service (repository) place in the reactor hall where all tests of its leak-tightness and other control operations are carried out. After completion of all checks, the cask is fully assembled including its third lid and it is secured using IAEA's seals. In such a configuration and following the dosimetry measurement and appropriate decontamination, the cask is transported on railway wagon and brought into the ISFSF (Interim Spent Fuel Storage Facility) within the area of Dukovany NPP. The building of the interim storage is a light-weight hall divided into reception and storage areas. Transport of casks is provided by a crane for 130 metric tonnes.

In addition to a service personnel room, the reception part comprises also a room for maintenance of casks as well as a small control room. The pressure monitoring system is wired to the measuring unit UPM 100 in this control room as well as all other radiation control and measurements. From this small control room, the information is transferred into the computer network of NPP and to the central dosimetry surveillance control room.

The storage hall allows up to 60 casks CASTOR® 440/84 type to be stored inside. Cooling of casks is provided by natural circulation using sets of lower and upper openings. For the working conditions during winter, the lower set of openings can be partly closed by roll-up shutter.

Following the transport to the entrance corridor, the cask is rotated into vertical position and then is transported directly to its storage position. At this place it is connected to the pressure monitoring system and it is included in the monitoring process performed by the computer network of the NPP.

## THE DESIGN DEVELOPMENT WORKS

### Reracking of Storage Pools Near the Reactor

After the final choice of interim spent fuel storage in Dukovany NPP, it was necessary to commence the fulfilment of necessary conditions for this choice. The most important feature was the enhancement of storage capacity in pools near the reactor in such way that the conditions for minimum cooling will be provided for the time period of five years. The capacity by the original design was provided for less than three years only. Reracking was the only available solution for capacity enhancement of storage pool near the reactor. This work was carried out from 1992 to 1993. By reracking of the pool, a very large effort was required concerning transport of appropriate spent fuel to other pools. Up to 35 transports per one pool was carried out. These transports were provided by an older type of cask C-30 accommodated from Bohunice NPP (Slovak Republic). The new storage grids have almost twofold capacity and regarding the fuel load enhancement, they allow the spent fuel storage up to 7 years of operation.

### Arrangement of the Casks Loading Pit

An other limiting factor for the CASTOR® technology application were the geometrical dimensions in reactor building in particular in the reactor hall . The system of fuel movement in pools can not be changed for the VVER 440 type of reactor, therefore the diameter of the cask shall be accommodated to dimensions of loading pit. Regarding the accurate positioning of the CASTOR® cask, all of the 4 universal nests on the bottom of pits were replaced. Further arrangement was carried out at the level of floor where special holders for the transport beam were assembled.

### Reconstruction of Service (Repository) Place in Reactor Hall

Another important feature was the reconstruction of the repository place in the centre of the reactor hall. This place allows loads up to 120 tonnes as well as thorough bedding of the cask. For maximal safety (capture of radioactive water), the bottom is provided by a 20 cm high collar. There are two such places in each reactor hall.

### Transport Path and Shock Absorbers

Significant problems were caused fulfilling the condition of vertical transport of cask down to the railway wagon. There the height up to 18 m must be passed over. According to our previous experience, a special heavy shock absorber was developed and it was placed on the other railway wagon. During the vertical movement of the cask, this special shock absorber is placed in the railway corridor. The transport path in reactor hall is exactly determined; on places where problems could occur special shock absorbers are placed.

The specific circumstances in pools near the VVER reactors (the level of water column above 14 m) were the reason for provision of an accurate insertion of the cask down to the loading pit. For the transport beam, a TV system was developed and assembled which provides several functions:

- Monitoring of crucial points during the transport down to the pit
- Accurate adjustment of the lower trunnions of the cask into universal nest on the bottom of the pit
- Insertion of the primary lid on the cask under water.

**Auxiliary equipment**

In addition to the original supply of various instruments and tools supplied by German firms, many other tools were developed ourselves, for example banks for handling with lids, cabinets for storage of expensive metal seals, pallets for handling with sets of bolts etc.

## COMMISSIONING OF THE INTERIM SPENT FUEL STORAGE FACILITY

After a severe approval process, the construction of ISFSF building was started in the summer 1994. In less than a year in summer 1995 the construction of building was completed and at the same time the first CASTOR® 440/84 cask was supplied to Dukovany NPP. From September 1995 all tests and final adjustment of equipment were performed, so that the first loaded cask was transported into ISFSF building officially on 5th December 1995.

At this time also the trial operation of equipment was started with a duration of 14 months provided that certain capacity will be reached (as a minimum 7 casks in the storage hall according to the requirement of regulatory body).

In order to have a full control concerning the status of the cask, a temperature measurement is performed on the surface approximately at the level of half-height of the cask. Continuous measurement of temperature is provided for all casks.

During the trial operation also the solution of the following important process was reached, which can not be excluded in spite of its very high unlikelihood. Should a failure of leak-tightness occur, for instance on the primary lid, and/or the fuel should be unloaded, then we face the following situation. On the one hand a dried and heated-up cask, on the other hand the pool with cold water (temperature about 25 °C) . It was evident that even a simple insertion of the dried cask into the pool could be crucial. After difficult negotiation, the equipment for controlled filling of the dried cask with water (very slow filling) was developed by GNB. This process is performed on the service (repository) place in the reactor hall and it was tested using simulation equipment also with the real cask loaded with fuel (in connection with transports from Slovakia NPP). In January 1997 the trial operation was successfully completed and the normal continuous operation of the Interim Spent Fuel Storage Facility began.

