Enusa signs contracts for the supply of nuclear fuel and associated services for Doel 4 and Tihange 3 NPPs in Belgium during the period 2016-2021

Enusa has been awarded contracts for the supply of nuclear fuel and associated services for Doel 4 and Tihange 3 Nuclear Power Plants in Belgium for the period 2016-2021, covering the delivery of four lots of nuclear fuel and two optional lots for each unit. The contract signature took place in July 2014 and was the result of a tender process initiated in April 2013 followed by the submittal of the Enusa offer in July 2013 and which, after several months of interaction with Electrabel and Tractebel Engineering have successfully concluded with the final award. The volume of nuclear fuel to be provided to both units will be equivalent to 240 tons of Uranium.

These new contracts will be executed by Enusa in the framework of the EFG (European Fuel Group), joint venture of Enusa with Westinghouse, created in 1991 for the cooperation in the marketing, design, engineering, sales and servicing of PWR fuel in the European market.

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Enusa will supply 17x17 RFA-2 Opt XLR fuel design which is identical to the 17x17 RFA-2 XLR currently supplied to Doel 4 and Tihange 3 except for the Optimized ZIRLO™ cladding material and the zirconium dioxide protective coating on fuel rods.

Eight fuel assemblies with Optimized ZIRLO fuel rods have operated in Tihange 3 NPP during the last three cycles and the characterization of the corrosion behavior has allowed to confirm the significant improvement in resistance of the Optimized ZIRLO™ cladding as compared to the Standard ZIRLO®.

The oxide coating on the lower part of the fuel rod provides an additional protection against debris and grid-to-rod fretting by the increase of the surface hardness, and thus the wear resistance, of the ZrO2 layer.

The robust fuel, RFA-2 and its precursor RFA, have extensive operating experience in Europe and USA including 14 ft. reactors that have similar characteristics to those of Doel 4. Optimized ZIRLO cladding continues to gain experience since its first introduction in LTA programs in 2002, with a wide irradiation experience involving discharge fuel rod burnups beyond 72,000 MWd/tU. The oxide coating was introduced in the mid-1990s and is currently used by almost all Westinghouse customers in US.
This award is the proof of confidence that Electrabel and Tractebel Engineering have put on Enusa/EFG again. The relationship among these companies started back in 1993 with the signature of the first contract for the fuel supply to Doel 4 for the lots 12D4-14D4. Later on, in 1996, Enusa signed with Electrabel/Tractebel the second contract for the supply of the lots 15D4-20D4. In 1998, under this new contract, Enusa reached the first 100 tons of Uranium delivered to this unit. Subsequent extensions allowed Enusa additional supplies of the lots 20D4-25D4.

In 2007 and following a similar tender process as the one already described, Enusa was awarded contracts for fuel supply of the lots 26D4-30D4 as well as, for the first time, lots 21T3-25T3 of Tihange 3. During this prolonged time frame, a total of 1048 fuel assemblies have been supplied to both units, equivalent to 564 tons of Uranium.

For the new contracts awarded, Enusa will produce the nuclear fuel in its manufacturing facility in Juzbado (Salamanca), with fuel assembly components and conversion services provided by Westinghouse in the US and Springfields Fuels Ltd. in UK respectively.

A significant scope of engineering related activities are also envisioned for the time frame of the new contracts including, among others, the justification to support fuel extended operation at reduced power as well as the engineering evaluations that will be required to support the introduction of the new regulatory rules for LOCA and RIA.

In the on-site services area Enusa, in collaboration with its partner Westinghouse, will continue to support Electrabel and Tractebel in the close follow up of the fuel behavior in order to ensure a reliable operation.

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Fuel inspection technology for the Chinese market

After a long negotiation process Enusa, in cooperation with its partner TECNATOM, and the Suzhou Nuclear Power Research Institute (SNPI) a subsidiary of the China General Nuclear group (CGN) conglomerate, have reached an agreement for the supply to the Chinese company of a SICOM-UT equipment for the detection of leaking fuel rods in irradiated fuel assemblies.

