

R&D LMFRs KNOWLEDGE PRESERVATION FRENCH PROJECT

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Abstract

The French Institutions involved in LMFRs development (EDF Utilities, CEA Research Institute and FRAMATOME-ANP Engineering) decided in 2000 year to preserve the R&D knowledge which was raised during the last four decades of the 20th century: the long term availability (some decades) of LMFRs experience should be maintained thanks to an extensive, everlasting and intelligible form which could allow future designers to use this great amount of knowledge. Among different types of architecture, the LMFRs Fund of Knowledge is being raised in 2001 and 2002 along two complementary ways:

- The main one gives an overall vision of R&D work undertaken through 23 R&D items: an overall view of LMFRs conception; 9 items about Core R&D work (Safety, Working, Thermohydraulics, Thermomechanics, Design Rules, Materials, Fuel clad failure, Neutronics, Nuclear fuel; 13 items about Reactor R&D work (Safety, Working, Sodium Coolant, Sodium Technology, Thermohydraulics, cover gas Aerotics, Thermomechanics, Design Rules, in sodium equipment Mechanics, Materials, In Service Inspection and Repair, Sodium Fires, Decommissioning).
- The other one deals with the Design of what can be a LMFR: Superphénix Plant was chosen as the largest and validated industrial size LMFR through the conception of its 41 systems (Core system, Monitoring systems, Protective and Shut-down systems, Primary systems, Secondary and Steam Generator Systems, Decay Heat Removal system, Primary and secondary Handling systems, Cleaning and Decontamination systems, Fuel Storage system).

Each R&D item and each Superphénix system is described with a Documentary Form, written by French specialist: after a brief description of the different sub-items (some pages), the list of relevant references are listed (some dozens to some hundreds of synthesis reports, basic literature, specialist interviews, Superphénix measurement data, EFR Project synthesis...). Thus, the LMFRs Fund of Knowledge is made of the 64 Documentary Forms and of all the relevant bibliography (more than 10 000 documents). It is made of paper documents and of computerised CD-ROMs. Bibliographic research can be made easily thanks to computerised organisation. The Fund is recorded under safe conditions by the CEA Record Office. Of course, accessibility and up dating are strictly limited.

1. INTRODUCTION

After four decades of R&D work, and also of design, construction, operation and decommissioning of prototype LMFRs (Rapsodie, Phénix and Superphénix1 reactors, Superphénix2, 1500Project and EFR projects), the absence of French and European future project highlighted the risk of loss of knowledge in various fields (excepted maybe decommissioning aspects). As R&D work came in the same time to its end, a number of synthesis reports were written and it became obvious that an overall preservation work had to be undertaken.

Thus, the French nuclear partners (CEA Research Institute, EDF electrical Utilities, FRAMATOME-ANP Engineering Compagny) have decided in 1999 to perpetuate this huge amount of knowledge and experience which have been acquired on LMFRs.

The aim is to create an everlasting data base of documentation, with easy access for consulting, in order to help the LMFR designers of the next future (in 2040...): help for understanding the design and technical options which were selected in the 20th century (coolant, pool or loop type, fuel...), so that they will be able to make properly their own choice and face their R&D need.

In that way, only consistent documents have to be selected by specialists, to not overcrowd such a base with worthless information.

2. AVAILABLE DATA

The French sodium LMFRs knowledge is based on a large and consistent background: four decades of R&D work (1960-2000), on all the fields of sodium nuclear plants: neutronics, safety, thermalhydraulics, mechanics, sodium technology... A huge database lies in test results, modelling effort and licensing documents. A number of specific databases exists in different services of the CEA and can be extensively used for the preservation project.

For one decade, the ACCORE system has been specified by the CEA in order to preserve and provide easy access to the experience gathered during nuclear studies (principally for LMFRs but also for PWRs): the ACCORE team deals with the management of technical documentation, identify experience underlying to existent documents, find out non-written experience through specialist interviews and, last but not least, provide an interactive access to knowledge for every CEA agent. Of course, this system is of a great help for the Documentary Fund project.

The industrial feedback of existing LMFRs is also of great interest because it gives a high level of qualification to R&D work and to design options, thanks to operating conditions. Rapsodie first prototype allowed feasibility tests from 1967 to 1981, Phénix NPP is still running until 1974 and Superphénix1 NPP was the largest worldwide LMFR between 1985 and 1998.

After two intermediate steps (Superphénix2 and 1500 Project), the EFR project allowed to finalize in the 90s a full detailed European LMFR design.

Due to the French cooperation between CEA, EDF and FRAMATOME-ANP LMFR specialists, the large range of R&D knowledge could be faced: a lot of specialists were still involved in the powerful Superphénix Plant and/or EFR Project in the end of the 90s.

In the same time, the international cooperation was strong enough to also enlarge the French specialist view and let them embrace all the variety of design and technical options (principally: DFR and PFR British Plants; BOR60, BN350 and BN600 Soviet Plants, Joyo and Monju Japanese Reactors).

3. BUILDING AN EVERLASTING DOCUMENTARY FUND

As soon it was decided to preserve the LMFRs knowledge, the specifications of the project were raised: type of architecture (see hereafter), type and number of selected documents, LMFRs specialist work, access and up to dating of the Fund, confidence of the information...

It was decided that the CEA specialists should work for R&D items dealing with the core and that the FRAMATOME-ANP specialists should work for R&D items dealing with the NPP and for Superphénix conception files.

