30 JAPANESE PROGRAMME ON THE DEVELOPMENT OF HIGH DUTY FUEL AND RELATED POWER RAMPING TESTS

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ABSTRACT

Power ramping tests hitherto planned or carried out in Japan can be classified into two categories: 1) The tests programme by private organizations on fuel behavior under various conditions of power ramping, in participating international programmes and 2) a partially government sponcered Programme, which was officially inaugulated in 1981 under the title of High-Duty Fuel Development Programme. The latter has been carried out by the Nuclear Power Engineering Test Centre, based on the schedule decided by the MITI Committee (chaired by the author), for the period of 10 years.

These programmes will be discribed with emphasis on the latter (National Programme).

1. Introduction

Japanese programme on the development of high-duty fuel has been carried out closely related to her programme for improving and standardizing the light water reactor to be better fitted to the way of utilization in Japan in the coming years. The latter programme has been inaugurated in 1975 under the sponcership of the government and its phase two was completed in 1980, followed by the phase three which is to be carried out between 1981 and 1985.

The main items of the programme are the following six: 1) to enhance reliability to make public acceptance easier, 2) to increase load factor, 3) to improve operationability, 4) to reduce the dose of employee further, 5) to improve the situation about siting and 6) to shorten lead time for future reactors.

Among the seven details of improvement based on this programme, which should be carried out during the phase three, two are related to fuel. They are, a) to enable daily load following operation by later '80s and b) to enable longer cycle of power reactor operation. Utilization of plutonium in light water reactor in both BWR and PWR is also included in the items to be developed.

Related to this programme, both BWR and PWR groups has proposed so-called advanced type of the respective LWR (APWR or ABWR), which will be better fitted to the future use of LWR in Japan. Fuel development programme to get what the author has been calling "high-duty fuel" has already been proposed by the three fuel manufacturers and they will be put into practices under a partial sponcership of the government. An advisory committee on planning of this programme attached to the Ministry of International Trade & Industry (MITI) started last year, chaired by the author. The actual work has been performed by the Nuclear Power Engineering Test Centre (NUPEC) and the detailed plan to carry out the programme along with the directions authorized by the MITI committee has been planned by the specialist committees of the NUPEC for BWR fuel and PWR fuel, respectively, both of which has been conducted again by the author. Hitachi-Toshiba proposal is

taken into consideration in the and Mitsubishi and Nuclear Fuel Industries (NFI) proposals are considered for PWR fuel. The schedules can be shown in Fig. 1 for BWR and in Fig. 2 for PWR, respectively.

As the detailed programme on Mitsubishi plan is to be presented in another paper, here. The author would like to describe, mainly, the rest of the plan. The related study through the participation in international programmes has been reported elsewhere.

2. BWR fuel programme

Due to the difference in the way of controling, they seems to have judged that the BWR fuel of the current design, has the difficulty to withstand such a load following operation as, from half to full power within, say 3 hours. They have decided, therefore, to find the candidate remedy fuel based on the previous data and try to verify its satisfiable behavior through power ramping test in a research reactor such as JMTR equipped with Boiling Water Capsule (BOCA), followed by the irradiation test in a commercial BWR power plant. The details on the ramping test will be decided in a near future. The candidate fuel for BWR to be tested are based on the three ideas shown in Fig. 3, that is a) modification on cladding tube: copper barrier applied by plating and pure zirconium liner applied through co-drawing, and b) modification in the fuel pellet : annular pellet. The location of the segmented fuel rod in the assemblies is proposed to be such as shown in Fig. 4.