This is the first contract awarded to Enusa by the CGN group. Starting with this agreement SNPI and Enusa intend to intensify their collaboration in the frame of irradiated fuel inspection systems and equipment so that the SICOM technology become the main reference in fuel inspection in the country housing the most ambitious nuclear development plan worldwide.
The SICOM-UT equipment is a joint Enusa-TECNATOM development and therefore is a technology fully developed in Spain. The first SICOM-UT became operational in 2013 and it is currently operated by Enusa and TECNATOM in different Spanish nuclear power plants. The equipment uses ultrasonic technology for the identification of leaking fuel rods in the fuel assembly by means of the detection of water inside the fuel rod. Once the leaking rod is detected it is possible to replace it by using fuel repair tooling so that the fuel assembly resumed operation without leaks.

**Official signature ceremony**

The official signature of the supply contract took place on September 25 at the Great Hall of the People in Beijing, in the frame of a State visit of the Spanish Prime Minister, Mariano Rajoy to China. The President of the China General Nuclear Group, Mr. He Yu and the Enusa Chairman and CEO, Mr. José Luis González signed the contract on behalf of their respective companies. Mr. Rajoy and the Prime Minister of China, Mr. Li Keqiang witnessed the ceremony.

Contract signature ceremony in Beijing

Mr. He Yu, CGN President and Mr. Gonzalez, Enusa Chairman

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Enusa activities in Nuclear Power Plants during outages

For more than 10 years, nuclear power plants of Almaraz, Vandellós and Asco have relied on Enusa for the execution of fuel assemblies handling, inspection and repair operations during outages. Fuel Services are considered by the customers as part of the fuel management and an appropriate complement to the manufacturing and engineering activities.

There are numerous activities that are executed and some of them are programmed in critical path, which requires an excellent planning and coordination to achieve the results required by the Nuclear Power plant management.

The main activities performed during the outages are:

- Availability, transport and reception of fuel inspection and repair equipment.
- Preparation and verification of cranes, handling tools and other fuel equipment.
- Fresh fuel delivery, handling and receiving inspection.

Transferring from the new fuel storage area to the Spent Fuel Pool (SFP):

- Unlatching control rod drive shafts.
- Installation of lighting systems in refuelling cavity.
- Sipping inspection of the fuel on-line during core off-loading. This inspection is performed when the chemistry data are indicating the presence of leaking fuel at the end of the cycle. After the core off-load, and in the Spent Fuel Pool (SFP), the fuel identified by the sipping equipment is inspected by UT to identify the specific leaked fuel rod.
- Core off-loading, transferring 157 fuel assemblies from reactor core to SFP.
- Handling and shuffling of core components in SFP (thimble plugs and control rods).
- Fuel Assemblies Repair, as needed, with RTN or MFRS equipment.
- Ultrasonic Fuel Assemblies Cleaning with HE-UFC equipment.
- Fuel Assemblies visual inspections for integrity verification if required.
- Fuel Assemblies characterization if required: peripheral fuel rod oxide thickness measurements (SICOM-COR), fuel assembly dimensional measurements (SICOM-DIM).
- Fuel Pool mapping to verify the traceability and identification of the fuel to be loaded for the next cycle.
- Foreign material inspection and retrieval, using special tooling like the ART-FOSAR and HD-cameras.
- Core loading, transferring fuel assemblies from SFP to the core vessel (see fig. 1).
- Core Mapping and gap measures between fuel assemblies (see fig. 2) to verify the appropriate position of the fuel and core components.
- Latching control rod drive shafts.

Core unloading and loading are performed in continuous (24 effective working hours per day) and four rotating shifts are implemented during these phases. The four shifts require additional qualified people but it makes possible the breaks for the personnel and permits to increase the capability for any additional activity or contingencies.

Site operations are managed by Enusa-ENWESA AIE, a company formed by Enusa, ENWESA and WTS.

