Spent Fuel Acceptance for Transport and Reprocessing

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1. Introduction

From several years decades FRANCE has gained a very important experience in numerous parts of the nuclear field.

This experience devoted among others in the last 30 years to the fuel reprocessing makes possible for COGEMA to offer an important range of services.

Presently, with 32 customers in 7 different countries, COGEMA serves 82 reactors to reach approximately 110 reactors in the future.

2. Preliminary

More than 10 years ago, the first COGEMA LWR contracts has made necessary a perfect organisation to ship the fuel from the reactor ponds to La Hague, with practically no accident admissible during all the operations.

This necessity has made compulsory criteria whose content has been established between the different involved partners : COGEMA, customers, transporters, safety authorities.

These documents give an assurance to COGEMA for :

- A good knowledge
  - . of the fuel before irradiation with drawings, technical notes, data.
  - . of the fuel after irradiation with data giving :
    - the nuclear characteristics (irradiation history, specific power, equivalent full power days ...).
    - Uranium and transuranic isotopes weights.
    - fuel rods distribution.

- A good estimation about
  . fuel soundness with the sipping results.
  . cruds deposits.

- A perfect identification and location of the fuel assemblies in the reactor pond before their loading in the flask.

They are treated according to the quality assurance principles with audits of the QA organization to make sure the good following of the procedures so that their improvements if necessary.

By the way, a continuous knowledge is obtained which allow the best estimation to keep the manipulation and the main fuel parameters inside the safe working range of the equipements or operations going from the transport cask loading at the reactor to the fuel assemblies reprocessing.

These fuel parameters are involved in the different facilities in the following way :

- Decay heat : casks transport and unloading facilities limits.

- Irradiation : same as above.

- Criticality : same as above plus storage pond and head end limits.

- Handling : safe manipulations from the flask loading up to the shearing.

- Fuel rods distribution : shearing.

- Fuel soundness : pond contamination and surrounding equipment.

- Cruds deposit : flask cleaning and UNH filtration.

In fact, the main question was to adapt the technology of the equipments to an important variety of situations subject to a wide range of:

. fuel types

. manufacturors

. customers

as summarized in the following tables.

- PWR

Fuel Section	Fuel Array	Manufacturors	Reactors served
197x197	15x15	ASEA-Atom	All EDF reactors 900 and 1300 ie presently
201x201	16x16	FRAGEMA	34 900 MW reactors
214x214	17x17	MHI	9 1300 MW reactors - Philippsburg - Grafenrheinfeld
215x215	18x18	NHI	- Obrigheim - Biblis
230X230		SIEMENS	- Stade
		WESTINGHOUSE	Unterwesser Neckarwestheim Gröhnde Mühlheim Karlich Gundremingen Beznau Goesgen Borselle Tihange Doêl Fukushima OHI Takahama Mihama Ikata

- BWR

Fuel Section	Fuel Array	Manufacturors	Reactors served
140x140	7x7	ASEA-Atom	Philippsburg Brunsbüttel
147x147	8x8	General Electr.	Würgassen Isar
	9 x 9	JNF	Krümmel Mühlberg
		NFI	Leibstadt Fukushima I-II
		SIEMENS	Hamaoka Shimane Tokaï-2 Onagawa

3. Fuel acceptance system

The system based upon checking of the parameters listed in the above paragraph 2, brings a judgement which files the fuel assemblies in 3 categories:

- . fuel accepted as they stand
- . fuel accepted with bottling
- . fuel non accepted.

In this last case, additionnal comments can be done to give the criteria making acceptable the fuel with adequate reparation.

The evaluation is performed with comparison of the results and information of the customer given in documents as shown in the reprocessing contracts and COGEMA fuel criteria for reprocessing listed in various documents hold by each customer.

3.1 Customer fuel information

The following 3 documents are provided to COGEMA:

3.1.1 - COGEMA TRANSPORT AND REPROCESSING:

where is given for each fuel assembly:

- . the identification (number, technical documents)
- . characteristics before irradiation (weight and U_5 enrichment)
- . irradiation history (BOC, EOC, JEPP, specific power)
- . characteristics after irradiation (U and Pu isotopes)
- . Euratom code
- . Remarks.