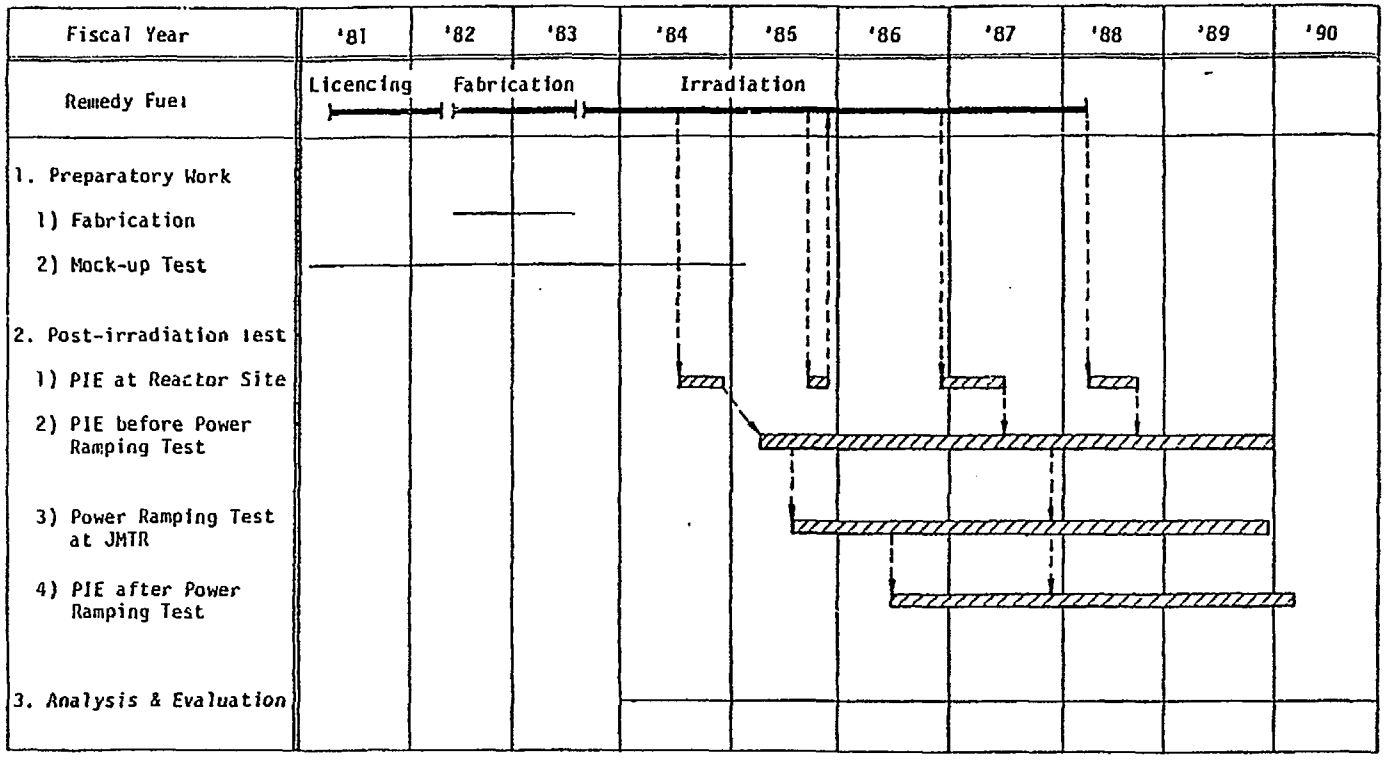
Segmented fuel rods, containing such a candidate or candidates will be assembled into the power reactor fuel bundle and are decided and permitted by the regulatory to be loaded in Fukushima Power Reactor. After the planned irradiation is over, the segmented fuel rods will be disassembled and carried to JMTR to be ramp tested. These specimen fuels will be post-irradiation examined for verification and after the improving effect will be successfully verified, a high-duty BWR fuel fabricated in this way will apply for permission of the regulatory for the commercial use.

3. PWR fuel programme

As they believe that a certain degree of load following operation can be performed, say so-called 12-3-6-3 type, on the PWR fuel of the current design, they planned to verify this in a commercial power plant (Mihama) in Japan through so-called PRD (Power Ramp Demonstration) tests; Task 1 to 5. Five tasks in PRD test is shown in Fig. 5. Among them Task 1 has already finished at the end of last year.

