

# GNF/GEH Perspective on DG-1261, 1262, and 1263

Public Meeting on Draft Regulatory Guides

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# Outline

General Comments on DGs

DG-1261, DG-1262 and DG-1263 Specific Comments

Question 2 on Breakaway Oxidation

Breakaway Oxidation Testing

Quality Assurance Program

Thoughts on Proposed Hydrogen Model



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# General

- Detailed requirements in DG-1261 and DG-1262 on T/C calibration and certification are redundant and duplicate routine activities performed under fuel vendor's quality assurance program that comply with 10 CFR Part 50 Appendix B and NQA-1.
- Recommend removal of requirement in DG-1261 and DG-1262 to attach calibration certificates to data reports.
- Recommend removal of weight-gain within +/- 10% of CP correlation for <2000 s at 1000 °C; instead, benchmark against database.



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# DG-1261

Address embrittlement not already limited by ECR

- Recommend revisit technical basis and purpose for periodic testing and associated reporting.
  - Vendor quality control and assurance program capable of assuring only loading unaffected fuel into reactors **Primary Focus**
  - Narrow objective of periodically testing for and reporting on variations in onset time to breakaway oxidation is unnecessary **Secondary**
- Recommend test repeats be set as two repeats.
  - Avoid introducing undue burden
  - No more than two repeats were conducted at any given test condition in NUREG/CR-6976, Tables 19, 20, 23, 29 and 36
- Recommend removal of 45 ppb oxygen requirement on water quality.



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# DG-1261 (2)

- Seeking option to use Thermogravimetric Analysis (TGA) instruments.
  - Use of weight gain to determine breakaway oxidation
  - Steam introduction and temperature ramp conditions
  - Minimum sample length



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# DG-1262

- Recommend that 1000 °C be removed for the purpose of weight-gain benchmarking.



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# DG-1263

- Recommend allowing other methods for determining the transition ECR, e.g scatter plot of ECR versus post-test hydrogen.
- Recommend the NRC follow through with the suggestion of providing ECR versus burnup plot.
- Recommend testing of pre-hydrated cladding as acceptable surrogate for irradiated cladding.
- Recommend using consistent wording that models address circumferentially averaged H content.



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# DG-1263 (2)

- Recommendation on analytical limits associated with breakaway oxidation:
  - The term “temperature at which the zirconium alloy has been shown to be susceptible” be used consistently throughout DG-1263
  - Both time and temperature obtained using DG-1261 be used to define analytical limit in DG-1263. For example, the analytical temperature limit could be based on testing for 5000 seconds at different temperatures.



# NRC Question 2 - Periodic Breakaway Testing

- Breakaway oxidation to be addressed as part of the fuel supply quality assurance program.
- Data expected to be pass or fail relative to approved time (not a numeric value for breakaway onset time).
- Test frequency be set as part of the quality assurance program built on statistical confidence based on test data, rather than as part of the rule.



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# Breakaway Oxidation Testing

- Testing is integral part of the fuel supply quality assurance program.
- Integral program should focus on addressing known causal factors.
- Level of testing should be consistent with risk



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# Breakaway Oxidation

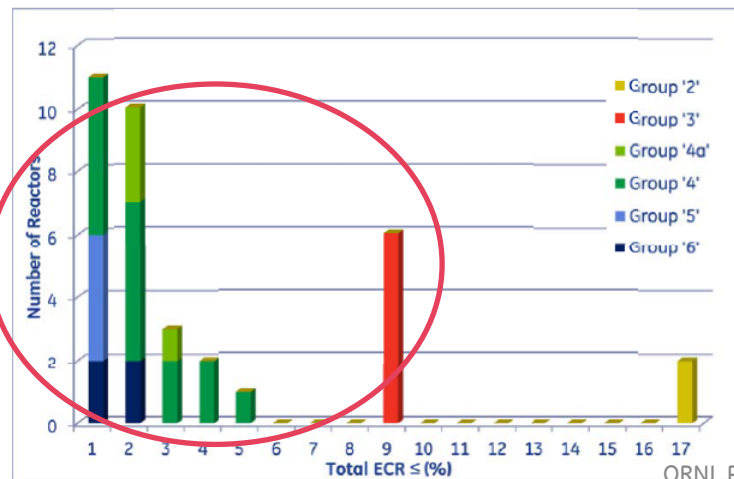
## Key Factors are Known:

[NUREG-6967, NUREG-IA0211, Chung NET (2005), OECD -NEA 6846 (2009 )]

- Scratches (small impact)
- Surface contaminant (strong impact)
- Source material type from Zr extraction (strong impact)

## Low risk of current Zry2 used for BWR

Majority have <1000s  
above 800°C



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Figure 4. Histogram of AOR Oxidation Results

# Breakaway Oxidation – Quality Assurance

Assurance that affected fuel is not loaded into reactors is achieved through addressing causal factors

- Qualify procurement and manufacturing processes
- Additional testing to ensure process remain qualified

Use Quality Assurance program to

- **Control allowable scratch depth** (Scratches)
- **Prevent use pickled final finish** (Surface contaminant)
  - testing every lot is not necessary
- **Prevent use of electrolytic Zr** (Source material)
  - readily preventable without testing
  - detectable at ingot stage; basis for per ingot test if needed
  - testing at ingot stage is an option

Addressing known issues in QA program minimizes burdensome testing



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# Quality Assurance and Manufacturing Process Control

## Example: **Texture** of Cladding Tubes

Texture has strong effect on cladding irradiation growth.

