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FAILED FUEL LOCATION BY XE133 TREND IN CANDU6

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ABSTRACT – Thisarticle interprets how to locate failed fuel by Xe133 trend analysis. Xe133 trend is related tobundle burnup, bundle power history, bundle movement and other factors. Xe133 trend following fuel defect can help to find failed channel, Xe133 trend following bundle movement can help to confirm the bundle position in the channel. GFP handswitching can help to locate the half loop in which the failed fuel situated.

Introduction

CANDU6 reactor use FFL system to locate failed fuel, but it is not helpful for pinhole defect. Because of the aging, the discrimination ability of FFL system is weakened, even if fuel failing deteriorates, FFL system lose effectiveness.

Beside FFL system, the most useful method isanalysis Xe133. Xe133 trend is related to bundle burnup, bundle power history, bundle movement and other factors.Xe133 trend following fuel defect can help to find failed channel, Xe133 trend following bundle movement can help to confirm the bundle position in the channel. GFP handswitching can help to locate the half loop in which the failed fuel situated.

1. Typical fuel defect and consequent Xe133 trend

1.1 Long dwelling bundle fails during purturbation

The Xe133 come out with the form of a large step increase, then decrease because of decay, and escape from coolant to air, finally reach a balance level which is much lower than the spiking peak. This phenomena suggests that the failed fuel has a long dwelling time and the Xe133 concentration has reached steady level. Because of some kind of severe perturbation like shifted by fueling machine, plenty of Xe133 accumulated in the gap between UO2 pellet and fuel sheath release to coolant at one time, and the spiking forms.

1.2Long dwelling bundle fails in steady state

The Xe133 come out with a step increase and keep increasing at a high speed and reach a balance level in several days, then almost stay at the balance level if in a steady state. This phenomena suggests that the Xe133 concentration in the gap also reached a balance level, but the hole failed fuel occurs in steady state, because there is no perturbation, the Xe133 release to coolant at a high speed rather than spiking. When the Xe133 reached a level at which release rate equals to total disappear rate mainly about decay, escape and other reasons, the Xe133 concentration does not increase any more.

1.3Fresh bundle fails

The Xe133 increase with a very low speed for more than one month, the trend slope almost does not change. This phenomena suggests that the failed fuel is new loaded, before failing, the Xe133 concentration in the gap is minor.

1.4Short dwelling bundle fails

The Xe133 emerge with a very tiny step increase, and then keep increasing at a low speed, and reach balance level in more than one month. This phenomena suggests that the failed fuel is recently loaded, the dwelling time is proportional to the step increase amount. Basically this type is between the type of section 1.2 and section 1.3. Before failing, the Xe133 in the gap has accumulated to some extent, but not reach balance, when hole occurs, the pre-accumulated Xe133 releases and lead to a step increase, and then keep increasing because of fuel fission.

2 Xe133 trend of failed bundle refueling

If refueling activity discharged failed fuel for one push, about one hour later, a high spiking of Xe133 and some other fission product will occur. However, the Xe133 concentration level will return to the level before refueling in several hours. This spiking must be fake because the half-time of Xe133 is 5.3 days the reason maybe that the Xe133 is not mixed well. And the one hour delay time is still unknown.

If refueling activity just moved the failed bundle position within the fuel channel, a high spiking will occur about 15 minutes after the refueling activity. This indicates the existence of failed bundle in the remaining fuel bundles. Consequently discharge of failed fuel won't lead to the fake spiking mentioned in last paragragh, because the accumulated Xe133 has released out in last pushing perturbation.

3 Xe133 trend of GFP loop switching.

Heat transport system has two separate loops, which are connected by pressurizer and degasser-condenser, but the coolant flow exchange between two loops is minor. Theoretically, the Xe133 concentration in the loop which contains failed fuel should be explicitly higher than the other, but the reality is opposite. The difference is very little which can only be observed in severe fuel failure with a very high Xe133 concentration level. If one loop has higher Xe133 concentration level than the other loop, it is sure that this loop contains failed bundle, or that this loop has more failed fuel elements than the other.

4. Conclusions

Xe133 trend analysis method is useful for failed fuel location, especially for pinhole and when FFL aged. The applicability of this method has been demonstrated in years of operation of TQNPC.

4. References

[1] Wei Hu, “Failed fuel analysis and summary in 2015”, 98-37000-ITR-15-084