



ATF Programme – Spain

INTRODUCTION AND BACKGROUND

The CEIDEN Technology Platform (PT CEIDEN) established in 2017 the development of ATF fuel as one of the three "Priority Technological Initiatives" of the nuclear sector within the framework of the ALINNE alliance (Alianza por la Investigación y la Innovación Energéticas) promoted by the Administration to help establish the Spanish R&D+i policy in the field of energy generation.

In 2019, PT CEIDEN organized a workshop on ATF fuel that brought together a total of 26 Spanish entities and allowed the identification of the Spanish capabilities with significant potential to contribute to the development of this type of fuel.

Among the conclusions of the workshop, the following stand out:

- The development of ATF fuels that provide more time for the emergency systems to regain control of the installation is one of the main medium-term actions that the nuclear industry has undertaken

- At an international level there is a firm commitment to accelerate this development and it is expected that, in less than a decade, commercial solutions can be applied thanks to the support and guidance provided by international institutions such as the NEA (Nuclear Energy Agency) of the OECD or the IAEA (**International Atomic Energy Agency**) as well as by national programs, for example, the one promoted by the US Department of Energy.
- The active participation of the Spanish nuclear industry in the field of ATF fuel is technologically possible, since it has capabilities to develop and validate important parts of the processes involved, with the experience in demonstration programs for innovations in the fuel, own regulation and also has solid technological and institutional relationships with international equivalent entities that are currently leading the push for ATF fuel. However, the current (2023) time frame established for the possible closure of Spanish NPPs conditions the real opportunity for the commercial introduction of ATF fuel in Spain.
- Despite the reality cited in the previous paragraph, the PT CEIDEN plays a role as facilitator and channeler of information of interest, of the search for financing and the conclusion of agreements to carry out specific R&D projects. These last will allow both the creation of national programs for the implementation of ATFs in the Spanish NPPs, in case of modification of the current situation, such as the overall positioning of the Spanish nuclear sector in the international arena, favoring its visibility and ensuring the maintenance of Spain's capabilities

For all these reasons, the PT CEIDEN Management Council (Consejo Gestor) of July 2021 agrees to create a CEIDEN Programme on new ATF fuel to explore opportunities and promote projects related to the development and implementation of ATFs.

GROUP OBJECTIVE AND COLLABORATIVE FRAMEWORK

The main objective of this group is to promote the participation of the Spanish nuclear sector in research, development, industrialization, manufacturing, supply, operation or inspection of ATFs, as well as in all types of associated or derived services.

To this end, collaborative research programs must emerge from this working group between any of the entities that make up the group originating from:

- a. Activities promoted in any European collaboration framework.
- b. R&D activities corresponding to specific proposals from members.
- c. R&D activities to be identified within the group itself as a consequence of the reflection process.

Due to the wide catalog of ATF solutions in development, the Programme has focused its actions on preferably evolutionary ATF solutions based on current fuels (chrome plated tubes or Fe-Cr-Al type alloys for the cladding and uranium

dioxide pellets with additives) that can be marketed in the short term. From the organizational point of view, the programme is articulated through the creation of a Working Table coordinated by the Technical Secretariat of the Program, held by ENUSA. The working table is governed by operating rules included in the so-called “*Collaboration protocol in the CEIDEN programme on ATF fuel*”. The different entities of the PT CEIDEN who have joined or wish to join as Programme Participants do so formally by signing a Declaration of Adherence that is annexed to the Protocol.

ADHERED ENTITIES AND REPRESENTATIVES

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COLLABORATIVE PROGRAMS

Several of the entities participating in the CEIDEN programme on ATF fuel are developing their research within the international framework of the IAEA. Specifically, in the **Coordinated Research Project (CRP) 'Testing and Simulation for Advanced Technology and Accident Tolerant Fuels (ATF-TS)'**, in which CIEMAT and the Polytechnic University of Madrid (UPM) participate, the latter bringing together the work of the Center for Research in Structural Materials at the UPM, at the UPM School of Mining and Energy Engineering (SMEE), from the Polytechnic University of Catalonia (UPC) and from NFQ Advisory Services (NFQ). The research areas of these Spanish entities include Task 1 Experimental Program: RRTs, Task 2: Modelling and Task 3: LOCA Evaluation Methodology.

On the other hand, the CSN subsidizes the following R&D+i projects led by different entities attached to the CEIDEN programme on ATF fuel:

- From the 2021 call:

"Increase in safety margins in LWR plants using accident-tolerant fuel (ATF)", led by the Energy and Fuels Department of the of the UPM SMEE in collaboration with the Polytechnic University of Valencia (UPV).

"Influence of defects on the behavior of Zr-Nb ATF clads with metallic coating (INDECOVA)", led by the Materials Department of the UPM School of Civil Engineering (SCE).

- From the 2022 call:

"Methodologies for analyzing the thermomechanical behavior of accident-resistant fuels (ATFs): development and applications (M(AT)2F)" directed by CIEMAT.

"Analysis of DEC scenarios with core reflooding for chromed ATF fuel: study of the integrity of the control rods (ATF-DEC)" directed by the UPC.

Another cooperation project between the CSN and adhered entities is the “*Development of thermo-mechanical analysis methodologies for AOO and DEC-A scenarios in nuclear reactors of LWR plants with ATF fuel (Metatf)*” led by NFAQ.

There are also two programs proposed by ENUSA (Enusa Industrias Avanzadas S.A) in the CEIDEN framework: “Design and Optimization of the chrome plating process with different thermal spray techniques” and “Quality welding with ATF chromed clads”. These projects could be addressed if any of the program entities decide to participate in their execution.

In the field of dissemination and training, the following collaborations have been carried out between adhered members:

- CIEMAT is currently directing a doctoral thesis with the UPM School of Industrial Engineering (ETSII) on the extension of fuel rod thermo-mechanical computer codes to “near horizon” ATF fuels (FeCrAl, cladding with chromium coating and chromium-doped pellets). Its completion and defense will take place in 2024.
- The UPM and in particular, the SMEE has incorporated specific talks on ATF into its Seminars on Nuclear Fuel Thermo-mechanics program in 2022 and 2023. Specifically, “Introduction to the ATF Concept-Application to a MELCOR Analysis” in 2022 taught by School professors and “ATF Seminar” in 2023, taught by CIEMAT. These are training-dissemination cycles in a collaborative environment between different entities affiliated or not to the CEIDEN programme on ATF fuel.
- Within the *Recycling and Sustainability* subject of the Materials Engineering Degree of the UPM SCE, the Nuclear Fuel Cycle seminar taught by ENUSA was included in the 2021-22 and 2022-23 courses, including ATF fuels.
- The *Journal of Nuclear Engineering and Design* will include the *Special Issue* entitled “*R&D in Advanced Technology Fuels (ATFS) in Spain*” in which all the R&D actions on ATF carried out by the entities adhered to the programme are listed and briefly developed.

Finally, we should mention that the designated representatives from ENUSA and IBERDROLA Generación Nuclear S.A.U. were appointed by **Foro Nuclear** as representatives of the Spanish nuclear industry in the Ad Hoc Group of **nucleareurope** for the rationalization of the ATF requirement in the sustainable taxonomy of the European Union for the generation of energy of nuclear source.