Texture in Zr-alloys is strongly dependent on manufacturing process parameters such as reduction in area and annealing time and temperature.

Assure consistent texture through QA control of known manufacturing process parameters and equipment, e.g. T/C.

Texture is measured to qualify the product manufacturing process.

Only qualified material can be used for reactor use.

Texture measurements on final cladding on per lot basis not necessary.

# Breakaway Oxidation Program

(from 2014 Technology Update)

## Framework Addressing Breakaway Oxidation

Revise GESTAR II

- Cladding shall not exhibit breakaway oxidation in less than xxxx s at zzzz °C.
- Requires NRC approval

GNF specification and QA program (includes testing) ensures only cladding with breakaway  $\geq$  xxxx s at zzzz °C is used for fuel manufacture; also ensures electrolytic Zr and pickled cladding finish will not be used.

LOCA analysis for NFI (fuel and plant specific) ensures compatibility between ECCS response and cladding breakaway oxidation behavior.

Reload specific assessment confirms test data from cladding remains bounded by LOCA analysis; part of SRLR to customer.



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# Breakaway Oxidation Program (2)

(from 2014 Technology Update)

Need to strike balance between low risk of loading affected fuel against testing purpose

## Breakaway Oxidation Testing

Most likely test conducted on a go/no-go basis, i.e. stop at preset time.

Test time same or longer than approved time, e.g. xxxx s.

May be feasible to measure time for breakaway onset, e.g. up to 5000 s if using commercial online TGA system.

Cladding specification revised (GNF internal) to meet GESTAR requirement

Manufacture Quality determines, with Engineering approval, test frequency depending on size of database

- Expect high frequency initially, but lower frequency as process capability is established
- Typically test replicates (rather than 5 per DG-1263)

Note: Testing for breakaway oxid. Is NOT like corrosion testing (uniform or nodular) where multiple samples (>100 ASTM lots) could be tested at a time.



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# Breakaway Oxidation Program (3)

(from 2014 Technology Update)

## Breakaway Oxidation Data

All test data will show pass, i.e. meet spec requirement

GNF/GEH internal process to provide test data related to cladding used in reload to LOCA group

Test data assessed to confirm cladding remains consistent with LOCA analysis; Statement provided to customer

Summary of test data to be reported to NRC during annual technology update or separate report

Test data will be available for NRC audit





# Comment on ASTM Lot

Tied to ingot and final furnace charge for given cladding design:

- Ingot for chemistry
- Furnace run/charge for properties that depended on microstructure (e.g. mechanical properties, grain size) set by furnace anneal

Breakaway oxidation onset is NOT known to be influenced by annealing. Testing tied to furnace charge is not justified.

Recommend testing requirement be commensurate with knowledge of factors affecting early breakaway oxidation.

- Each furnace charge typically less than 1000 tubes.
- GNF has experience with > 800 ASTM lots per year  
→ 800 days of testing per year assuming 2 tests/lot and 2 tests/day.



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# Remaining Breakaway Oxidation Concerns

- Selective adaptation of proposed alternatives results in shortfall of the rule:
  - Testing and reporting requirements changed from licensees to vendors, but
  - Vendor alternative QA programs abating causal factors ignored
    - Chemical Effects -> can be avoided, **tested at the ingot level/basis** (eventually relaxed)
    - Surface contamination effect -> can be avoided, **no testing is required**
    - Surface-finishing Effects -> addressed by process control, **no testing is required**
- Excessive amount of testing
  - Appears to be assuming 'breakaway oxidation' could creep into process – knowledge on causal factors is ignored.
  - Current proposal: more than ~1600 tests/year for GNF (from #of ASTM lots and 2/lot)
  - More onerous than any other testing applied in fuel fabrication.
- Frequency should be flexible as *endless* data is collected.



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# Hydrogen Model

Based on “50.46c Implementation: Cladding Hydrogen Uptake Models”

- GEH/GNF welcomes provision of default hydrogen model
- Burnup dependent model for BWR on slide 7
- Application of +2-sigma
- Range of Applicability: new issue introduced on oxide spallation



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# Comments and Questions

