Chapter 10

REACTOR SETBACK PROGRAM

10.1 INTRODUCTION

The aim of this program is to diminish automatically the reactor power when important parameters reach certain values. Ten parameters are watched by reactor setback. These are:

- High local neutron flux
- LZC control system
- Zonal control
- Feedwater level
- Steam generator pressure
- Moderator temperature
- Differential pressure of moderator pumps
- Manual reactor setback
- Condensor pressure
- Water level of axial shields

We will concentrate on two of these to illustrate how reactor setback works. These will be reactor setback on high local neutron flux and zonal control.

10.2 SLOW PART AND FAST PART

The reactor setback module has only a fast part, executed at each fast cycle of RRS, ie each half second or so.

10.3 GENERAL APPROACH

When a parameter watched by the reactor setback module reaches a setpoint, the reactor setback process will start. Depending on which of the ten parameters reached a setpoint, a reactor setback endpoint power will be established, as well as a power maneuvering rate. These will have precedence over those calculated in the CEP module. The reactor setback will remain in force as long as the endpoint power has not been reached. Once it is reached, the power maneuver index, DPLIM, will be set to zero, which corresponds to 0% per second. The power should not vary from then on. If the reactor power is below the endpoint power, reactor setback will not make the power to increase to the endpoint value.

10.4 HIGH LOCAL FLUX

This is to detect the appearance of important deviations between the reactor power as measured by the MCP module and the local powers obtained by the Flux mapping module. The information required for this function is provided both by Vanadium detector readings (slow response) and fast responding Platinum detector readings, if the power is sufficiently high.

As a first step, the FLU module produces, using the modal synthesis, the values of 500 fuel bundle fluxes. The fifteenth highest of these is chosen, and labeled PGMAX.

The variable PLNCA, output of MCP, is then filtered with a time constant of 5.4 minutes so that the time variation of the PF variable thus produced is consistent with the Vanadium detector readings:

$$\text{PF} = \text{PLNCA325} \tag{10.1}$$

Finally, a maximum acceptable value of linear power is calculated from the formula

$$\text{PLNMAX} = \frac{1.1 \times PF}{PGMAX} \tag{10.2}$$

A reactor setback will start if PLNCA > PLNMAX. This reactor setback will only stop when

$$\text{PLNCA} < \text{PLNMAX} - 0.05(\text{FPP})$$

is verified. The power maneuver will be maintained until the endpoint power, 60% in this case, is attained. The maneuvering rate DPDSB will be -0.1%/second or -0.000434 decades/second.

10.5 ZONAL CONTROL SYSTEM

This type of reactor setback is to reduce the importance of power tilts in the core. The tilts are evaluated by taking the differences between the control zone powers. If such tilts were observed, we could presume that the LZC's are not adequately controlling their zones, which is not a desirable situation. Furthermore, power tilts could lead to Xenon oscillations, which must be prevented from happening.

First, the maximum, PZCMAX, of the calibrated zonal powers PZC_i, output of MCP, is obtained. Then the maximum PZCH and minimum PZCB of the same PZC_i are also obtained, but excluding PZC_4 and PZC_{11} (the central control zones of the core) from the calculation.

Then the tilt is defined as:

$$\text{TILT} = abs(\text{PZCH} - \text{PZCB}) \tag{10.3}$$

A reactor setback on power tilt will be started when

- TILT > 20% FP
- or PZCMAX > 110% FP

This reactor stepback will disappear only when the two conditions

- PZCMAX < 105% PP
- and TILT < 15% PP

are met simultaneously.

just like the case of high local flux, the endpoint power is 60% FP and the maneuvering rate DPDSB is -0.1%/second (or -0.000434 decades/second).