**FUEL SERVICES.**

*A. SILBERSTEIN (Fragema)*

**8eme REUNION ANNUELLE DE LA SOCIETE NUCLEAIRE ESPAGNOLE**

**Santander (Espagne) 20-22 septembre 1982**

FRA - 137 - 5

# F U E L  S E R V I C E S

## I. FUEL SERVICES TO SUPPORT FUEL DESIGN

Feedback on the design derived from data acquired through post irradiation fuel inspection is synonimous of progresses in fuel quality and fuel reliability. In order to acquire the data on operating fuel, it is necessary to have the proper tools and make the proper campaigns on the very reactor site without disturbing the reactor availability.

FRAGEMA has developed most types of inspection equipments to work on irradiated fuel assemblies and on single fuel rods during reactor outages with an efficiency compatible with the utilities operating priorities.

In order to illustrate this statement, two specific examples of inspection equipments will be shortly described :

- The on-site removable fuel rod assembly examination stand.

- The fuel assembly multiple examination device.

ITEM 1 : DESCRIPTION AND CHARACTERISTICS

The on site removable fuel rod assembly examination stand is temporarily installed for the duration of the inspection campaign in the spent fuel pool at the location where the spent fuel cask is loaded.

- Removable fuel assembly

Basically it is a standard production fuel assembly (15x15 or 17x17) of which the upper nozzle opening has been machined by trepanning away some of the ligaments in order to give access to the top of the fuel rods and through which certain rods may be extracted, reinserted or exchanged.

- Examination stand

Portable, autonomous unit, from the time the monitored handling tool approaches the selected fuel rod to be inspected up until the time the very tool leaves, it everything and any event is programmed, monitored, controlled, recorded.

- Inspection potential

  - Complete visual inspection of the rod and recording.
  - Continuous diameter measurement and track recording along 2 x 90° spaced axes.
  - Continuous measurement and recording of fuel rod extraction and reinsertion force.
  - Fuel rod length measurement.
  - Cleaning and corrosion products sampling for analysis.
  - Eddy-current testing.
  - Gammametry measurements.

ITEM 2 : DESCRIPTION AND CHARACTERISTICS

The multiple examination device is permanently installed in the reactor spent fuel pool although it is dismountable for maintenance purpose.

. General description

The multiple examination facility consists mainly in three parts :

- a rigid vertical guiding structure fixed to the spent fuel pit wall and floor ;
- a motorized bidirectional carriage able to travel along the vertical structure ;
- a special stand located on the pool floor next to the vertical structure and its carriage and able to hold the fuel assembly vertically and rotate it around its axes.

The bidirectional travelling carriage supports the examination units with the appropriate speeds and travel distances. The three directions are used in moving the camera and light pack around the fuel assembly. The vertical and transverse directions are used in operating the shielded gammametry unit in front of the fuel assembly during its examination.

. Its main features are presently :

- visual examination of peripheral rods ;
- visual examination of the fuel assembly top and bottom nozzles ;
- measurement of peripheral rods channel spacing and length ;
- measurement of fuel assembly bow and twist ;
- gamma scanning of corner rods and fuel assembly side ;
- crud scrapping unit for the peripheral rods.

## OPERATING EXPERIENCE

The on site removable fuel rod assembly examination stand is used with total success and interest since 1977 in Tihange reactor on 15 x 15 fuel assemblies and then in Bugey on 17 x 17 fuel assemblies. Potentially this equipment is highly interesting for any lead assemblies that are presently introduced in a PWR such as those with gadolinium oxyde containing fuel rod and high enrichment fuel rod.

The fuel assembly multiple inspection device is used since 1979 and as it is permanently installed it is naturally utilized by the utility for routine and specific fuel assembly inspection.

## PRODUCT DEVELOPMENT AND PROSPECTIVE

Without entering into the details of the above listed inspection operations, it should be pointed out that :

- by carrying on to repeatedly these operations on various reactor sites at moments where time is really money i.e. electricity for the utilities, a very significant amount of experience has been gained in a wide range of disciplines,
- in designing the equipment, testing and qualification,
- in viewing and acquiring familiarity with irradiated materials, fuel as well as structure,
- in developing reliable transducers that work under severe environmental conditions,
- in acquiring familiarity with handling fuel and equipments, in assembling under water,
- in acquiring familiarity with organization, and methods necessary to operate with safety for the personal and preventing any damage to the object of the inspection,

These typical examples of equipments and the experience accumulated through their use allow FRAGEMA to qualify for offering the supply of such devices or the supply of inspection services when a close follow and surveillance of the fuel is required for design and safety purpose.

## II. FUEL SERVICES FOR PLANT OPERATION

During reactor operation as well as during reactor outages it is compulsory for the utility to follow the fuel behaviour and be able to anticipate and cope with various type of situations which may develop. FRAGEMA has designed and is developing most of the materials necessary to follow and solve the problems that may arise : through coolant activity follow, fuel sipping system, fuel repair station, to name some examples of available items presently in operating or under development.

### . IN PILE FUEL BEHAVIOUR FOLLOW UP

FRAGEMA has developed methods for determination of the fuel behaviour through coolant activity data analysis. The choice of the proper data as well as the frequency of data acquisition allow an accurate diagnosis of the fuel cladding status as it is directly related to the type and nature of the fission product released.

From well known situations for specific fuel cycles with given released activity levels models have been derived and confirmed by fuel operating experience.

Equipments and techniques have also been developped and are under development to monitor isolant activity such as delayed neutron detection and on line gamma spectrometry.

. OUT OF PILE FUEL BEHAVIOUR

Essentially, the inspection technique allowing the determination of the fuel assembly status is the sipping test.

- Sipping test cells

FRAGEMA has developped this equipment which is presently widely used in FRAMATOME power plants and which allow to detect a minimum activity level of $1 \times 10^{-5}$ ci/$m^3$ and has a rate of 3 fuel assemblies per hour. The present generation of equipment under construction that will equip the french 1300 MWe PWR plants will be movable in order to be switched from one reactor building to the next one.

It must be noticed that all our equipment not only allow a qualitative detection of the soundness of the fuel assembly but also a quantitative determination of the fission product leakage rate.

It must be also noticed that FRAGEMA has developped complementary sophisticated visual inspection techniques for close viewing, recording and processing of images acquired on video tape of irradiated fuel assemblies.

## INTERVENTIONS

Whenever it would be necessary due to higher than allowed coolant activity level a fuel assembly may be unloaded. At that time it may be interesting for the utility to have it repaired.

FRAGEMA has developped techniques for the identification of the leaking fuel rods in the fuel assembly and the tooling necessary to perform the replacement of the faulted element.

## PRODUCT DEVELOPMENT AND PROSPECTIVE

These examples of methods, techniques and equipments described hereabove and the experience accumulated through their use allow FRAGEMA to qualify for offering the supply of the corresponding software, hardware or both whenever an accurate understanding of the fuel behaviour is necessary and whenever direct intervention on the assembly and associated components is necessary due to safety, operating or economical reasons.