Design, Development and Production of the TNF-XI New Powder Package

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The TNF-XI was jointly developed by COGEMA LOGISTICS of France and Nuclear Fuel Industries, Ltd. (NFI) of Japan. The design and development of this package were started in 2000 and it was first used in 2003.

The package design was based on the COGEMA LOGISTICS TN™UO2 package, which is cylindrical. To optimize the use of space and to facilitate operations, the TNF-XI incorporates four cavities. Each cavity is similar to one TN™U02. The overall shape of the package is approximately a one-meter cube, which allows it to be easily arranged and stacked in a transport container. It has a total weight of nearly 1 metric ton when loaded with 300 kg of uraniferous oxide material. The powder (or pellets) is placed inside NFI pails, and three pails are placed inside each cavity.

The test results and analyses were documented in the French, Japanese, and United States 'Safety Analysis Reports' in order to get approvals in these countries. Additionally, the French license was validated in other countries. The 'Safety Analysis Reports' were prepared by COGEMA LOGISTICS in France, NFI in Japan and PACKAGING TECHNOLOGY, Inc. in the USA.

In order to transform the TNF-XI design into a fleet of 800 packagings, a successful mass production process had to be developed and put into place by COGEMA LOGISTICS and the fabricator MECAGEST. Adopting mass production methods was challenging – not only because of the large quantity of packages, but also because of the rate of production (50 units per month minimum), quality requirements and the need to keep low packaging costs. This resulted in a significant challenge for mass producing the packaging: what was needed was a robust, efficient, and well-organized process. During the development of the manufacturing process, we also worked on shortening the learning curve.

Introduction

Around the beginning of the year 2000, COGEMA LOGISTICS, a subsidiary of COGEMA (AREVA group) and a specialist in the transport of nuclear materials, was contacted by Nuclear Fuel Industries (NFI – Japan) to provide a reliable, easy-to-use and economical U02 powder packaging solution for transport.

The objective of this project (the need for which was further emphasized by the accident at TOKAI (Japan) in 1999 and the adoption of IAEA TS-R-1 into Japanese domestic regulations) was to develop a type AF and Type IF package which could replace an ageing fleet of NT-IX packages and could significantly increase the amount and rate of UO2 powder transported between Europe, the United States of America and Japan.

The design and development of this package was started in 2000, and is based on COGEMA LOGISTICS' knowledge of front-end transports and experience in designing and licensing radioactive material transport packages. It is also based on the TN™UO2 package design, which was developed by COGEMA LOGISTICS at the end of the 1990s for the transport of UO2 powder and pellets.

Description of the TNF-XI

The TNF-XI significantly modifies the TN™UO2 package design resulting in many technical improvements – most notably a large increase in the package's payload capacity. Each TNF-XI package can be loaded with 300 kg of uraniferous oxides material compared to 32.5 kg in one TN™UO2 package.

An additional feature of the TNF-XI package comes from the fact that the diameter of the packaging cavities was modified to permit direct loading of the metallic pails used for handling and storing of the powder in the NFI's fuel fabrication plant. This simplifies operations and eliminates the need for the polyethylene jug.

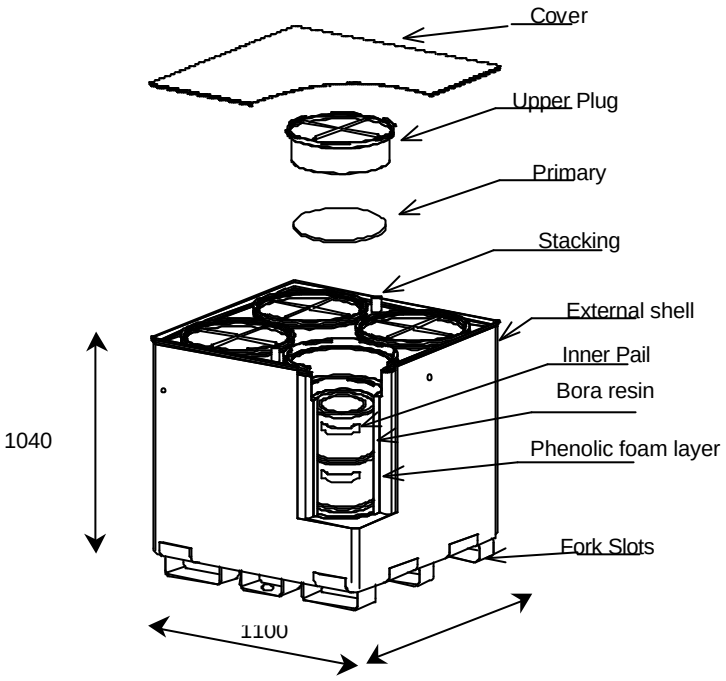
The package consists of 4 cylindrical cavities each capable of carrying 3 inner pails. Each of the four cavities consists of:

- a stainless steel inner cavity,
- a layer of BORA™ resin (for criticality control),
- a phenolic foam layer (for impact absorption and fire protection)

- and an external stainless steel shell.

