# Neutron Overpower (NOP) System Coverage During Bruce NGS A Channel Turn - Around

by

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## Summary

In the CANDU Safety Analysis process, a series of design basis accident are analyzed to confirm safety system effectiveness. Among all the postulated accidents, the Large Break Loss of Coolant Accident (LBLOCA) sets the most demanding requirements on the speed and the reactivity depth of the shutdown reactivity devices. In such an accident, coolant discharge out of the fuel channels lead to a reactivity increase and power increase which is turned around by the shutdown systems action within seconds. In March 1993, the issue of fuel string relocation introducing additional positive reactivity for reactors fuelled against flow during a LBLOCA was identified. The combined reactivity effect could lead to power pulses much higher than would rise due to coolant voiding alone. To maintain adequate safety margins in the event of such postulated accident, the eight units of Bruce NGS A and B were derated to 60 % full power (Reference 1).

Any further power increase at Bruce NGS A and B have been contingent on implementation of some design solutions to mitigate the relocation reactivity effect. Among the solutions are modified inlet shield plugs, using longer fuel bundles, and fuelling with flow. The fuel string relocation, in reactors fuelled with flow, results in a negative reactivity because the fuel bundle axial burnup profile increases from channel inlet to outlet. The use of long bundles decrease the available gap for bundle relocation in the channels and therefore, reduces the fuel string relocation reactivity. The long bundle solution is adopted for Bruce NGS B while the fuelling with flow solution is adopted for Bruce NGS A.

The NOP trip systems provide trip coverage for a wide range of loss of regulation (LOR) events. The trip setpoint for each shutdown system is determined such that a reactor will trip prior to the onset of fuel sheath dryout with a probability of 98 percent or higher, by 3 out of 3 safety channels in the event of slow power increase arising from a LOR incident. The accident could be initiated from any of the initial flux shapes defined by the NOP design basis set .

A fueling against flow (FAF) core is converted to fuelling with flow (FWF) by successive fuelling operations consisting of pushing the bundles out of an east fuelled channel, reinserting them into a west fuelled channels, inserting the contents of that west channels into some east channel, and so on. During the turn-around process, clusters of 5 or more neighboring channels with bundle irradiation distributions increasing in the same axial direction will be created. This produces very unusual axial power distributions because of

the relatively fresh fuel in the same end of the channels and relatively high burnup fuel in the other end. Such configurations may negatively affect the NOP coverage during the transition process.

The conversion of the core from the current fuelling against flow scheme to the target whole core fuelling with flow will be achieved in four phases. The NOP coverage during each phase is examined and the required penalty is established to restore the NOP coverage. During phase I, a maximum of 13 clusters of 8 channels with the same fuelling direction are assumed. A maximum penalty of 4.75 % in the NOP trip setpoint is obtained during phase 1. However, after the whole core is turned around the required penalty is back to 0.0 %.

## References


1- M. Gold, et al.,"The Fuel String Relocation Effect - Why the Bruce Reactors were Derated", Paper presented at the 16th Annual Conference of the Canadian Nuclear Society, Saskatoon, Saskatchewan, June 4 -7 1995.