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Determining Reactor Operating Conditions to Prevent Xenon Walkaway Accident

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Determining Reactor Operating Conditions to Prevent Xenon Walkaway Accident

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Xenon Criticality Analysis

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Background

A xenon walk-away accident is a theorized uncontrolled criticality event that could occur when an operating crew is forced to evacuate the control room during certain xenon transients. Because of this possibility, certain restrictions are placed on reactor operators and engineers for power changes.

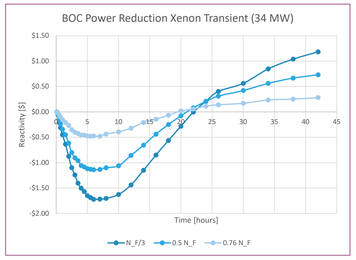
The xenon walk-away can not occur as long as the following holds true:

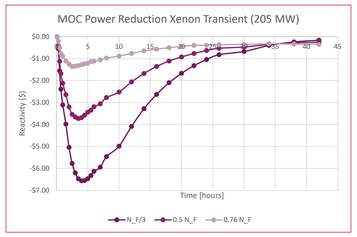
$$\rho_{SR} = \rho_{OSCC} + \rho_{NS} + \rho_{PD} + \rho_{FP} + \rho_{SD}$$

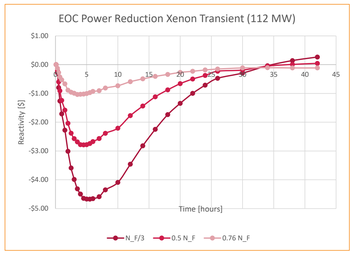
SR – Safety Rod
OSCC – Outer Shim Control Cylinders
NS – Neck Shims
PD – Power Defect (≈0.16$)
FP – Fission Products
SD – Shutdown Margin (2$)

Methods

In order to dissuade fears of the xenon walk-away, it is necessary to show under which circumstances it can and cannot occur. Using MC21 and some existing literature, the reactivity worths of various control elements were found, in addition to the reactivity worth of xenon in various situations.

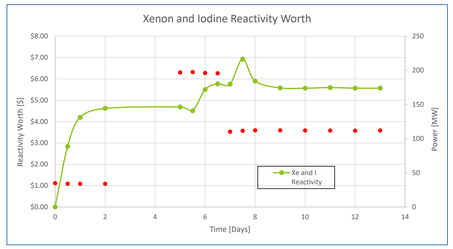




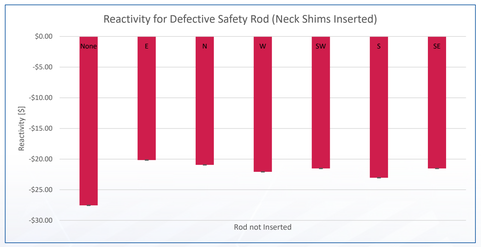


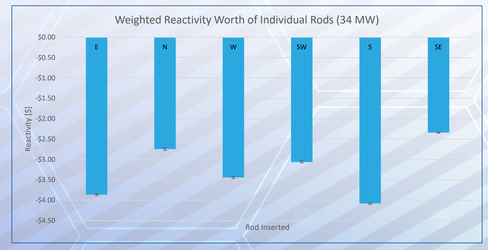
54
Xe
xenon
131.293

Xenon



The concentration of xenon is dependent on the power the reactor is operating at and the magnitude of any recent changes in power. If the reactor is left unattended for a few days in an emergency scenario, the xenon will decay, and the reactor could become critical again. However, in all but the most extreme reductions at the highest power levels, the safety rods have more than enough negative reactivity to keep the reactor subcritical without operator intervention.



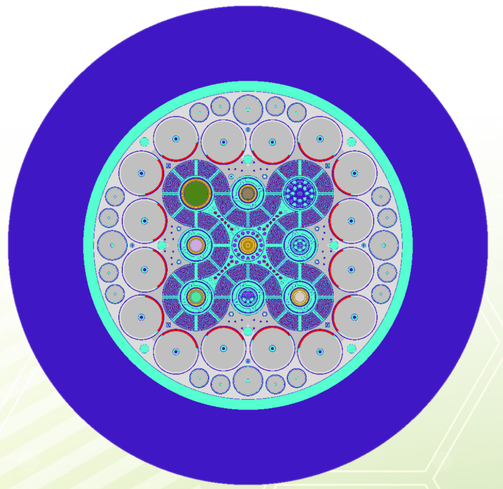


Safety Rods

To be a conservative estimate, only five rods activate. Safety rods are more effective than the sum of their parts. This means that historical methods of adding the worths of each rod together actually greatly underestimated the worth rods would provide in a shutdown.

Conclusions

The xenon walk-away is an incredibly unlikely accident that would require multiple highly reliable components to fail or a severe lapse of judgement on the operators` part, in addition to being unable to return to the site for dozens of hours. Despite this, to uphold the nuclear industry's history of safety, they must be investigated. This work showed a higher safety rod worth than previously assumed, demonstrating safety during a larger number of power transients.



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