Each of the four cavities is covered by a primary lid, which is, in turn, protected by an upper plug.

The four primary lids and the upper plugs use a bayonet closure mechanism, which facilitates operation when compared to a traditional closure mechanism using screws.



Drop test at COGEMA LOGISTICS' test facility in Laudun (France)

Content

The content of the TNF-XI package is uranium oxide (UO2, UO3, U3O8…), with enrichment up to 10%, in the form of powder, pellets or scraps. For enrichments between 4% and 5%, a 0.1% step enrichment table was issued to optimize the payload to the material to be transported. Uranium from reprocessing is also allowed up to the limit of the definition of Low Specific Activity material (except in USA and Canada as explained further down).

The structural integrity and thermal resistance of the package were verified by full-scale tests conducted at COGEMA LOGISTICS' test facility in Laudun (France). Thus, the package's design evolved as a result of the development of five test prototypes, and an extensive test program of drop and oven tests. After each series of tests, the successful confinement of the powder was checked and the packages were dismantled to confirm the package's performance.

The criticality safety of the package was demonstrated by computer models using the codes APOLLO-2 / MORET-IV for France and KENO for both Japan and the United States. Assumptions and methodology refer to standards and rules of each country. These differences were taken into account during the testing program, as well as during the design process, so as to comply with the requirements of each competent authority. They explain, in part, why the payload capacity is not exactly the same in France, in Japan or in the US. For example, 300 kg of uraniferous material enriched at 5% can be transported in France and in Japan compared to 239 kg in the US.

The results of these design-by-test and design-by-analysis efforts were documented in the French, Japanese, and United States 'Safety Analysis Reports' for the purpose of requesting licenses in these countries, as well as validation of the French license in other countries.

One design, three approvals

The TNF-XI is licensed in three major countries – Japan – the United States – France.

Due to the specificity of the regulations, standards and requirements of the competent authority of each country, the 'Safety Analysis Reports' and licensing process were managed by NFI, COGEMA LOGISTICS, and PACTEC in Japan, France (and Europe for the validations), and USA respectively. However, close cooperation between the three teams was required, in order to:

1. Take into account the requirements of each competent authority during the design and testing process.

   Given the importance of the criticality control of the package, criticality analyses were performed early in the project by the three teams, using their own computer codes (APOLLO-2 / MORET-IV for France and KENO for both Japan and United States), as well as assumptions and methodology referring to standards and rules approved by the competent authority of each country. This permitted validation of the design, the content definition, the material characteristics (for example of the neutron absorber BORA™ resin), and the testing program performed on full-scale units.

2. Ensure the equivalence of information in documentation.

   The Safety Analysis Report and drawings (design and manufacturing) were initially issued by COGEMA LOGISTICS, and became a starting point for NFI and PACTEC to issue their own documentation (report, drawings...) taking into account the particular regulations of each country. Likewise, all documentation – including manufacturing drawings, specifications and reports – were reviewed by the three teams for compliance with the licensing documentation.

3. Answer the requests of competent authorities during the review process.

   During their review process, the competent authorities of each country issued requests for additional information. To answer them, the three teams worked together through regular meetings and shared knowledge and expertise to respond as quickly as possible.

   One example is that for the Canadian validation of the French license, the criticality analysis from the US SAR was additionally submitted to the Canadian authority to meet their requirements. Thus, the Canadian validation using payloads defined in the US SAR was obtained without additional analysis.

   A second example is that the US competent authority required additional information regarding the qualification of the new Boron resin material used for criticality control. Although the same data was not explicitly required by the French competent authority, the data already existed, as a result of the qualification process. Only a study (and no additional testing) of this data was required.

Nevertheless, adaptations were necessary to comply with the differences remaining between regulations. Two relevant examples are described below.

