BWR – Spent Fuel Transport and Storage with the TN™9/4 & TN™24BH Casks

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ABSTRACT

The Swiss Nuclear Utilities have started in 2001 to store spent fuel in dry metallic dual-purpose casks at ZWILAG, the Swiss interim storage facility. BKW FMB Energy Ltd., the Mühleberg Nuclear Power Plant owner, is involved in this process and has elected to store its BWR spent fuel in a new high capacity dual-purpose cask, the TN™24BH from the COGEMA LOGISTICS/TRANSNUCLEAR TN™24 family.

The Mühleberg BWR spent fuels are transported by road in a medium size shuttle transport cask and then transferred to a heavy transport/storage cask (dry transfer) in the hot cell of ZWILAG site. For that purpose, COGEMA LOGISTICS designed and supplied:

- Two shuttle casks, TN™9/4, mainly devoted to transport of spent fuel from Mühleberg NPP to ZWILAG. Licensed according to IAEA 1996, the TN™9/4 is a 40 ton transport cask, for 7 BWR high burn-up spent fuel assemblies.
- A series of new high capacity dual-purpose casks, TN™24BH, holding 69 BWR spent fuels.

Two transport campaigns took place in 2003 and 2004. For each campaign, ten TN™9/4 round trips are performed, and one TN™24BH is loaded. 5 additional TN™24BH are being manufactured for BKW, and the next transport campaigns are scheduled from 2006.

The TN™24BH high capacity dual purpose cask and the TN™9/4 transport cask characteristics and capabilities will then be detailed.

CONCEPT

Medium Size Cask Road Transport Allowing High Capacity Cask Loading at the Storage Site

Transportations of spent fuels from the Swiss NPP to ZWILAG, the Swiss interim storage facility, are done in most cases with dual-purpose transport and storage casks from the TN™24 family. The first of these casks was the TN™24G cask developed for the PWR NPP of Goesgen, followed by the TN™52L and the TN™97L developed for the BWR NPP of Leibstadt. These

casks are loaded with spent fuels in the NPP pool and then transported to ZWILAG. In ZWILAG, they are moved in the storage hall for interim storage where they are planned to stay up to 40 years.

In the case of the Mühleberg NPP, the spent fuels are transported by road in a medium size transport cask and then transferred in a heavy transport/storage cask (dry transfer) in the hot cell located on the ZWILAG site. Based on this principle, COGEMA LOGISTICS has designed and supplied:

- Two shuttle casks, TN™9/4, mainly devoted to transport of spent fuel from Mühleberg NPP to ZWILAG.
- Two new high capacity dual-purpose casks, TN™24BH, adapted to BKW spent fuels

Fig. 1. TN™24BH and TN™9/4 metal casks in ZWILAG storage hall

TN™24BH Cask, A High Capacity Transport and Storage Metal Cask

Two TN™24BH casks were delivered to BKW in 2002. As all TN™24 casks designed for Switzerland, the TN™24BH is B(U)F licensed in France with a validation of the packaging approval license in Switzerland. The allowable content is given in Table I.

Table I.

Cask	TN™24BH
Spent fuels capacity	69 BWR
Fuel types	BWR 8x8, 9x9, 10x10
Max thermal power	40 kW
Reference Burn Up and Cooling time	50 000 MWd/tU and 6 years
Max Enrichment in U235	5 %

TN™24BH, a proven design

Fig. 2 shows the design features of the TN™24BH dual-purpose cask, which is constructed as follows:

- The basic structure is a thick steel cylindrical forging with a welded on forged bottom and two forged steel lids. Containment and gamma shielding features of the cask are mainly provided by this basic structure.
- 4 trunnions are attached to this structure for handling, tilting and tie down.
- Inside the cylindrical cavity, a boron aluminum basket is fitted and provides a structural support for the fuel assemblies and criticality control.
- Surrounding the cylindrical cavity, a resin layer is encased in an outer shell and provides the neutron shielding features of the cask. Heat conductors (longitudinal copper plates) ensure the thermal evacuation of the heat from the main shell to the outer shell of the cask.
- A permanent leak tightness monitoring system for the pressure in the interspace between primary and secondary lids and an anti-aircraft crash cover are installed during the storage period of the cask.
- A set of shock absorbing covers is fitted to the cask for transport operation, as well as lateral impact limiters.