Another important activity performed by Enusa and its partners (UTE Enusa-TECNATOM-WTS), in the ANAV’s Nuclear Power Plants, is the outage coordination tasks through SIR (Integral Reloading Service). This service coordinates all the works inside the containment building, serving of connection between contractors and the different departments that collaborate during the outage, with the purpose of carrying out the several tasks as planned.

The vast and wide experience gained during our trajectory is our most valuable asset and makes us currently have a highly qualified staff representing a guarantee to perform these works with the quality demanded by our customers.

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Implicit knowledge management techniques in operations engineering

The replacement of an expert in mature organisations is not a trivial matter and requires a different approach than followed for training new staff especially when replacing engineers with large expertise. This situation is typical in cases of generational replacement or cases due to a possible restructuring of the organization. Organizations are slowly becoming conscientious of the lack of suitable practices, however there are many initiatives to cope the situation, and learn from the past. Therefore, it is critical to follow a simple but rational process for capturing the know-how and essential information and making it accessible to the rest to the organization.

Tacit knowledge is not included in the classical training plan. This is hidden and intangible wisdom that is not shared by other colleagues, it is rather informal but strategic. This knowledge is acquired through the experience and some circumstances during working life. It belongs to the person and, it is not written in any guidebook, but it represents 90% of the results of the work of the expert. It is necessary to transmit this knowledge before the expert leaves the Company or he changes to another job. It is known that the tacit knowledge is difficult to capture because, some times, the expert is not available to share it, due to lack of time or because these skills are personal. Some times, the receiver neither is willing to accept other’s skills.

The IAEA study (ref A) suggests some “best practices” for capturing these skills including performing interviews of employees and questionnaires, conducting mentoring/coaching by experts or senior personnel, encouraging informal communication and implementing a culture of team working.

These practices are implemented in the day to day work in Enusa, and now, we want to go beyond, maintaining this knowledge ready to be retrieved when needed. If a person is leaving the company, he must compile the following:

- The history of past projects, identifying the circumstances and problem and how they were dealt with.
- The on-going and future ones, as well as all pending actions, relevant events and hot topics. It is important to...
summarize the modus operandi as fundamental guidelines and procedures, provide tips, warnings and best practices. It should include a roadmap of the essential steps to take over the job.

- The key information, guidance materials and reference documents in current use such as books, magazines, standards, web pages, and any useful digital information.
- Finally, it is a great help to indicate the list of relationships, who-is-who in the environment near the workplace including committees, associations, internal and external customers, colleagues from other private and public institutions as well as possible contacts with regulators.

A situation of tacit knowledge transfer is presented in the search of the loading pattern (LP) in the frame of the core design tasks for the fuel reload. Due to the difficulty and uniqueness of this task, the transmittal of both tacit and structured knowledge is critical. The loading pattern design is classified as a large-scale discrete and combinatorial optimization problem. A typical size of the design space amounts to approximately $10^{20}-10^{30}$. Since no automatic method can perform this formidable task throughout all possibilities, this is actually done manually by combining expert judgment with 3D neutronic calculations.

Although the objectives of the optimization problem are firmly defined as in most nuclear design tasks, there is no a straightforward or unique guidance for the definition of the LP. For this reason, the formation of a neophyte designer in this task requires the support of an expert core designer to guide him in his first steps to achieving a LP. During a period of time both of them work together in the LP definition while he neophyte designer observes the process used by the expert core designer. Besides the above mentor method, the following initiatives are being considered to complement and facilitate the learning of the LP definition process: Internal seminars where expert core designers share their experience, loading pattern databases and combination of manual and automatic LP searches.

The training of a neophyte in the loading pattern definition is an example of tacit knowledge transfer in the frame of core design activities for the fuel reload engineering but the experience can be extended to other areas. The training based on a mentor program is currently used but several initiatives are considered interesting to complement the mentor training. All these activities are evaluated from the point of view of the four phases of the Nonaka knowledge transfer model: socialization, externalization, combination, and internalization.