- Content restriction: reprocessed uranium is generally authorized up to the limit of the definition of Low Specific Activity material. The package is then considered as an Industrial Package Type 2 (IP-2) with fissile material. However, US and Canadian regulations do not authorize fissile material to be transported in Industrial Packages. As a consequence, in these countries, the content is restricted to Uranium meeting the requirements of Enriched Commercial Grade Uranium as defined in ASTM C996-96 standard.
- Labeling: until the US adoption of the IAEA-96 regulations takes effect, the marking and labeling of the package has to comply with the IAEA-85 edition. Specifically, the definition of the Transport Index in the US regulations still combines the radiation level around the package with the criticality measure, whereas IAEA-96 differentiates between the two indices. A practical solution was the use of stickers to adapt packages to the applicable regulations.

TNF-XI labeling

License available in July 2004 :

F / 381 / AF-96 Ab

USA / 9301 / AF-85

J / 2006 / AF-96

GB / 5108 / A-IF-96

Endorsements available in July 2004 :

GB : F381 / AF-96 (2)

Sweden : F381 / AF-96 Ab

Canada : CDN / E210 / -96 Rev. 0

US DOT / 0653 / AF-96

Even so, the close and successful collaboration between NFI, COGEMA LOGISTICS and PACTEC led to the approval of the TNF-XI design in Japan, France and the USA in less than 18 months for each country. Validations of the French license were also issued by United Kingdom, Sweden and Canada, and are in progress in Belgium and the Netherlands.

An optimized process of manufacture

To transform the design of the TNF-XI into a fleet of 800 packagings, COGEMA LOGISTICS used two key partners: MECAGEST (member of the AREVA group) located at Valognes near Cherbourg (France) and WEBER located at Rouhling near Strasbourg (France).

The manufacturing of these packagings represented a challenge for COGEMA LOGISTICS, NFI and its partners. In addition to the challenge presented by the number of packages, the following constraints were imposed:

- short development time for the industrialization process: < 6 months
- high rate of production: > 50 packages per month
- compliance with the European, American and Japanese regulatory and quality requirements. All manufacturing processes were qualified and approved by the Japanese side before starting the mass production.
- competitive production costs with respect to the market price for this type of packaging.

The contract for the manufacture of the first 800 TNF-XI packagings began at the beginning of 2002.

It took less than 6 months to industrialize the manufacturing process of the TNF-XI packaging. During this period, it was necessary to set up the production process and to coordinate the major phases, which are:

- The definition of the manufacturing steps.
- The definition and manufacture of the specialized equipment required for the special processes.

Dedicated room for the manufacturing of the Bora™ Resin shells

At MECAGEST, a dedicated facility, staffed by 8 operators in 2 shifts, was built to optimize the manufacturing output and quality of the Bora resin shell. This facility is air-conditioned. The air is renewed as necessary to facilitate the various processes. The facility is also equipped with several workstations allowing :

- The weighing of the components used in the Bora™ resin composition.
- The mixing and the pouring of the components into the moulds.
- The polymerization of the resin
- The testing and control of the final products with the aim of satisfying all the requirements of the 'Safety Analysis Reports'

At WEBER, a casting machine was developed to automate the casting of phenolic foam inside the TNF-XI packaging. Two large heated facilities were built to handle up to 15 packagings at the same time.

- The production of the prototypes – the purpose being to verify the manufacturing process and to optimize both the manufacturing operations and the quality of the manufacturing.
- The establishment of qualification reports for the welding processes and other special processes (such as the manufacturing of Bora™ resin shells and phenolic foam components) and the submission of these reports to the Safety Authorities.

The first batch of 60 packages was delivered in August 2002 according to the contractual schedule and subsequent batches were delivered to our customer with an average of 50 packagings per month.

During the two years that were necessary for the manufacture of the first 800 TNF-XI packagings, COGEMA LOGISTICS and its partners have continued to optimize the manufacturing processes to improve the quality of the manufacturing and reduce costs.

On several occasions, NFI positively assessed the quality of packages, and all of the 800 packagings were accepted and approved by the Japanese competent authority.

Conclusion

The first transport using the TNF-XI packaging was done at the beginning of 2003 between Europe and Japan. The transport experience for 2003, including the transportation of reprocessed uranium (RU), represented more than 90 tons of uraniferous oxide material and more than 400 TNF-XI transported in 12 transports.

The 800 TNF-XI packagings were delivered to NFI at the beginning of this year, 2004 and the TNF-XI's fleet should about one thousand packagings by the beginning of 2005.

These 2 accomplishments validate the project's success, thus illustrating COGEMA LOGISTICS' abilities to:

- Develop a new package and obtain the desired certificates of approval in a very short period of time. The development started at the end of 2000 and the 2 first certificates of approval (French and Japan) were obtained in less than 1.5 years.
- Produce high quality, competitively priced 'mass produced' packages.

References :

- International Patent application WO 03/030183 ("BORA" resine for TNFXI packaging)