Proceedings of the 19th International Symposium on the
Packaging and Transportation of Radioactive Materials
PATRAM 2019
August 4-9, 2019, New Orleans, USA

Paper No.19-A-1117-PATRAM

Case Study for the Coordination of Multiple Transports of Irradiated Fuel from Finland to Sweden and Belgium as well as Final Disposal Following Post-Irradiation Examination

Author
Arnaud Cazalet
Studsvik Nuclear AB
SE-61182 Nyköping
SWEDEN

Abstract

Studsvik has sent three shipments of irradiated fuel on behalf of its customers (TVO, POSIVA, FORTUM): two shipments from Finnish power reactors to the Studsvik Hotcell laboratories in Sweden and thereafter a third containing fuel samples prepared at Studsvik to the SCK-CEN Hotcell Laboratories in Belgium for post-irradiation examinations. The fuel – BWR UO2 rods from Olkiluoto 1 – and – VVER UO2 rods from Loviisa 1/2 – were transported with the NCS-45 Type-B(U)F owned by Studsvik from each plant to Studsvik in two separate transports in 2017 and 2018. Part of the Olkiluoto fuel rods were cut into samples at Studsvik and reconditioned to be accommodated into the Transnubel TNB-170 Type-B(U) transport cask for further transport to SCK. This transnational operation required a cold trial for handling the NCS 45 at Olkiluoto and Loviisa before fuel loading, and a technical walk-through for using the TNB-170 in the Studsvik HCL as it was their first use in those facilities. In addition to this technical challenge, Studsvik, in partnership with consigner, consignee, and carriers, coordinated the various applications for transport, safeguards, physical protection and material final disposal approvals, as well as cask validation when necessary. A primary challenge when moving irradiated fuel from one country to another is waste management after examinations and tests. Studsvik has obtained a final disposal permit for a yearly maximum quantity of imported foreign fuel and material which can be disposed of in Sweden provided that the material is imported for research purposes and minimized as much as possible to suffice for the tests to be performed. Waste management of the fuel samples transported from Studsvik to SCK also needed to be specified in the transport permits applied for by Studsvik to the Swedish authority. Import approval was granted by the Belgian authority to SCK to dispose of the fuel residues after tests as the latter were destructive and the quantity of the former, small. The fuel residues after tests at Studsvik have been approved to be transported to the Swedish interim facility storage for irradiated fuel (Clab), ready for final disposal.

1 – Introduction

Studsvik Nuclear AB (hereafter referred to as “SNAB”) is offering transport & packaging, post-irradiation examination (PIE) and disposal waste management services for any foreign irradiated fuel transported to Studsvik for research purpose. All three issues need to be considered already before starting with project management kick-off. The performance of some specific PIE on the irradiated fuel are the main reasons why customers are contracting with SNAB. However, this cannot happen without a viable transport & packaging solution with SNAB’s own fleet of casks or other hired casks and transport services. But the most sensitive issue is to solving the problem of final disposal of the irradiated fuel residues after PIE at Studsvik, a prerequisite for the regulator to allow import of the material to Sweden without necessary return shipment of the waste to the producer. This is also true when exporting irradiated fuel rods from Sweden to another country for PIE work where the regulators from both the exporting and the importing countries will require an end user statement to the applicant for granting the transport permit.

What is presented below is Studsvik’s specific transport project experience of multiple transports of imported irradiated fuel from Finland to Sweden and re-export to Belgium using two Type-B transport casks for the first time in the loading/unloading nuclear facilities (Loviisa and Olkiluoto NPP, Studsvik and SCK-CEN hotcells), enhancing all logistical, technical, and legal aspects for moving such a material between countries.

2 – The involved stakes

SNAB arranged in 2017 and 2018 two consecutive irradiated fuel transports from Finland to the Studsvik Hotcell facilities in Sweden. The first one was a transport from Olkiluoto NPP of four (4) BWR UO2 fuel rods irradiated in Olkiluoto 1. The second one was a transport from Loviisa NPP of five (5) VVER UO2 fuel rods irradiated at Loviisa 1 and 2. Both shipments were performed with the German licensed NCS 45 transport cask (B(U)F Type).