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Proposed methodology for classification of Spent Fuel

Enusa, the Spanish nuclear fuel manufacturer since the 1980s, is the main connoisseur in Spain of LWR nuclear fuel design and performance. Due to our customers’ needs, Enusa has also specialized in spent fuel management offering integrated engineering and on-site services to the Spanish plants. In fact, Enusa currently has the lead in classification of spent fuel for dry storage and transportation projects, such as decommissioning of José Cabrera NPP and all dry storage cask loading campaigns in Ascó I and Ascó II NPPs.

Since the Spanish Centralized Interim Storage Facility (ATC) construction has already begun and the first spent fuel casks are expected to be delivered by 2018, the Spanish nuclear industry is making big efforts in developing a spent fuel management model. In this sense, Enusa, in agreement with ENRESA and the Spanish PWR and BWR utilities, has recently proposed a methodology to classify spent fuel for dry storage and transportation of the spent fuel contained in the Spanish NPPs pools. In the following paragraphs a brief description of the methodology is provided.

The main goal of the proposed methodology is to establish an agile and objective characterization and classification process for the Spanish plants spent fuel, for both PWR and BWR fuel designs, manufactured either in Enusa, Westinghouse or Global Nuclear Fuel (GNF). This methodology comprises all the stages that a particular spent fuel assembly during interim storage will undergo. These stages, expected to last more than a hundred years, cover cask loading, drying process, sometimes dry cask storage at independent spent fuel storage installations at the plants, transportation to the ATC, unloading operations and storage at the ATC until permanent disposal and all necessary handling operations.

The proposed methodology is based on current international regulations. The Spanish regulatory body, the Nuclear Safety Council (CSN), through the safety instruction IS-20, follows the US NRC regulations for storage (10CFR-72) and transportation (10CFR-71). The NRC also edits the Interim Staff Guidance (ISG) in order to clarify or address particular aspects of the regulations. Particularly, the criteria for classifying the spent nuclear fuel for interim storage and transportation are collected in the ISG 1 Rev. 2, which defines damaged spent nuclear fuel as any fuel rod or fuel assembly that cannot fulfill its fuel-specific or system-related safety functions: Confinement, Radiation Shielding, Sub-Criticality.
Control, Temperature Control and Retrievability. This definition, even though it establishes the classification criteria, it is a general definition and does not define specific fuel assembly defects.

The development of the spent fuel classification methodology started with a wide research of all the known fuel assembly potential defects. Taking into account the damaged spent fuel definition given in IGS-1 Rev. 2, each possible defect was evaluated to determine whether it actually affected the spent fuel or system-related safety functions for dry storage and transportation. Thus, this first analysis concluded in a list of particular defects affecting the fuel classification.

In the second part of the analysis, all fuel assembly characteristics that can affect the classification are identified in order to know whether it has one of the previously defined defects. Some of these characteristics could be operation parameters, geometric dimensions, chemical data; which may be compiled from historic records. However, there are characteristics as the potential presence of leaking fuel rods or damage in structural components, that leads to an inspection of the fuel before dry cask loading. In these cases, justification for the need of inspections and the more appropriated inspection technique is provided. Once the characteristics are evaluated, the fuel can be classified into Damaged or Undamaged.

Additionally, in some cases, the damaged fuel assemblies may be conditioned in order to finally classify them as Undamaged.

For example, if a leaked fuel rod is detected along the process, the fuel assembly could be classified as Damaged for storage and transport. However, the fuel assembly may be conditioned by replacing the leaking rod by a reconstitution rod, changing the fuel assembly classification to Undamaged. The better conditioning solution for every defect is proposed, if any.

The process to characterize and classify a fuel assembly into damaged or not damaged, is collected in flux diagrams (one per defect). The proposed flux diagrams include all characteristics, inspections analysis and fuel assembly-conditioning options if applicable as well.

In summary, ENUSA has developed, in agreement with ENRESA and the Spanish Utilities, a proposal for methodology to classify fuel assemblies for dry storage and transportation. The methodology translates the general damaged spent fuel assembly definition provided in ISG-1 Rev.2 into a unique, systematic, agile and objective characterization and classification process for the Spanish PWR and BWR plants.