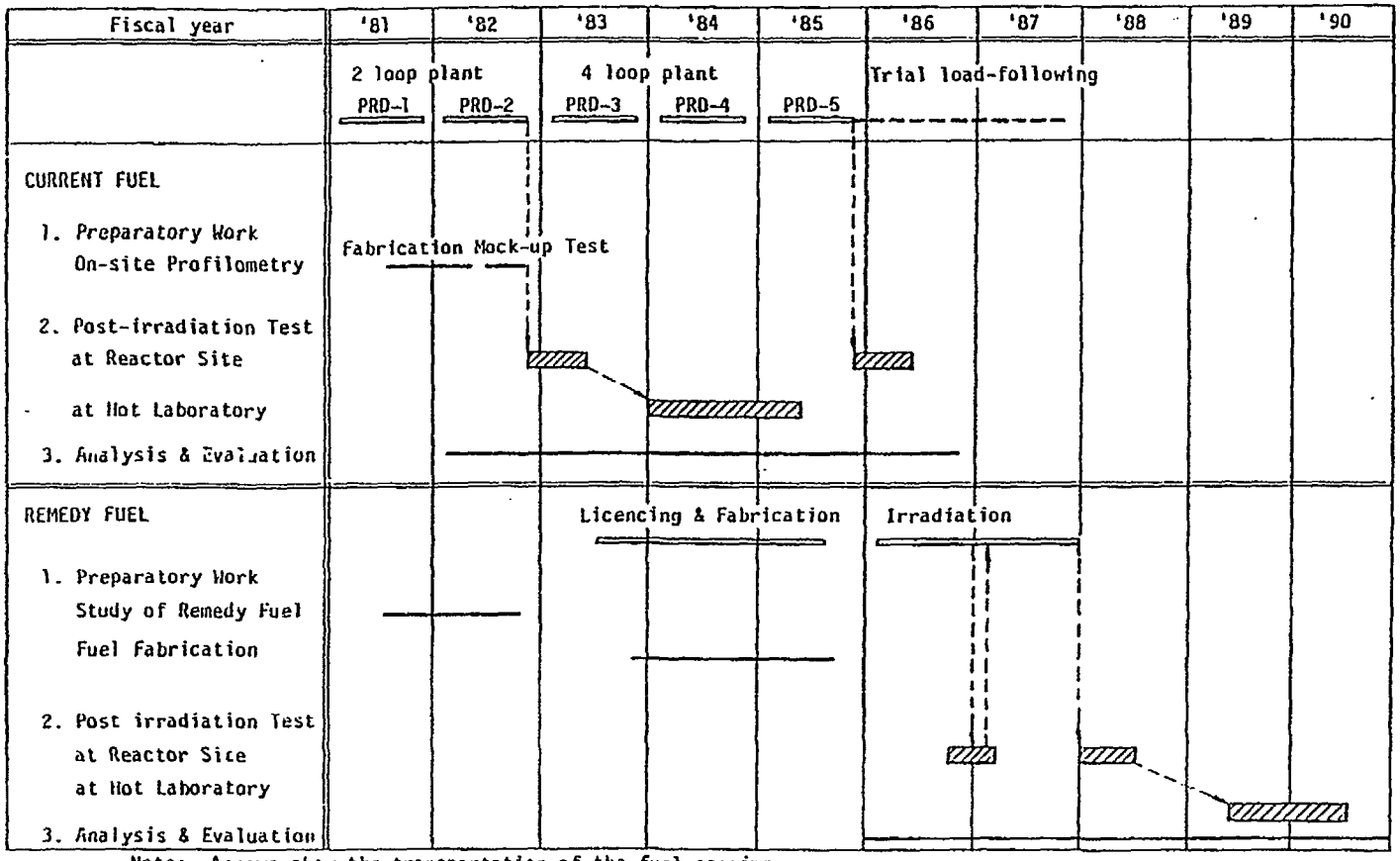
Therefore the PWR group think it necessary to develop a remedy fuel for the severer load following, say 14-1-8-1, in future, for which the Mitsubishi people is planning to verify the usefulness of their remedy fuel idea, shown in Fig. 6.; pure zirconium lined cladding tube and annular pellet to reduce the anticipated possibility of PCI failure. NFI also plans a remedy fuel for the future use of PWR and this type of fuel will also be tested in the partially government-sponcered programme. The thickness of the pure zirconium lining inside the zircaloy-4 cladding tube will be 70μ and they have computed the linear heat rating of the remedy fuel rod at the load-following operation even in 14-1-8-1 phase is to be well below the threshold value of PCI failure.