For these shipments Studsvik faced the following challenges:

- 1st time of NCS 45 cask handling at Olkiluoto NPP with SNAB cask technicians;
- 1st time of NCS 45 cask handling at Loviisa NPP with SNAB cask technicians;
- 1st time NCS 45 cask validation in Finland applied by DAHER, owner of the package certificate for approval.

Following the delivery of the material from Olkiluoto, some of the fuel rods upon arrival at the Studsvik Hotcell, were cut into samples and specially encapsulated to be placed in the Belgian licensed TNB-170 transport cask (B(U) Type) before shipment to the SCK-CEN Hotcell facilities at Mol, Belgium, in order to undergo some destructive tests. For this shipment, the cask design and transport company Transnubel (TNB), with Studsvik support, faced the following challenges:

- 1st time TNB 170 licensing as a Type B(U) in Belgium, since it was originally a Type A cask;
- 1st time of TNB 170 cask handling at the Studsvik HCL with TNB cask technician;
- 1st time export application including waste disposal after fuel tests in Belgium.

Finally, the fuel residues produced at the Studsvik HCL after performed PIE tests of the full-length Finish fuel rods, will have to be specifically conditioned, packaged and transported with the NCS-45 transport cask to the CLAB interim spent fuel storage facility located at Oskarshamn, Sweden. To achieve this, some technical challenges needed to be addressed:

- Meet the acceptance criteria at CLAB concerning fuel residue conditioning (encapsulation for transport and storage purposes) and unloading;
- Use of new inner containers adapted to the smaller diameter of the NCS 45 cask compared to the historically-used 29-ton cask no longer licensed for transport;
- Planned modification in the NCS-45 certificate (due to the Finnish fuel) with new inner component to be accommodated by CLAB;
- Successful cold trial for handling and discharging the NCS 45 at CLAB facility before fuel transport.

Some transports of Swedish spent fuel residues from Studsvik to CLAB are already planned for 2019, though for the Finnish spent fuel it is not planned before several years since the PIE work is not completed.

3 – The Finnish spent fuel

The reasons for shipping the Finnish spent fuel rods to a Hot cell lab like SNAB are manifold:

- Cut the full length spent fuel rods at Studsvik since there is no hot lab licensed to accommodate and cut spent fuel rods for post-irradiation examinations in Finland;
- Validate previous measurements performed at the power reactor with less precision (e.g. dimensions, oxide thickness, etc.);
- Verify and provide benchmarking data for codes which are used for reactor operation, and which are thereby safety-related information;
- Verify fuel behavior for burnup up to 55 MWd/kgU;
- Provide root failure cause evaluation for PCI-failures (Pellet Cladding Interaction);
- Verify and improve those codes which are used in safety analyses for the ongoing licensing and construction of Onkalo, the Finnish final repository for spent nuclear fuel. Code inputs are expected to include data regarding heat evolution, activity, criticality, etc;
- Use spent fuel data in international programs with research focus on improving safety such as Halden Research Project (HRP) and Studsvik Cladding Integrity Program (SCIP);
- Use SNAB’s license for importing foreign irradiated fuel on research purpose allowing import up to 20 kg of heavy metal per year to be disposed of on Swedish ground which for the customer has for an advantage not to have to pay for a return shipment to the shipping country.

The reasons for shipping part of the Olkiluoto spent fuel to a Hotcell lab like SCK-CEN in Belgium via Studsvik are the following:

- Transport the spent fuel rods to Studsvik first for cutting and start PIE at Studsvik, and in parallel prepare other, similar samples by cutting and conditioning them before shipment to Belgium;
- Perform some specific nuclides analysis to be used in safety analysis for the Finnish final repository for spent nuclear fuel of Onkalo;
- Use two different labs for performing independent analysis and obtain results that could further be secured by comparison method.

4 – Step-by-step planning overview

Managing such an international project with transport cask that were never used before in a loading alternately unloading nuclear facility, applying for cask licensing & validation, transport permits, import/export license, final disposal approval, perform PIE work, arrange fuel residues packaging and transport to final repository, is quite demanding and time-consuming. It is often admitted that the duration of such a project spans between 2 and 4 years.

