United States Nuclear Regulatory Commission

# NRC PLANS TO REVISE THE *LOCA* REGULATION 10 CFR 50.46

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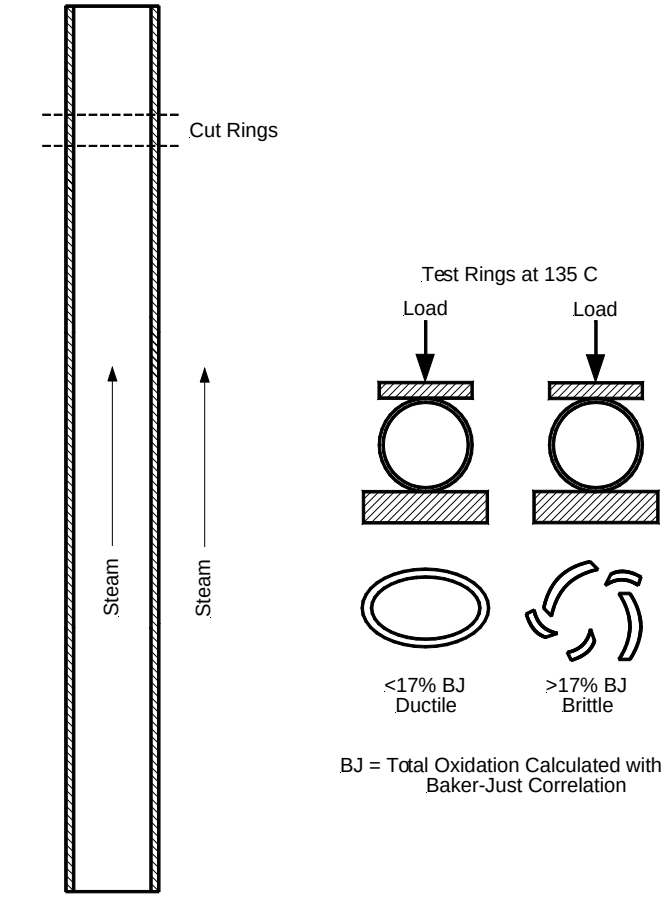
## CURRENT FORM OF EMBRITTLEMENT CRITERIA IN 10 CFR 50.46

(1) Peak cladding temperature shall not exceed 2200$^{o}$F (1204$^{o}$C)

(2) Maximum cladding oxidation shall nowhere exceed 17% of cladding thickness
- Includes ruptured cladding balloons, with double-sided oxidation
- Corrosion thickness should be subtracted from 17% (“total oxidation”)

These criteria only apply to Zircaloy and ZIRLO cladding.

# RING-COMPRESSION TESTING SCHEME



## BASIS FOR EMBRITTLEMENT CRITERIA IN 50.46

Maintain coolable geometry

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Keep fuel pellets inside the cladding

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Don’t let the cladding fragment or break in several pieces

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Retain some **ductility** in the cladding

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Limit cladding oxidation and temperature

## TYPES OF DATA BEING GENERATED IN CURRENT PROGRAM AT ANL

- Ductility tests (ring-compression tests) to determine the dependence of ductility on burnup, corrosion, and alloy type — similar to original approach
- Integral tests, followed by bend-to-failure testing, to confirm that application of ductility data to ballooned region achieves objective (Do you retain sufficient ductility if you follow directions in 50.46 and Appendix K?)
- Oxidation tests to see if burnup, corrosion, and alloy type affect kinetics correlations
- Current data base for resolution includes (a) high-burnup rods with Zircaloy cladding and (b) unirradiated M5 and ZIRLO cladding
- Future data base for confirming burnup behavior and developing a pre-hydrided surrogate will use high-burnup fuel with M5 and ZIRLO cladding, subject to the availability of fuel rods and the continued cooperation of the industry

## PLAN FOR CONFIRMED AND GRANDFATHERED RULE

- Data are being generated for Zircaloy (high burnup and unirradiated), ZIRLO (unirradiated), and M5 (unirradiated) cladding to determine if sufficient ductility is retained in the ballooned region when the current embrittlement criteria (17%, 2200$^{o}$F) are applied (including the corrosion subtraction).

- Irradiation effects (largely due to corrosion) in ZIRLO and M5 will be assumed to be the same as in Zircaloy, for a given amount of corrosion.

- This determination would apply for burnups up to at least 62 GWd/t and corrosion up to at least 100μ.

- If the the current embrittlement criteria (including the corrosion subtraction and perhaps the Baker-Just correlation for ECR only) are confirmed to be adequate, these criteria could be grandfathered in the new rule.

- M5 could then be added to the grandfathered part of the rule because equivalent data are being taken for M5 as for ZIRLO.

- Additional confirmation would be needed subsequently to make sure that high-burnup ZIRLO and M5 behave as assumed from current testing (not needed before rulemaking).

## PLAN FOR OPTIONAL PERFORMANCE-BASED EMBRITTLEMENT CRITERIA

- Ring-compression tests, which are being used for the confirmatory activity, are being considered as a general test for all alloys, burnups, and corrosion thicknesses.
- Ring compression tests might be used to find the temperature and oxidation conditions corresponding to zero ductility.
- A test procedure with acceptable results could be specified in 50.46 instead of fixed values for temperature and oxidation limits (details in a Regulatory Guide).
- Appropriate temperature and oxidation limits could be determined from this performance-based procedure by the fuel manufacturer for use in LOCA safety analyses.
- These limits would be expected to be a function of burnup (or corrosion), and corrosion would not have to be subtracted as in the grandfathered part.
- Because this performance-based procedure would permit cladding temperatures above 2200$^{o}$F, an independent temperature limit might be needed to ensure against runaway temperatures from excessive metal-water reaction heat.

Note: Metal-water heat calculated by Baker-Just at 2200$^{o}$F equals metal-water heat calculated by Cathcart-Pawel at 2307$^{o}$F (discussion in RIL-0202).

## SCHEDULE

- Formal NRC schedule to complete technical basis for rulemaking by September 2005
- Rulemaking would start shortly thereafter

## BACKGROUND DOCUMENTS

W. D. Travers (NRC) memo to the NRC Commissioners, “Update to SECY-010133, ‘Fourth Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.46 (ECCS Acceptance Criteria)’,” March 29, 2002 (NRC Adams ML020660607).

A. C. Thadani (NRC) memo to S. J. Collins (NRC), “Research Information Letter 0202, Revision of 10 CFR 50.46 and Appendix K,” June 20, 2002 (NRC Adams ML021720744).

A. L. Vietti-Cook (NRC) memo to W. D. Travers (NRC) ,”Staff Requirements — SECY-02-0057 — Update to SECY-01-0133, ‘Fourth Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.46 (ECCS Acceptance Criteria)’,” March 31, 2003 (NRC Adams ML030910476).

F. Eltawila (NRC) letter to R. L. Yang (EPRI), [basis for embrittlement criteria in 10 CFR 50.46], February 25, 2004 (NRC Adams ML040570034).