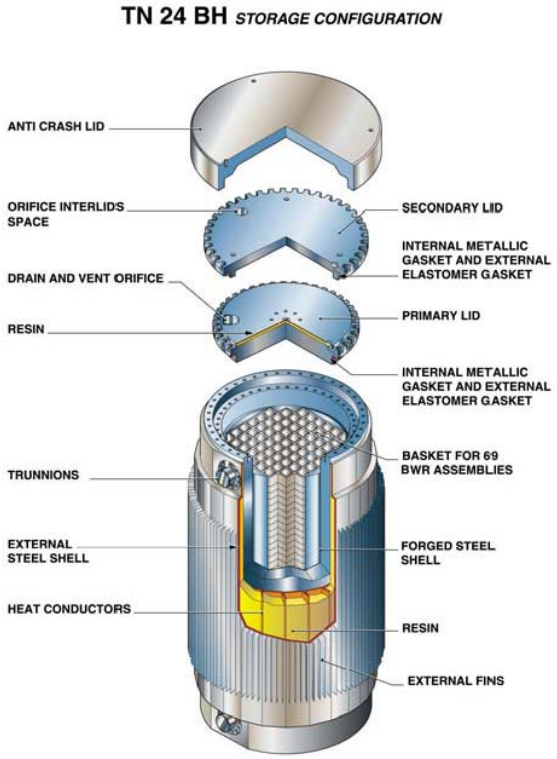

Fig. 2. TN™24BH storage configuration

The TN™24BH has: -a total loaded weight of 135 tons, -a diameter of 2750 mm with the shock absorbing covers but without lateral impact limiters -and a total length of 6272 mm with the shock absorbing covers in the transport configuration.

TN™24BH in operation

A storage safety analysis report for the TN™24BH cask was performed by COGEMA LOGISTICS and submitted by BKW to the Swiss competent Authority, which delivered the storage license for this cask at ZWILAG.

From beginning of June 2003 to end of November 2003, the first TN™24BH was loaded with 69 spent fuels in ZWILAG hot cell. Further to this successful operation, BKW ordered COGEMA LOGISTICS 5 additional TN™24BH with the first delivery scheduled at the end of 2005.

TN™9/4 CASK, A SPENT FUEL SHUTTLE TRANSPORT CASK

The TN™9/4 is also B(U)F licensed in France with a validation of the packaging approval license in Switzerland. The allowable content is given in table 2.

Table II.

Cask	TN™9/4
Spent fuels capacity	7 BWR
Fuel types	BWR 8x8, 9x9, 10x10
Max thermal power	6,16 kW
Reference Burn Up and Cooling time	70 000 MWd/tU and 4 years
Max Enrichment in U235	5 %

One of the first COGEMA LOGISTICS IAEA 96 package

Licensed in France for five years since May 2002 and in Switzerland since August 2002, the TN™9/4 cask is one of the first casks to be designed with two independent containment barriers.

TN™9/4 design

The TN™9/4 transport cask is mainly constituted of: the cask body (first containment barrier), the canister (second containment barrier), the 7 lodgement basket, and the shock absorbing covers. The safety is mainly ensured by the mechanical properties of the cask body equipped with its shock absorbing covers. It insures as well the shielding and the transfer of the decay heat.

The canister (the second independent containment barrier) is removable. It can be inserted and withdrawn in dry conditions for maintenance. The canister contributes also to the mechanical strength of the cask and to the shielding.

The basket, manufactured mainly of aluminum plates, is set in the canister and:

- mechanically supports fuel assemblies,
- maintains sub-criticality in transport conditions, during fuel loading and unloading operations,
- transfers the fuel decay heat to the cask body.

One lodgement is designed to allow the transport of one failed fuel in bottle. The leak tightness of this cask is ensured by: -the primary lid with 2 elastomer (EPDM) gaskets closing the first containment barrier -and the secondary lid with 2 elastomer (EPDM) gaskets closing the second containment barrier.

TN™24BH AND TN™9/4 OPERATIONAL EXPERIENCE IN SWITZERLAND

The TN™9/4 cask is used as a shuttle cask between Mühleberg NPP and ZWILAG. The TN™9/4 cask is loaded under water with 7 spent fuels in Mühleberg NPP. It is then transported by road to ZWILAG where the spent fuel assemblies are transferred under dry conditions, in the ZWILAG hot cell, from the TN™9/4 to the high capacity storage cask TN™24BH.