The main logistical, technical, and administrative steps or milestones could be listed as below:

- Technical site walk-in at the loading/unloading facility to study the reception conditions for the new transport cask and feasibility study;
- Prepare overall planning cask handling cold trial, cask loading, transport to hot lab, PIE work, transport to CLAB;
- Cold trial for handling/lifting the transport cask; loading at NPP, fuel transport to Studsvik/SCK, PIE, re-packing, transport to CLAB;
- Application for European trans-shipment permit, national transport permit, Transport Security Plan, Safeguards application to ESA, Nuclear Liability Insurance before shipment to Studsvik;
- Transfer of Responsibility agreement for the NLI, Transfer of Title agreement, End User Statement to be written and signed between consigner, fuel owner and consignee;
- Assessment to ensure adequacy of fuel data and package certificate content;
- Cask licensing and foreign validation;
- Provide all necessary medical and training certificates for arranging site access to the cask technicians and drivers;
- Transport of a fully serviced NCS 45 transport cask and equipment to the Finnish NPP with suitable transport basket inside the cavity;
- Transport documentation and radiological control on NCS 45 and equipment on departure / arrival;
- Technical assistance for cask handling during loading phase with SNAB technicians;

- Transport of the loaded NCS 45 transport cask and equipment from the Finnish NPP to the Studsvik Hotcell;
- Security escort car services on Finnish and Swedish territories;
- Fuel unloading at the Studsvik Hotcell as per previously approved loading plan;
- PIE work;
- PIE results reports;
- Fuel residues production;
- Fuel residues conditioning before transport to CLAB;
- Contracting with TNB for using new licensed Type B(U) transport flask to ship fuel samples;
- Fabrication of a specifically designed transport basket by TNB to be sent to SNAB before fuel transport date;
- Application for European trans-shipment permit, national transport permit, Safeguards application to ESA, Nuclear Liability Insurance before shipment to SCK-CEN;
- Fuel rods cutting and fuel sample encapsulation before loading into the transport basket;
- Arrange site access to the TNB cask technician and drivers;
- TNB-170 reception at the Studsvik HCL;
- Fuel loading into the TNB-170;
- Transport documentation and radiological control of TNB-170 and equipment on arrival and departure;
- Trucking from Studsvik to SCK-CEN;
- Fuel unloading and transport basket disposal at SCK-CEN;
- Radiological control on TNB-170 and cask, decontamination work of the cask cavity;
- Return shipment to cask storage place;
- PIE work on fuel samples at SCK-CEN;
- PIE results report;
- Fuel residues final disposal.

5 – Casks licensing and validation

Both transport casks that were used in the transport of the Finnish spent fuel were Type B as per below:

- The NCS 45 package certificate is a Type B(U)F certificate, owned by DAHER, and is licensed in Germany (D/4347/B(U)F-96). The cask is currently validated in Sweden, Norway, Finland, and Switzerland allowing the transport of UO_2 and MOX, irradiated PWR and BWR fuel, and of activated material;
- The TNB-170 package certificate, originally a Type A cask, was licensed as a Type B(U) in 2017 (certificate B/101/B(U)-96 owned by TNB) by the Belgian authorities. It allows the transport of small UO_2 fuel samples irradiated in PWR and BWR power reactors.

6 – First handling of new Type B(U) transport cask in nuclear facilities

Any transport cask that should be handled in a nuclear facility must be approved by the operator of the facility by using different methods:

- Study of the cask and equipment and facility interface based on drawings and cask handling instruction; a specific handling procedure for using the cask in the loading/unloading facility may be written by the cask operator and approved by the facility owner, and in some countries also by the nuclear competent authorities;
- Arrange a technical walk-in on the nuclear site (truck access, route) and the loading building (truck entrance hall, cask preparation hall, pond or cell docking area) in order to map the transport flow of the cask and equipment inside the site/facility and identify the sensitive spots and handling operation steps; in that sense even a HAZOP (Hazard & Operability analysis – a risk assessment tool) could be performed to pinpoint all possible risks and plan for mitigation measures;
- Arrange a cold trial of the handling/lifting of the transport cask and transport basket with a particular focus on the interface device between transport cask and crane hook (lifting beam or soft lashes attached to the cask trunnions), between the basket handle and the crane hook in case the basket needs to be removed out of the cask cavity for loading the fuel rods. The depth of the pool will have also an impact on the arm lashes size to be used. Equally, the electrical supply connection, service air, provision of helium gas, deionized water, access to under water CCTV cam and other handling standard tools will need to be checked.