Those remedy fuel for PWR are planned to be loaded directly in commercial power reactor without carrying out any power ramping test.



Note: Arrows show the transportation of the fuel specimen.

Fig. 1 Programme for BWR fuel



Note: Arrows show the transportation of the fuel specimen.

Fig. 2 Programme for PWR fuel

The plan is subject to change through future discussions. The most favourable position is the reactor core for the verification has been proposed through computation, by the respective fuel designers (Mitsubishi and NFI).

4. *Closing*

As the partially government-sponcered programme has begun just last year, no reportable results has been obtained but the items carried out during the first fiscal year (April '81 to Mar. '82) are as follows:

1) Government-licencing of the remedy fuel with segmented rods for BWR has finished.
2) Fabrication of on-site profilometer to be used for PWR fuel irradiation programme has finished.
3) The behaviour of PWR remedy fuel and its irradiation programme has been considered and approved.

References:

(1) Y. Mishima, N. Oi and Y. Kondo; Special Issue on Development of High Performance Fuel for LWR, Nuclear Engineering (Japan), Vol.28, No.8, p.27-43 (1982).

(2) M. Nagai, Y. Kondo, et al.; Progress and Prospects of Nuclear Fuels Development in Japan, Journal of the Atomic Energy Society of Japan, Vol.24, No.6, p.404-419 (1982).

