

# HEAVY WATER REACTORS SAFETY

© M. Ragheb  
12/12/2010

## INTRODUCTION

Heavy water reactors use natural uranium as a fuel and hence require on-line refueling using horizontal channels. If steam forms in the horizontal channels as a result of a power surge, “gravitational stratification” occurs with the steam accumulating in the top part of the channel.

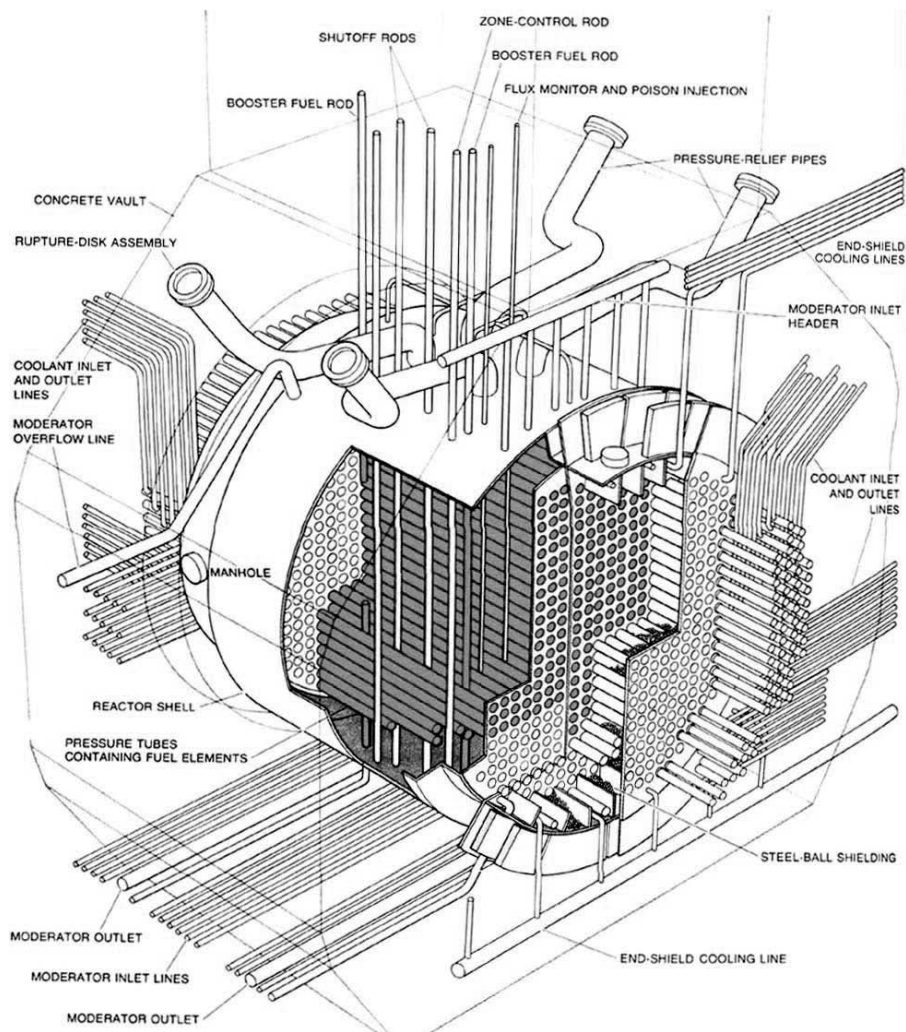


Figure 1. Canadian Deuterium Uranium, CANDU vessel configuration.

“Flow stagnation” can occur in heavy water reactors. Since the heavy water coolant is sucked out from one end of a horizontal tube by the coolant pump, and leaves from the other end, the central part of the tube can be left stagnant in the case of a break

in the tube. At the center of the channel where stagnation occurs, the fuel can rapidly overheat.

On the other hand, substantial amounts of the heat generated in a transient is transferred to the moderator, which has its own cooling circuit.

In addition, the control rods which are inserted into the cooler moderator are more reliable than those inserted into the higher pressure and temperature environment of a BWR or PWR.

## **VOID COEFFICIENT OF REACTIVITY**

Heavy water reactors that are moderated with heavy water and cooled with either pressurized heavy water or boiling light water possess a positive void coefficient of reactivity. In a typical transient, the fuel power can increase by a factor of 2 within 1 second into a transient.

This suggested the incorporation of three independent shutdown mechanisms:

1. Shut-off rods cadmium control rods are inserted under gravity from the top of the reactor.
2. A neutron poison such as boric acid is injected through horizontal nozzles into the heavy water moderator.
3. The moderator can be dumped out of the core into a dump tank stopping the fission chain reaction.

## **LOSS OF COOLANT ACCIDENT, LOCA SCENARIO**

If a Loss Of Coolant Accident, LOCA occurs in a heavy water reactor, an emergency coolant supply is automatically injected into all the tubes headers by a separate emergency coolant system. This system supplies more available light water, which has a lower moderating ability, rather than heavy water into the reactor.

The system possesses a high pressure injection stage in which gas pressure is used to inject the water into the initially highly pressurized headers.

In some designs high pressure pumps are used to draw water from an emergency water tank. High pump pressure implies a flow rate limited in magnitude.

When the high pressure emergency water supply is exhausted, and the system would have depressurized, water can now be pumped at low pressure at a high flow rate from a separate tank and fed into the pressure tubes.

Water leaking into the containment structure is recovered in a sump and pumped back to the pressure tube headers by way of a heat exchanger that cools the incoming water flow.