## TECHNOLOGICAL MONITORING IN THE ISFSF

During operation, the greatest importance is laid on monitoring of the casks and on measurements of the radiation protection. Further periodical inspections of the individual equipment parts in the storage building inclusive of the cask body are prescribed.

### System of Pressure Measurement for CASTOR® 440/84 Cask

The CASTOR® 440/84 cask is monitored by a system which measures the pressure in the gap between the primary and secondary lid. This hollow space is filled with pure helium with the pressure of 0.6 MPa during the cask assembly. Obviously the pressure varies with the temperature of the ambient atmosphere. Especially the lowering of the pressure below the lower limit 0.45 MPa is a signal for us to begin with checking whether the cask has any leakage.

The identification of a leakage is solved simply and smartly. The distribution of pressures for a cask is the following:

- There is an underpressure in the cask cavity (0.08 MPa)
- There is an overpressure in the hollow space between the primary and secondary lids (0.6 MPa)
- There is an atmospheric pressure all around the cask, i.e. above the secondary lid (0.1 MPa).

In case of a pressure change in the monitored hollow space, the following possibilities are investigated:

- Failure of the measuring chain (checking of electric circuits)
- Leakage of the secondary lid (indication of helium leakage above the secondary lid)
- Leakage of the primary lid (evaluation of all verifications leading to this conclusion)

In the latter case (a highly improbable one of course) transport into the reactor unit follows, the cask is filled with water by a special procedure and then it is unloaded in the pool at the reactor.

But let's return to the system of pressure measurement. The values from all the casks are led into measuring unit which evaluates these values. Further it is able to analyse failures of the routes, ensure auxiliary power supply and the like. As the ISFSF building has no permanent operational staff, we have chosen the personnel of the central dosimetric control room (CDCR) to supervise this system.
The data from ISFSF are led via the computer network of the power plant to a panel in CDCR inclusive of signalling. In case of an off-normal situation, the chief worker of CDCR reports non-complying parameters to the plant shift supervisor who starts remedial measures in accordance with the procedures.

**Periodical Inspections of Pressure Sensing Units of Casks in ISFSF**

The pressure sensing unit is the basic part of the chain for measuring of the pressure in the space between the cask lids. According to the legislation of the Czech Republic an interval for every operating measuring instrument must be determined when it will be calibrated regularly. With regard to the terms of the CASTOR® casks we have proposed a period of six years, which gives ten cask to be checked per year with full capacity of the ISFSF. This proposal has been approved by the metrologic service authorities and therefore we are preparing to begin with these checks in the year 2001. Because of the principle which forces us to test the sensing unit outside the CASTOR® cask, it is not a short and easy operation. It will be necessary to dismantle the protective lid, let out the gas between the primary and secondary lids, then to dismantle the sensing unit with flange. Subsequently the cask is completed again into the condition for further storage by a reverse procedure together with leakage tests.

## INTERNATIONAL TRANSPORTS OF SPENT FUEL UTILISING CASTOR® 440/84 CASKS

Before 1989 in former Czechoslovakia, the issue of spent fuel storage was solved by transport to the only interim storage facility in the area of Bohunice NPP (Slovakia). Almost 1200 spent fuel assemblies from Dukovany NPP was cumulated in such a way in Bohunice NPP up to year 1992. Of course after the splitting of the former Czechoslovakia, the Czech Republic was asked take back the spent fuel into its own interim storage.
The idea to apply the CASTOR® casks for 84 fuel assemblies for this purpose was evident, however an intensive effort was spent for implementation of this idea. These transports were implemented with no problems due to friendly approach of the Slovak colleagues in spite of a slightly excited atmosphere.
Initially the transports were carried out using the older C-30 casks (contents only 30 assemblies), but an intensive development was carried out in order to provide CASTOR® technology also in the Slovak ISFSF. This problem was solved and in total 9 CASTOR® casks were transported between both NPPs.

In such way the transports were completed sooner as it was expected. However, one small problem was still remaining: What to do with the last cask which was loaded only to 50 %? Just in this case the solution was applied with the back cooling of the CASTOR® cask. In November 1997 under surveillance of regulatory body with participation of many experts, the cask containing 48 fuel assemblies was filled with water, cooled and then transported into the loading pit. Subsequently it was assembled by the standard process and stored in the ISFSF in Dukovany NPP.

## THE OUTLOOK FOR FURTHER STORAGE OF SPENT NUCLEAR FUEL IN DUKOVANY NPP

To make our situation clear, we must return back into history. When we were building the present ISFSF (see Figure 1), it was necessary to limit its capacity to roughly one third of the necessary one. Then we were able to pass the approval procedure for the construction successfully. This capacity will be exhausted roughly by the year 2005. With regard to the further necessary capacity of over 1300 tonnes of heavy metal we have started the approval procedure for another ISFSF building. The corresponding processes have begun of which the EIA (Environmental Impact Assessment) process seems to be the critical one. We have passed a number of negotiations and public hearings, where difficult discussions about the new project were held. All the participants in the approval procedure (investor, municipal authorities, citizens' groups, ecological groups) tried to put through their own views and interests. At present the winning type of the cask has been selected from the offers of three companies. The winner became the new advanced CASTOR® 440/84M cask in May 2001. Now we have to accelerate the technical project of the construction of the 2$^{nd}$ stage of ISFSF.

## CONCLUSION

Looking back to almost 6 years of operation of our Interim Spent Fuel Storage Facility it can be said that this operation is safe and in practice with no abnormal events. On the contrary the Interim Spent Fuel Storage belongs to the best practices and as such it became the part of all programs of professional as well as common visits. It could be noted that also the public opinion was transferred from initially a strictly adverse attitude to an understanding on the part of the public.