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NEWS BRIEFS

From September 14th to 17th the Water Reactor Fuel Performance Meeting took place in Sendai (Japan). This conference is sponsored by the Atomic Energy Society of Japan, the Korean Nuclear Society, Chinese Nuclear Society, European Nuclear Society and American Nuclear Society in cooperation with IAEA. A total of 224 participants from many different countries have attended this key conference on nuclear fuel.

Enusa has contributed to this conference by authoring or co-authoring a total of four technical papers on Spent Fuel, Fuel Behavior under LOCA and Pellet-Clad-Interaction. Cristina Muñoz-Reja and Manuel Quecedo attended the conference, presented two papers and chaired a plenary session.

The next conference, the TopFUEL Reactor Fuel Performance, will take place in Zurich, 13-17th September 2015 (http://www.euronuclear.org/events/topfuel/topfuel2015/index.htm). Enusa is already actively participating as member of the Programme Committee.

Enusa with its partner Westinghouse, have performed the blank test needed to prepare the delivery and reception of the nuclear fuel in Trillo NPP. During this campaign the equipment, tooling and other devices have been tested on-site using a dummy fuel assembly. CNAT personnel has been actively involved during these activities, supervising the performance. As a result, Enusa and its partners demonstrated the capability to carry out these activities. In addition, the blank test revealed the need of implementing some adjustments and improvements before the actual nuclear fuel assemblies shipment.

This test was conducted as part of the EFG (Enusa and Westinghouse) project to supply, in 2016, eight LTAs to qualify the operation of EFG nuclear fuel for the Trillo reactor.

Enusa has participated in the 40 Annual Meeting of the Spanish Nuclear Society, held in Valencia from October 1st to 3rd. In this Conference, around 600 people coming from all companies involved in the nuclear energy sector in Spain have attended. Enusa has contributed with 22 attendants.
In addition, the company was also present in the commercial exhibit organized during the meeting with an Enusa Group corporate stand. In total, 24 nuclear companies have shown their latest information in the Commercial exhibition.

This year, the Spanish Nuclear Society commemorated the 40th anniversary of the Conference. Due to this, a special Plenary Session discussed about the history of the conference and how to approach the future. There were two more plenary sessions: The “Chinese Nuclear Program”, with almost 20 new reactors under construction, and the “Energy Storage Technology”.

A total of 33 parallel technical sessions have been prepared this year. Enusa has been present with eight papers discussing about different technical topics, as new design codes or fuel design optimization.

In the frame of the activities of Enusa aimed to enhance the safety of its operations and to promote international collaboration, Enusa has attended the annual meeting of the Working Group on Fuel Cycle Safety of the Nuclear Energy Agency (NEA) held in Vienna. Issues of special interest in the mandate of this group include those related with fuel fabrication facilities and spent fuel management.

The current activities of the group also include the organization of a workshop on Operational and Regulatory Aspects of Criticality Safety in fuel cycle installations. Enusa is involved in the technical organization of the workshop, and will contribute several papers to the technical program.

Tecnatom and Enusa partnering continues its development. At the beginning of October, three new Agreement have been signed: The cooperation to develop the new passive scanner with regulated speed; the cooperation for the irradiated fuel sipping inspection; and the cooperation to develop manufacturing inspection equipments for Juzbado plant implementation as well as for marketing to other fuel manufacturers. The General Manager of Tecnatom, Javier Guerra, the Chairman and CEO of Enusa, Jose Luis González and the Business and Technology Development Director, Roberto González signed these Agreements on October 2nd 2014.
Enusa belongs to Grupo SEPI, a corporate holding which includes a total of 16 state-owned companies in which it has direct, majority shareholding participations, with a workforce of more than 75,000 professionals; it also includes the Spanish state-owned television and radio corporation, Corporación Radiotelevisión Española, which is attached to SEPI, and one public foundation. Equally, SEPI has direct minority shareholdings in a further nine companies, and indirect shareholdings in more than one hundred companies.