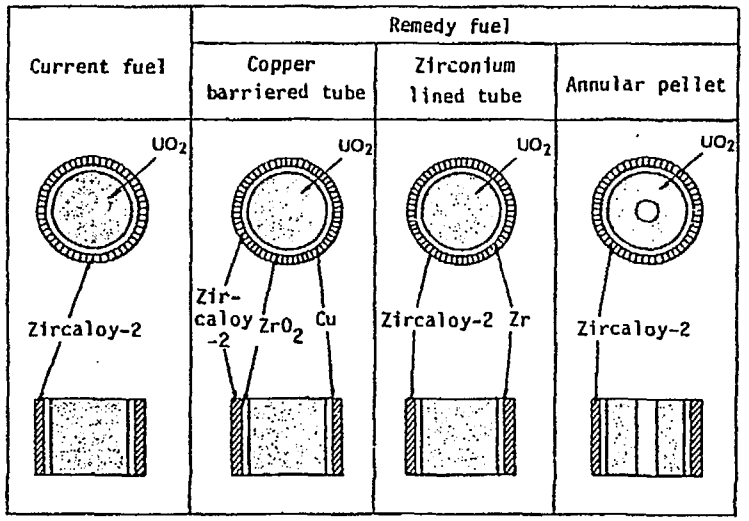


Fig. 3 Three ideas for the candidate for testing in remedy fuel for BWR

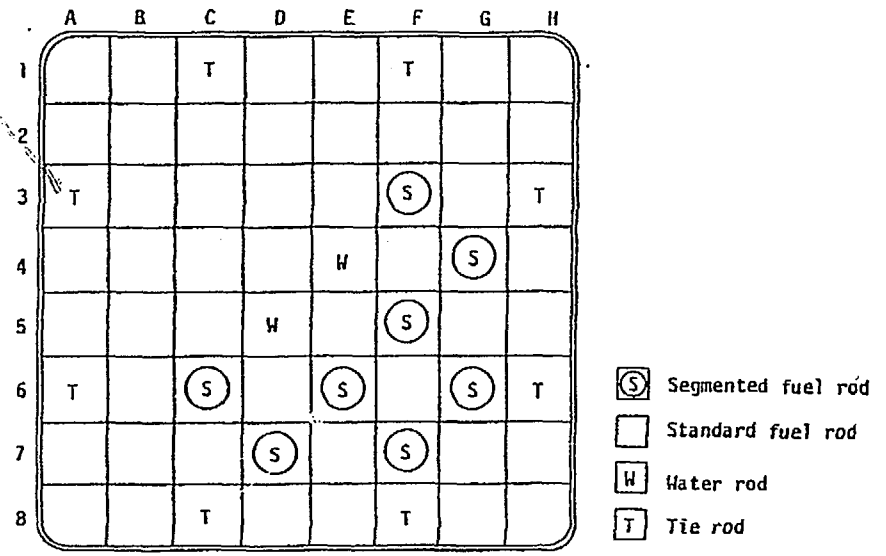
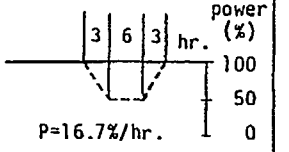
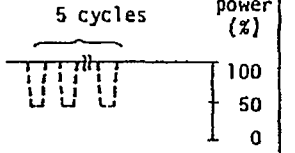
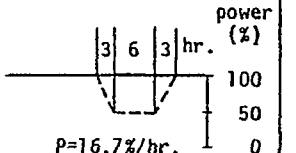
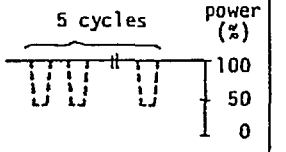
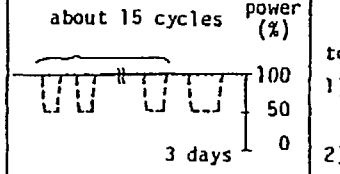


Fig. 4 Location of the segmented fuel rods in the assembly

Item	Power Plant	Contents of Test	
PRD-1	2 loop plant		to evaluate PCI (Pelled Clad Interaction) performance during simulating 12-3-6-3 load following.
PRD-2	2 loop plant		to evaluate 1) preconditioning at low power, 2) cycling effects.
PRD-3	4 loop plant		to evaluate first trial of PRD at a 4 loop plant.
PRD-4	4 loop plant		to evaluate 12-3-6-3 load following effects.
PRD-5	4 loop plant		to evaluate 1) 12-3-6-3 load following at repeated cycles, 2) weekly load following.

Note: ——— reactor power, — — — — local power

Fig. 5 PRD test programme

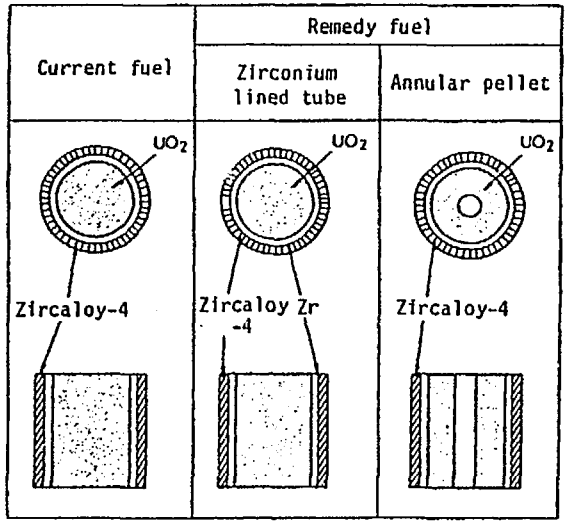


Fig. 6 Remedy fuel idea for future PWR use.