3.1.2 - FUEL INTEGRITY DEMONSTRATION:

This demonstration is quite important.
Indeed, damaged fuel bring a lot of problems related to contamination whose the most important is the storage pond contamination out of the normal range or at least an increasing of the normal activity of 10^{-4} to 10^{-5} $Ci.m^{-3}$ so that in the worst case an atmospheric contamination above the pond.

Consequently, to prevent such an eventuality, a strict checking of the fuel soundness is requested and performed according to several procedures.

These ones agreed between COGEMA and its customers belong to two main systems:

3.1.2.1 ***With the reactor primary coolant activity:***
during the last irradiation cycle and corresponding shut down.

The I_{131} concentration gives the soundness indication of the fuel:

No leakers with an activity smaller than 10^{-3} $Ci.m^{-3}$ and additionnal release acccumulation during shut down below 0,1 Ci^{-} or comprised between 10^{-3} and 10^{-2} $Ci.m^{-3}$ with a shut down peak smaller than three times the normal steady value

Xe_{133} is also used with similar criteria.

3.1.2.2 ***With sipping demonstration:***

When the reactor primary coolant activity don't fulfill the above criteria, at least one damaged fuel is present in the core and a sipping of each fuel assembly is to be done.

Two main families of technics are used:

3.1.2.2.1 - the in core technique only for BWR reactors due to the shroud which surrounds the fuel assemblies.

3.1.2.2.2 - <u>the sipping box techniques</u>:

with two main categories:

. <u>the wet sipping</u> technique in which are detected Cs_{134} - Cs_{137} and/or I_{131} in a liquid sample.

. <u>the dry sipping</u> technique with detection of Xe_{133} and/or Kr_{85} in a gas sampling.

The judgement is done upon the following criteria:

- <u>for the "in core sipping</u> technique" and the wet sipping box technique:

$$\frac{A1}{Ao} < 2 \quad \text{for sound fuel}$$

$$2 < \frac{A1}{Ao} < 5 \quad \text{for suspect fuel}$$

$$\frac{A1}{Ao} > 5 \quad \text{for leaky fuel}$$

Instead of $\frac{Ao}{A1}$ background value can be used with

$$\overline{A1} = \frac{1}{M} \sum_{1}^{M} A1$$

with M : number of fuel assemblies to be judged
A1 : fission product count per each fuel assembly with elimination of the high leaker fuel values.

- for the dry sipping technique:

$$\frac{A1}{Ao} < 2 \quad \text{for sound fuel}$$

$$\frac{A1}{Ao} > 2 \quad \text{for leaky fuel}$$

with the following alternative:

$$A1 < \overline{A1} + 3\sigma \text{ for sound fuel}$$
$$A1 > A1 + 3\sigma \text{ for leaky fuel}$$

with $$\overline{A1} = \frac{1}{M} \sum_{1}^{M} A1$$

and M, A1 same as for "in core sipping"
σ : sample standard deviation.

3.1.2.3 *Choice of the technique:*

Due to the presence of shrouds, BWR can use all technics, particularly the "in core technic".

PWR can use only the sipping box technic either wet or dry.

3.1.3 - **ADMINISTRATIVE PROCEDURE:**

Two weeks before the flask loading, this document sent to COGEMA confirms the soundness of the fuel assemblies - sipped generally one or several years before - with indication of no abnormality during the pond storage period posterior to the sipping.

If there is abnormality, all detailed information are transmitted to COGEMA in particular the technical reports issued to explain the accident to the safety authorities.

In such an eventuality, a new fuel evaluation is done by COGEMA before flask loading and by the way a new judgement.

3.2 COGEMA fuel criteria:

These criteria hold by each customer are produced in the following documents:

- Technical paragraphs of the reprocessing contracts
- Acceptance criteria of fuel by COGEMA (definition of non damaged fuel) in which are given all sipping methods and values concerning the fuel integrity demonstration
- Provisional acceptance criteria for LWR fuel assemblies used sometimes to confirm the fuel soundness
- Condition of no standard LWR fuel acceptance at La Hague
- Acceptance criteria by COGEMA of the irradiated damaged fuel assemblies.

4. Technical evaluation of the fuel assemblies:

As already explained in the paragraph 3, this evaluation is performed with comparison of the customer fuel information and the COGEMA fuel criteria.

Indeed, a first barrier is raised by the customer who proposes in principle only fuel assemblies acceptable to COGEMA, due to its perfect knowledge of the COGEMA criteria. However, a very strict checking is done by COGEMA to be sure of the good adequacy of the proposed fuel.