The TN™24BH capacity is 69 spent fuels. As a consequence, 10 TN™9/4 round trips are necessary to load one TN™24BH.

In 2003, BKW, ZWILAG and COGEMA LOGISTICS organised the first TN™9/4 transport campaign between Mühleberg NPP and ZWILAG. The transport campaign started early June 2003 to finish at the end of November 2003 with an interruption of 3 months between July and September. Thanks to several cold trials organised in Mühleberg NPP and in ZWILAG with both TN™9/4 and TN™24BH, the transport campaign ran perfectly well and the operation was a full success. The regulatory requirements for contamination have always been met.

In 2004, the second TN™9/4 transport campaign started in April 2004 and finished in July 2004.

The TN™9/4 is transported by road on dedicated trailers between Mühleberg NPP and ZWILAG. The transport itinerary has been carefully studied before the first campaign. The distance is approximately 250 km.

Generally, there are 4 main steps to perform a TN™9/4 transport campaign:

Campaign Preparation, Key Parameter to Perform a Successful Transport

The transport logistics is prepared by BKW and ZWILAG with detailed planning for Mühleberg NPP and detailed planning for ZWILAG. It is the key parameter to perform a successful campaign and to determine exactly the transport dates.

COGEMA LOGISTICS provides:

- the transport documentation file which will be filled by all the parties for each transport
- the fuel loading plans for the TN™9/4 transport cask and for the TN™24BH dual-purpose cask
- the transportability check of the fuel elements in these casks.
- the transports preparation itself with the corresponding Swiss authorisations and notifications: exceptional transport, heavy transport over 34 tons, etc…

Based on the fuel loading plans, the Swiss Federal Nuclear Safety Inspectorate, the HSK, gives the authorisation to load and store the TN™24BH in ZWILAG and the Swiss Federal Office of Energy delivers the permit for the transport of spent fuel assemblies with the TN™9/4 from Mühleberg NPP to ZWILAG

TN™24BH Cask Preparation in ZWILAG

The TN™24BH cask is prepared in ZWILAG: the secondary and primary lids are removed, the basket is controlled with a dummy fuel assembly, and then the primary lid is put back down on the cask. It is then transferred and accosted under the hot cell where the primary lid is removed. The TN™24BH cask is now ready to receive spent fuel assemblies. TN™24BH cask preparation takes approximately one week.

TN™9/4 Campaign, an Optimised Timetable

The TN™9/4 campaign consists of ten round trips by road between the Mühleberg NPP and ZWILAG, using two TN9/4 simultaneously: TN™9/4 n°1 and TN™9/4 n°2 but only one trailer. This is performed on the basis of the following optimised planning based on 5 working days, where the main steps are described day per day for each utility. The crossing of the loaded and emptied casks is done in the ZWILAG facilities. The use of one trailer eases and reduces the non-contamination control procedure, while the trailer stays in controlled area between the transports during the transport campaign.

Table III.

