# Failure Analysis on AFA 3G Gd Rod from Nuclear Power Plant

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The activity of the reactor coolant can indicate the failure of the fuel rod. The coolant radioactivity increased during reactor operation, and a Gd rod was found to be failed by poolside inspection. The failed rod was then transported to the hotcell for PIE to find out the root cause of the failure. Several reasons can cause the failure of the fuel rod, such as manufacture defects, PCI, grid-rod fretting, debris, handling, and each of these causes has their own feature on the primary failure. Once the failure occurred, the coolant can go inside the cladding and cause secondary failure by hydrogenation. To analysis the root cause of the failure, the primary failure should be identified from others.

The key method of primary failure identification is visual inspection. The high resolution visual inspection confirmed that both ends of the rod were failed, and the hydrogen content analysis showed that the hydrogen content at the position of lower plug welding was 1720 µg/g, while that was only 133 µg/g at the position nearby the upper plug hole welding. That means the failure at lower plug welding was a secondary failure, and the upper failure was primary. The failure root cause of Gd rod was hole welding defect.

## PIE method

Body Text Several PIE method was performed on the failed rod for failure analysis, such as visual inspection, dimension measurement, X-ray radiography, γ- scanning, eddy current testing, oxide film thickness measurement, metallography, hydrogen content measurement, SEM and EDS.

## PIE result

The high resolution visual inspection confirmed two failure on the rod, one was the hole welding, and the other one was lower plug welding, show as Figures 21 and 22, respectively. The whole hole welding part was missing, and there was a “H-type” cracking at the lower plug welding.

Figure 21: Hole welding failure

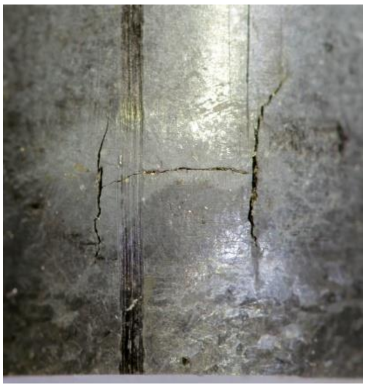

Figure 22: Lower plug welding failure

Hydrogen content analysis showed that the hydrogen content at the position of lower plug welding was 1720 μg/g, while that was only 133 μg/g at the position nearby the upper plug hole welding, the result showed at Table 1.

Table 1: Hydrogen content result

| Sample position | Sample index | Mass(g) | Hydrogen content (μg/g) | Average content (μg/g) |
|---|---|---|---|---|
| **5 mm lower than the upper plug** | D1-WRU-H-1 | 0.0575 | 130 | 133 |
| | D1-WRU-H-2 | 0.0582 | 136 | |
| **Lower plug** | D1-WRD-H-3 | 0.1242 | 1720 | 1720 |

## Conclusion

Due to the visual inspection result and the hydrogen content measurement, the failure at lower plug welding was a secondary failure, and the upper failure was primary. The failure root cause of Gd rod was hole welding defect.

## References


ASTM E-1447. C1457-00 (2010)e1 Standard Test Method for the Determination of Total Hydrogen Content of Uranium Oxide Powders and Pellets by Carrier Gas Extraction.

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