This checking performed on each fuel assembly from the customer documents, request a total confidence of the information accuracy. In fact, from the beginning, confidence and reliability were raised as two pillars of the relationship between COGEMA and its partners, with a perfect work performed according to the quality assurance principles approved by the safety authorities and the possibility of audit.

The evaluation is performed on the following parameters :

- Fuel information:
  With checking of the technical parameters. If necessary request of additionnal information.

- Fuel soundness:
  With checking of the ratio values or primary coolant activity. If necessary, request of a confirmation. (Leakers fuel assemblies are shipped with a bottle).

- Cruds deposit:

  Practically, it involves more or less only BWR fuel assemblies.

The evaluation is done from the reactor estimated values coming from calculation and lab results. If necessary, checking is done by COGEMA, visually, with pictures and/or video film.

This very important parameter can involve:

. Contamination in the transport flask cavity, in the storage pond so that on the flask outer surface during the unloading where clouds of cruds can be observed during the fuel manipulation through the pond
. Irradiation with the cruds deposit located in the hydraulic fold of the flask emptying network (piping elbow, valves and so on..)
. Clogging of the unloading facility filters.

On a first approximation we can say:

If P > 1000 g per fuel assembly, the fuel is accepted with a cleaning at the reactor.
If P < 100 g per fuel assembly, the fuel is accepted without cleaning.
P : Reactor estimated value.

Between these two values, the acceptance is done on a case by case basis with COGEMA evaluation at the reactor.

- U_{235} enrichment:

To eliminate all fuel assemblies out of the technical specification of the unloading facilities at La Hague and the transport flask certificate of approval.

- Irradiation:

To see if the fuel burn up is in agreement with the contractual documents.

- Cooling - Decay heat:

Depending of the irradiation values, they must be inside the contractual values enforced by the heat capacity of the transport flasks (up to 120 kW) and unloading facilities (< 40 kW and > 40 kW).

The decay heat is calculated from codes qualified by COGEMA and the French safety authorities for a cooling range comprised between 6 months and at least 5 years.

- No standard parameters:

They have to be mentioned to COGEMA in the "COGEMA TRANSPORT AND REPROCESSING" data together with detailed technical report if necessary.

They involved mainly the criticallity and the fuel skeleton strongness in the following area:

- Dummy or missing fuel rods
- Damaged grids
- Head and foot nozzle
- Tie rods (at least 4 intact tie rods are necessary)

5. General evaluation:

The result of the above various checking is given in a check list entitled "Evaluation technique des combustibles" which allow the issue of a final document for transmission to the various partners involved in the fuel management.

. The transporter in charge of the fuel shipment ie the adequacy between fuel assemblies, transport flasks and administrative aspects with authorities involved.

. The receiver in charge of the technical aspects for unloading, storage, reprocessing and administrative aspects with French safety authorities.

. The management in charge of the commercial aspects.

This final document attached to the customer fuel proposed list (COGEMA TRANSPORT AND REPROCESSING data) gives all remarks, eventual reservation, refusal, special care and so on... to treat safely the fuel assemblies all along the range of action.

In case of reservation, additionnal information are requested to the customer in the frame of a deviation treatment procedure.

According to the answers, reservation remains valid or not, with issue in this last case of a new final document.

In all cases, this one is signed jointly by the engineers in charge of the programm, of the technical aspects and of the commercial general manager.

6. Conclusion:

This organisation has given the proof of its efficiency. Installed 10 years ago, improved in the following years, it is the result of a cooperation between COGEMA, its customers, transporters and safety authorities.

All COGEMA and transporters documents are issued and treated according to the quality assurance principles to make practically impossible the transport of a non agreed fuel assembly.

At the request of the French safety authorities, COGEMA has started a statistical study for an evaluation of the degree of safety for this procedure.

All fault trees have been raised with subsequent calculation.

As a final result, the occurence of fault was found in the range of 10^{-6} ie taking into account the flux of fuel, one occurence per 86 years. Additionnal checking which was not formalized during loading period and by the way not taken into account in the study is now formalized and will improve these values.

As an illustration of these procedures, COGEMA has shipped up to now more than 20000 fuel assemblies with 2500 flasks without problems and due to its major concern in the head end took part in the good results of UP2-400.