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	ZWILAG Zwischenlager Würenlingen AG Transfer between TN™9/4 and TN™24BH cask	NPP of MÜHLEBERG Loading of TN™9/4.
Day 1	The TN™9/4 n°1 leaves ZWILAG in the morning to Mühleberg NPP. The TN™9/4 n°2 has arrived before from NPP and has been already connected to the hot cell after installation of the connecting ring and of the lifting pintail of the primary lid. The primary lid of the TN™9/4 n°2 is removed in the hot cell and a funnelshaped protective piece is installed.	Once arrived in Mühleberg, TN™9/4 n°1 enters the turbine hall where the shock absorbing covers are removed. Then the cask is raised horizontally and transferred on a trolley. After the non-contamination controls are performed, the cask is transferred in the reactor building, where it is raised horizontally and placed on a tilting frame. After the installation of the contamination protection system (bottom plate & self-adhesive film), the TN™9/4 is tilted in vertical position and transferred in the preparation cell close to the pool area. The secondary lid is removed and the cavity is filled with water.
Day 2	The transfer of the spent fuel bundles starts with the control of the serial numbers through video system, which eases the IAEA controls. Then the bundles are unloaded from TN™9/4 n°2 and put into the TN™24BH. During this transfer between the two casks, the IAEA can perform gamma and neutron measurements. The funnelshaped protective piece is removed and the primary lid of the TN™9/4 n°2 put in place. Then the TN™9/4 n°2 leaves the hot cell to the working place 3, where the screws are inserted.	The TN™9/4 n°1 is plunged in the pool and the primary lid is removed. The 7 spent fuels are put into the basket. After these loading operations, the primary lid is put in place and the cask is reinstalled in the preparation cell where the cavity is drained and dried during the night. COGEMA LOGISTICS checks the fuel loading operations.
Day 3	The primary lid screws are tightened on the cask and the leaktightness tests of the primary lid are performed. The TN™9/4 n°2 is moved to the working place 2 where the lifting pintail and the connecting ring are removed, and afterwards the secondary lid and his screws are put in place.	After the dry test of the cavity and the primary lid leaktightness test, the secondary lid is put in place and also tested. Then the TN™9/4 n°1 is tilted, cleaned and controlled
Day 4	The secondary lid screws are tightened and the final leaktightness tests are performed. Then the TN™9/4 n°2 is parked close to the working place 2.	The TN™9/4 n°1 is put back horizontally on the trolley and leaves the reactor building. The loaded cask is prepared for transport and the required non-contamination controls are performed.
Day 5	The TN™9/4 n°1 arrives from Mühleberg NPP and is installed in the first preparation area of the hot cell (working place 2). The secondary lid is removed and a protective connective ring is fixed on the cask. The primary lid lifting pintail is installed and the cask is transferred to the working place 3. There, the vacuum is broken and the primary lid is unscrewed. Then the TN™9/4 n°1 is transferred and connected to the hot cell. TN™9/4 n°2 is prepared for transport and the required non-contamination controls are performed.	The TN™9/4 n°1 filled with 7 fuel elements leaves Mühleberg in the morning to ZWILAG.

TN™24BH Cask Closing in ZWILAG

With an efficient preparation and co-ordination, loading the TN™24BH takes 10 weeks.

Two weeks are reserved in ZWILAG to close the TN™24BH, the primary lid is inserted in the hot cell and the secondary in the working place 2. COGEMA LOGISTICS offers its technical

assistance during this key operation.

A SUCCESSFUL RESOLUTION OF CHALLENGING ISSUES

Design: An IAEA 96 Package

The international regulation changed in 2000 with the IAEA 1996. The TN™9/4 preliminary concept had to evolve to take the new regulation into consideration. The TN™9/4 was one of the first casks designed by COGEMA LOGISTICS with two independent containment barriers.

Manufacturing: Innovative Solutions

- The TN™9/4 small size has revealed several technical difficulties. Generally the casks have a diameter larger than 2 meters. The TN™9/4 has only an external diameter of 1,33 meters with an internal cavity of 0,57 meter and an internal length of 4,55 meters. The machining of the canister was one of the challenging operations.
- The TN™9/4 cask finish is also innovating. In order to be able to keep the optimised planning of the transport campaign, a cask easy and quick to decontaminate was required. Several solutions were envisaged and tested. Finally a micro-balling was performed on the external surface of the TN™9/4. This was the best solution to obtain a thermally suitable surface easy to decontaminate, which reduces also the operator dose rates.

Licensing: Expeditious Reaction

The first TN™9/4 B(U)F license obtained in France in May 2002 was specifying TN™9/4 filling with helium for transport either empty or filled with spent fuels. In order to have more flexibility, ZWILAG needed nitrogen filling possibility in addition to helium. So an extension of the license was asked to the French competent authorities on April 24th 2003 in order to allow a transport with nitrogen with a limitation of the thermal power to 2,8 KW. The TN™9/4 licence prorogation was issued on May 7th 2003.

Work Organisation: Comprehensive Preparation

Being able to respect the planning was also a challenge. In order to ensure that timing for each operation was correctly evaluated and that all the tools were correctly set, several cold trials with TN™9/4 were organised in Mühleberg as well as in ZWILAG.

CONCLUSION

The TN™9/4, a 40 tons, shuttle transport cask, is a well proven customised solution, allowing high capacity storage cask loading at other locations than the NPP. COGEMA LOGISTICS has applied innovative, reliable and proactive solutions to meet its customer needs and requirements.

After twenty transports, the TN™9/4 design has proved its reliability and its ease of use. In the future about two TN™9/4 campaigns are scheduled to be organised every three years.

Following the TN™24BH loading, COGEMA LOGISTICS was asked by BKW to manufacture 5 additional TN™24BH and in the same time NOK, as Leibstadt Swiss NPP operator, awarded a new contract to COGEMA LOGISTICS to manufacture 6 TN™24BH.