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To the members of WENRA

No: 357-13/2013/27
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SUBJECT: Information about the fuel degradation in Krško plant

Dear colleagues, members of WENRA,

Krško NPP, which is in the refueling outage since the beginning of October, is experiencing problems with the fuel. As the issue has received also substantial media coverage here in Slovenia with this letter we want to inform WENRA members about actual facts.

The plant has operated in its 26th, 18 month long fuel cycle since May 2012. First indication of the leaking fuel appeared very early in the 53th day after the start-up. The primary coolant activity gradually increased during the cycle, showing possible three fuel rods leakages at the end of the cycle. During the cycle two unplanned reactor shutdowns occurred which have probably contributed to the development of fuel pin failures. As the activity of the primary water was far below the technical specification limit (at the end of the cycle it has reached 2.95% of the limit), the plant did not have to stop for midcycle refueling.

After the removal of the fuel from the core several broken fuel pins were found in three fuel elements and additional few fuel elements have been recognized to have tight leaks. During the transfer of the fuel from the reactor vessel to the spent fuel pool about half a meter long pin even broke and was found at the bottom of the transfer channel. All fuel elements with broken pins were positioned at the outer edge of the core next to the core baffle.

Westinghouse, who is the fuel supplier and main refueling service provider, has made preliminary analysis recognizing the influence of the *baffle jetting* as the main cause of troubles (See attachment). Therefore as the immediate corrective measure number of outer pins of the fuel elements at exposed locations are being replaced by dummy steel pipes just to avoid potential repeated damage. As a long term correction during the next refueling outage most probably the baffle plate arrangement will be converted from so called down-flow to up-flow thereby reducing the pressure difference and possibility for jetting.

None of the damaged fuel elements will be returned into the core. All the fuel elements were checked by In Mast Sipping methodology and visually inspected, while most suspected elements also by ultrasonic methods.

This is not the first time the Krško NPP experienced fuel leakage problems in its operation history. There were serious problems in mid nineties, while in recent years amount of leakages was relatively small. Two fuel cycles ago, however, there were even no leakages detected.

Slovenian Nuclear Safety Administration is tightly following the situation to be sure that the operator is doing everything that can be done. We want to be sure that the next fuel cycle is starting without suspicious fuel elements, that immediate corrective actions are in place and that straightforward and adequate action plan is prepared in case the activity of the primary coolant starts to increase during the next fuel cycle.

The formal root cause analysis will be completed during next 2 months. It will contain final leakage mechanism determination for all Cycle 26 leaking fuel assemblies, root causes, corrective actions and plans to follow up corrective actions.

Currently it seems that the refueling outage will be prolonged for ten days and the plant plans to restart in the middle of November.

We are available for any additional comments and also to any advice.

Yours sincerely,

Andrej Stritar

DIRECTOR

Attachment:

Potential causes and mechanisms for fuel leakage in the 26th cycle – PRELIMINARY ASSESSMENT

Based on the review and evaluation of the results of inspections on the fuel cycle core 26 it seems that there is a combination of multiple factors and multiple causes / mechanisms of a leakage in the fuel cycle 26. The assessment is that the mechanism is new for this plant, taking into account the size and nature of degradation of the fuel assemblies in the reactor.

1. ***Fuel elements with extensive visible damage***

Fuel elements AD11, AD12 and AD13: They have broken 2-3 fuel rods in the outer region of a fuel element, upper plugs of fuel rods are jammed in the top nozzle, protruding springs, fuel rods are lowered to the bottom nozzle, and all those fuel elements were in peripheral core locations during 26th cycle near the baffle plate. Visibly damaged outer rods are parallel to the slots of the two baffle plates. Based on experience and detailed visual inspections suggest that those three fuel elements experienced three mechanisms: primary, secondary and tertiary mechanism. Separation of the upper plugs of the fuel rods just below 8 the spacer grid is the tertiary effect caused by the secondary damage of the 7th grid. The mechanism at the 7th spacer grid is probably secondary hydration, which occurred due to primary damage of a fuel element somewhere lower from the 7th grid, either due to debris or "grid-to-rod fretting" mechanism or vibration. The primary mechanism occurred probably shortly after the beginning of the operating cycle 26 (this assumption is on the basis of the increase in radiochemical isotopes ~53 days after the beginning of cycle 26, i.e. in July 2012). The second mechanism, maybe a new mechanism or degradation of the existing defects, is likely to take place in February 2013. Tertiary mechanism - extensive degradation, is likely to occur only at the end of the cycle. Most probable contributory cause is called 'baffle jetting'.

2. ***Fuel element with a broken inner rod***

Fuel element AC29 has broken the inner fuel rod B-11. Fractures usually occur because of the secondary effects - secondary hydration, which makes fuel cladding brittle causing a rod breakage. Secondary hydration is caused by the penetration of a coolant in the fuel rod due to damage to the bottom of the fuel rod, which is probably the type GTRF 'grid-to-rod fretting' induced by a foreign object/particle. If the primary damage occurs early enough in each cycle, the greater is the likelihood that there will be a secondary hydration.

3. ***Fuel element - tight leak***

The fuel element AD17 was detected as a leaker during In-Mast_Sipping (IMS). Visual examination did not show anything, but the results of UT method have shown the 16 suspicious rods. The results of all three inspections checks carried out on the fuel element show a typical example of a 'grid-to-rod fretting' mechanism which is similar as observed in the previous cycles. Vibration wear occurring at the contact between the fuel rod and spacer grid may lead to perforation of the cladding. Such cladding damage is not visible from the outside. This mechanism can be confirmed by examination of individual fuel rods. The Krško NPP in 2008 licensed the method

for reconstitution of fuel assemblies in accordance with WCAP-13060-PA. The Krško NPP has so far carried out twice reconstitution of fuel elements - for the first time in late 2008 and the second one during the outage 2012.

4. Debris damage/fretting

Foreign material was detected in at least 30 fuel elements examined. Foreign material are generally smaller (up to a few millimeters), which are likely to be in large part a result of extensive damage to the three fuel assemblies. Foreign bodies typically damage cladding in the first 60 days of operation. As the first sign of such deterioration of the Krško fuel integrity occurred 53 days after the startup, it was assumed this to be damage from foreign material. Such damage due to secondary hydration led to blistering of the fuel rods and fractures. There is a high probability that foreign material may be the primary cause for fuel damage precisely in these fuel elements.