



Draft 10 CFR 50.46c and Draft Regulatory Guide Recommendations: Breakaway Oxidation

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Outline



- ▶ **Breakaway oxidation overview**
- ▶ **Initial scoping testing overview and recommendations**
- ▶ **Periodic testing overview and recommendations**
- ▶ **General testing overview and recommendations**
- ▶ **Summary**

Breakaway Oxidation

- ▶ **Breakaway oxidation should not be given any greater significance than other criteria**
- ▶ **Breakaway oxidation has a low probability of occurrence given manufacturing processes and LOCA transients**
- ▶ **Agree to testing, but the details of the testing should be better suited to the considerations of the manufacturing process**
- ▶ **Regulatory guidance should reflect the consensus of the international community of laboratories, experts, and manufacturers**
 - ◆ **Industry round robin testing only followed guidance to a practical extent and produced quality results**
 - ◆ **Detailed prescription is not necessary**

Initial Scoping Testing

- ▶ **Initial scoping testing (IST) is used to determine a time for which breakaway oxidation will not occur**
- ▶ **Established time limit used to demonstrate compliance**
 - ◆ **Established time limit can be less than the minimum time**
 - ◆ **Periodic testing only has to test up to this limit**
 - ◆ **LOCA analyses could be compared to this limit or to an even lower limit**

Initial Scoping Testing

- ▶ **There are two parts of the IST:**
 - ◆ **Part 1: Nominal determination of minimum time/temperature combination (maximum test time of 5000 seconds)**
 - ◆ **Part 2: Repeatability and scratch tests**
- ▶ **Two scenarios are possible from the first part of IST:**
 - ◆ **Scenario #1: Minimum breakaway time/temperature combination determined, <5000 seconds**
 - ◆ **Scenario #2: All temperatures test up to 5000 seconds showed no breakaway oxidation**

Initial Scoping Testing

► Scratch testing

- ◆ **Testing has shown that the impact of normal scratches is a low level effect**
 - NUREG-6967: “Thus, “normal” surface scratches that may form during handling and loading of rods into assemblies appear to have only a small influence on breakaway oxidation time for modern cladding alloys used in the U.S.”
- ◆ **DG-1261 scratch tolerance ($\pm 5 \mu\text{m}$) is unrealistic**
- ◆ **Recommend relaxation on the scratch prescriptions**

Periodic Testing

- ▶ **DG-1261 position: “measure the onset of breakaway oxidation annually for each reload batch” ... “and to demonstrate that breakaway oxidation is not experienced within the time of the established analytical limit.” (Appendix A-3.2, Appendix E)**
- ▶ **Only necessary to demonstrate that established limit is not challenged**
- ▶ **Testing and reporting requirements should align with the cladding manufacturing process**
 - ◆ **It is not known a priori which cladding tubes will be used in which plant’s fuel assemblies**
 - ◆ **A reload batch of fuel assemblies can be composed of a number of different cladding tube manufacturing lots**
 - ◆ **Grandfather fuel assemblies with cladding manufactured prior to implementation dates**

Periodic Testing

- ▶ **Testing should be performed to provide reasonable assurance that the manufacturing process is producing a consistent product**
- ▶ **Over time the confidence will grow**
- ▶ **Allow vendor documentation**
 - ◆ **Details of the testing are specific to each vendor**
 - ◆ **Demonstrates vendor production meets established time limit**
 - ◆ **If necessary, utilities could reference the vendor documentation as proof that they are using fuel from a qualified vendor**

General Testing Specifications

▶ **DG-1261 requests two benchmarks**

◆ **Thermal benchmark and**

◆ **Weight-gain benchmark: at 800°C and 1000°C**

- 1000°C
 - For Zr-2, Zr-4, or ZIRLO, benchmark to Cathcart-Pawel (C-P) prediction
 - Must be within 10% of C-P prediction at 2000 seconds
 - For other alloys, benchmark to vendor database
- 800°C
 - For all alloys, benchmark to well-established vendor databases

▶ **Most cladding alloys are not within 10% of C-P and vendor databases are limited**

◆ **Normal thermocouple calibration is sufficient, remove W-G benchmark**

◆ **Alternate:**

- One test is sufficient to provide an independent benchmark of the control process
- Relaxation on time and temperature requirements

General Testing Specifications

▶ Heating method

- ◆ **Problems with heating method are more of a concern with the temperature control as opposed to the impact on breakaway oxidation**
- ◆ **“Not recommended”**
 - A method that is “not recommended” can be easily interpreted as “not allowed” in the future if reasoning is not understood
 - Thermal benchmarks are required for both “recommended” and “not recommended” methods
- ◆ **Recommendations for specific heating methods should be removed**
 - If temperature control can be attained, heating method is immaterial

▶ Water quality

- ◆ **Source of water during LOCA not oxygen control**
- ◆ **Requirement on oxygen content in test (<45 ppb) is not needed**

Summary

- ▶ **Requirements in the guides should be relaxed for practical application**
 - ◆ **Scratch prescriptions should be removed or relaxed**
 - ◆ **Periodic testing should take into consideration the cladding manufacturing process**
 - ◆ **Weight gain benchmark should be removed or relaxed**
 - ◆ **Heating method recommendations should be removed**
 - ◆ **Water quality oxygen requirement should be removed**