According to a specific Quality Insurance Form, each specialist selected the consistent documents that he could find in his own literature fund and also through ACCORE system. He wrote a documentary sheet (see Section 5: a brief synthesis where sub-items and associated selected documents are listed. When it was considered that a strong synthesis was not available, the specialist wrote it.

About 20 CEA specialists, 10 FRAMATOME-ANP specialists and 6 EDF specialists were involved in writing and reviewing work.

After writing documentary sheets and, when necessary, synthesis documents, reviewing was performed by other specialists. The project team finally homogenized the documentary sheets and collected the documents.

The Fund will be made of about 15 000 paper documents (1 500 000 pages), of corresponding microfilms and files on CD-ROMs (both HTML and PDF type). When CD-ROM format will become unavailable, the data will be transferred on another support.

The Project team looked for all the selected documents then scanned them in order to obtain files and microfilms. Easy research will be possible through the Fund, using CD-ROMs, with exhaustive table of all the document characteristics (title, author, date of issue, place within the fund, key words). Active links exist within the data processing Fund: this modern approach avoids to deal with heavy catalogue of dispersed items (a former 'classical' LMFRs data base included about 250 items!).

The CEA Archive service will have the Fund in hand (papers, microfilms and CD-ROM) and keep it for the next decades in classical safe conditions, in order to assume the integrity of the Fund. EDF and FRAMATOME-ANP will have only the easy reproducing CD-ROM base.

Commercial to confidence is considered thanks to existing French LMFR Knowledge Procedure. Future addenda will be possible (mainly for dismantling item and for Phénix end of life phase).

The project took place from mid 2000 (specifications) to mid 2002 (fund available).

4. THE FUND ARCHITECTURE

Among different types of architecture, it was decided to simplify the Fund by sharing it in only two categories:

- R&D items that can be either scientific fields (neutronics, mechanics...) or polyvalent field (safety, design...);
- Conception files of Superphénix Plant (including R&D supporting work), considered as a large (industrial size) and qualified LMFR.

It is a simple way to preserve the great variety of knowledge (no huge subject catalogue) and, thanks to active links within the soft base (information processing), it will be possible to find any specific information which deals with any particular subject: for example, mechanical behaviour of core materials will lie in different R&D items (mechanics, safety) and Superphénix systems (core).

Of course, when looking after this information, the designer of the future will find a lot of documents and will have to organize, to select and to range them; but we think this is an important part of his job in order to an LMFR specialist of the future...

Among the selected documentation, some documents can be mentioned for their major interest: the Superphénix Plant Safety Report, the licensing documents (SYFRA system), the codes (only their documentation will be preserved: presentation, qualification, utilization, computer description), the RCC-MR rules (2000 version), LIMET'88 proceedings, ARCOPAC data base (Superphénix Plant measurement files) and EFR synthesis reports.

The overall architecture of the LMFRs Documentary Fund is finally:

- Overall view of the Fund;
- 21 R&D items:
 - 1) R&D items about the core:
 - Safety;
 - Thermalhydraulics;
 - Thermomechanics;
 - Codes and rules;
 - Materials;
 - Fuel clad failure;
 - Neutronics;
 - Fuel;
 - 2) 13 R&D items about NPP:
 - Safety;
 - Operational experience;
 - Sodium coolant;
 - Thermalhydraulics;
 - Cover gas aerualics;
 - Thermomechanics;
 - Codes and rules;
 - Materials;
 - In sodium equipments;
 - In service inspection and repair;
 - Sodium fires;
 - Dismantling;
- Superphénix conception systems: 9 main systems (41 systems):
 - 1) Core;
 - 2) Plant monitoring;
 - 3) Primary loop;
 - 4) Secondary loop;
 - 5) Handling;
 - 6) Steam generators;
 - 7) Cleaning and decontamination;
 - 8) Fuel storage;
 - 9) Decay heat removal.

5. DOCUMENTARY SHEETS

The LMFRs Documentary Fund is based on the 63 above-mentioned items: each item is described within a Documentary Sheet.

Each Documentary Sheet includes:

- A brief presentation of the R&D item (or of the Superphénix system): objectives, processes, successive evolutions,...;
- A list of all the sub-items and connected items;
- The knowledge assessment for each sub-item;
- The possible future prospects (ideas for future R&D...);
- The bibliographical list (title, author, reference, date of issue, Fund index).

Through writing, reviewing and project team final checking phases, one can consider that the state of the art could be reached. Of course, some specialists retired before this Fund was built, but their interviews, the existing documentation and so called 'lower rank' specialist work allowed to reach the goal.

6. CONCLUSION

After four decades of R&D, design and operation with LMFRs, and facing no project, CEA, EDF and FRAMATOME-ANP decided in 2000 year to preserve the LMFRs knowledge.

In the year 2002, this Fund is available: 63 items (overall conception, 21 R&D items and 41 Superphénix system conception files) have been considered. Consistent documentation has been selected (15 000 documents) and saved on paper, microfilm and CD-ROM medium. Easy access, integrity and up dating are available.

Among the risks that could disturb the LMFRs Documentary Fund building, the main one was the specialist missing. Thanks to coordinated efforts of CEA, EDF and FRAMATOME-ANP teams, and to extensive use of ACCORE system data (documentation and interviews), one can consider that the French LMFRs knowledge is properly perpetuated.