7 – Transport permits

There are basically four permits to be applied for depending if it concerns a shipment between EC member states or between an EC country and a third country:

- National transport permits to be applied to (Finland, Sweden, Denmark, Germany, Belgium);
- Trans-shipment permits as per the EC directive 2006/117/Euratom;
- Transport Security Plan to be approved by the Finnish regulator and the Swedish police authorities;
- Export control permit used for shipment from/to the EC from/to a third country (was not needed for the shipments of the Finnish spent fuel though).

8 – Other legal documents

Before transport departure some important points must be clarified in specific legal documents between consigner and/or fuel owner and consignee:

- Fuel final disposal: an End User Statement to be written by the consignee that shall state the outcome of the fuel after delivery for PIE work as well as the place of disposal;
- Title of the fuel/material: a Transfer of Title document must be written between the fuel owner and the consignee, particularly if the fuel will be disposed of in the consignee's country. This

document shall state the point upon which the title to the fuel/material is transferred during transport to the consignee (for ex: upon truck passage through the exit gate of the consigner's place or through the entrance gate of the consignee's place);

- Nuclear Liability Insurance: a transfer of responsibility agreement for the Nuclear Liability Insurance of the shipment must equally be signed between consigner and consignee so as to clearly identify who and from/to which point the responsibility for the NLI is transferred from consigner to consignee.

9 – Post-irradiation examinations & tests

Basically, the so-called PIE scope of work for imported irradiated fuel is as described below, but is not exhaustive:

- Non-destructive tests (Fuel visual inspection, gamma-scanning, profilometry, BU-evaluation, EC-oxide, puncture test and fission gas analysis);
- Destructive tests (Fuel cutting, microscopy, mechanical testing, hydrogen measurement, fuel dissolution for nuclides analysis).

10 – Waste disposal approvals

The main principle of the European directive 2007/117/Euratom for the shipments between countries of spent fuel and radioactive waste that is applicable is that each country is responsible for the disposal of its produced waste. Any radioactive fuel that is sent to another country for been re-irradiated in a reactor, after irradiation cycles and cooling time, shall be returned to the country of origin. Any spent fuel shipped to a foreign country, even for research purpose, shall be returned to the consigning country.

However, in Sweden there is an exception, as Studsvik has obtained a permit issued by the Swedish regulator (SSM) allowing it to import a limited amount of irradiated fuel (equivalent to 20 kg of heavy metal per year) within the framework of ongoing research activities. Following the conclusion of research PIE activities Studsvik is permitted to dispose of the fuel residues on Swedish ground.

It can also occur that small quantities of spent fuel samples are exempted to be returned to the consigner's country, as it was the case for Studsvik when the Olkiluoto fuel samples were re-forwarded to SCK-CEN lab in Belgium. As a matter of fact, and this was an exceptional case, the fuel samples were to undergo destructive tests where not only the fuel but also the cladding would be dissolved in the acid, which was a prerequisite for analyzing the samples with an ICP-MS (Inductive Coupled Plasma – Mass Spectrometer). Retrieving the fuel and cladding residue in a liquid form would have been technically too complicated and the risk too high to even load alien residue not belonging to the delivered fuel samples, in addition to risks of cross-contamination. Furthermore, there is no existing licensed transport cask on the market that could have shipped back this kind material to SNAB.

11 – Transport to CLAB spent fuel interim storage facility

Studsvik is regularly shipping spent fuel residues to the interim storage spent fuel facility (CLAB), waiting that the final disposal storage facility (SFR) at Forsmark receives authority's approval.
To achieve these transports, the fuel residues must be re-packed in small inner containers approved by the CLAB facility, as detailed in Section 2 above. This nuclear fuel residue was transported with the 29-tons transport cask until 2018, after which time it will be forwarded with the NCS-45 cask.

12 – Lessons learned

Based on the experience of the transport of this Finnish fuel, Studsvik could draw some interesting lessons to be applicable for some future transport projects:

- Always plan for a realistic timeline for treating all transport, cask and disposal issues;
- Anticipate the regulator's questions concerning the open issues stated above;
- Have a good knowledge of the international, European, and national regulation for transport, packaging licensing, and disposal approval in order to dodge administrative entanglement;
- Rent a reliable, approved cask and transport service suppliers.
- Arrange regular both face-to-face and follow-up phone conference meetings with all involved parties of the transport project.