Nuclear Power Plant Operation Mode Detection System

M. V. Oliveira[1], J. C. S. Almeida[1], G. D. G. Jaime[1], S. C. Augusto[1], N. Fernandes[1], H. C. L. Oliveira[1]
e-mail: mvitor@ien.gov.br

[1]*Division of Nuclear Engineering - IEN*

Introduction

The specification of supervision and control tasks in complex processes requires definition of plant states on various levels of abstraction related to plant operation in start-up, normal operation and shut-down. The identification of the plant operation mode helps operators to monitor and control complex systems, such as a nuclear power plant (NPP), through information on the state of the plant. Operators can use this information to define which procedure to use at any time during plant operation.

Plant Mode Detection

The operation modes of the reference NPP [1]are refueling (RFL), cold shutdown (CSD), hot shutdown (HSD), standby(HSB), startup(STP), and power(PWR).Fig. 1 presents the plant operation modes of the reference NPP in regular situation.
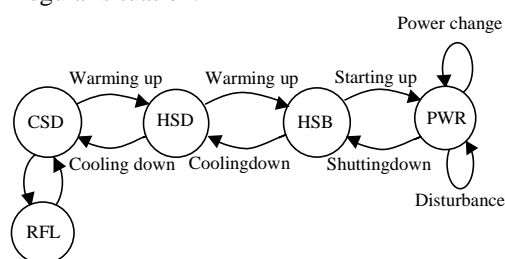

Fig. 1 - Operation modes of the reference NPP in regular situation.

The operation modes of a PWR NPP can be stated by monitoring a set of nuclear parameters. Normally, these parameters are correlated to the reactor reactivity and temperature in the primary coolant. Table 1 presents the operation modes of a simulated plant, as well as the parameters used and the set points to define each operation mode. The selected parameters are the nuclear reactivity, K_{eff}, the rate of thermal power in percentage, and the cold-leg temperature, T_{cold}, in °C. Reference [2] gives more information about the design of the plant operation modes system.

Table 1 - Plant operation modes.

Operational mode	Reactivity condition (K_{eff})	Thermal power[1] (%)	Cold-leg temperature (°C)
Power	≥ 0.99	> 5	≥ 177
Startup	≥ 0.99	≤ 5	≥ 177
Hot standby	< 0.99	0	≥ 177
Hot shutdown	< 0.99	0	$177 > T_{cold} > 99$
Cold shutdown	< 0.99	0	≤ 99
Refueling[2]	≤ 0.95	0	≤ 57

[1]Excluding decay heat
[2] Fuel in the reactor vessel with the head removed

The implementation of the automatic plant mode detection in the LABIHS NPP simulator interfaces [3] takes into account the human factor guideline [4]. Information on the plant mode operation was added to all the top left corners of the operation screens of the simulators to help operators monitor and control the simulated plant. This way, the operator can always be aware of the current operation mode of the plant. Fig. 2 shows an example of how this information appears to the operators. In this example, the plant is operating in power (PWR) mode.
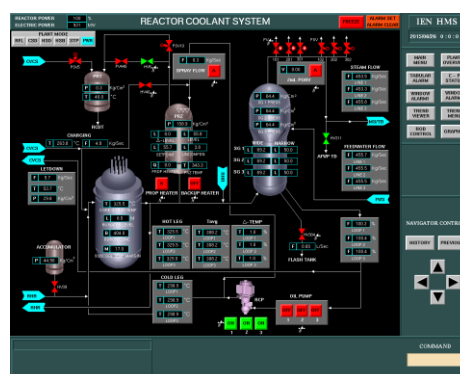

Fig. 2 -Plant mode detection.

References

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