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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NOS. 50-445 AND 50-446
TOPICAL REPORT ERX-2001-005

REF: TXU Electric Letter, logged TXX-01171, from C. L. Terry to the NRC dated October 8, 2001

Gentlemen:

Per the above referenced letter, TXU Electric submitted topical report, ERX-2001-005-NP, "ZIRLO™ Cladding and Boron Coating Models for TXU Electric's Loss of Coolant Accident Analysis Methodologies." This topical report was provided to the NRC on the CPSES Dockets in order to facilitate NRR reviews of the topical report. Subsequent to TXU Electric phone conversations with personnel from NRR and Westinghouse Electric Company, LLC, it was determined that additional information may be categorized as non-proprietary.

Please supplement topical report ERX-2001-005-NP, "ZIRLO™ Cladding and Boron Coating Models for TXU Electric's Loss of Coolant Accident Analysis Methodologies" with the attached pages.

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Should you have any questions, please contact Mr. J. D. Seawright at (254) 897-0140 or jseawright@txu.com.

This communication contains no new licensing basis commitments regarding CPSES Units 1 and 2.

Sincerely,

C. L. Terry

By: Roger D. Walker

Roger D. Walker
Regulatory Affairs Manager

JDS/js

Attachment

c - E. W. Merschoff, Region IV
C. E. Johnson, Region IV
D. H. Jaffe, NRR
Resident Inspectors, CPSES

# Attachment to TXX-01205

Pages: 2-2, 2-27, 2-28, 2-29, 2-36, 2-37, 2-38, 2-39, 2-40, 2-41, 2-42, 2-43, 2-44, 2-45, 2-46, 2-47, 2-48, 2-49, 3-2

difference requires that a few of the Zircaloy-4 material property models be modified to more appropriately represent ZIRLO™. Specifically, the models for specific heat, cladding creep, cladding rupture temperature and strain, and assembly blockage following rupture were modified to represent ZIRLO™ in the Appendix K evaluation models.

Westinghouse also demonstrated that the use of the Baker-Just model for the calculation of the metal-water reaction rate, which is a required feature of Appendix K evaluation models, is suitably conservative for ZIRLO™ cladding. Accordingly, the TXU Electric evaluation models retain use of the Baker-Just model.

Lastly, it is noted that 10 CFR 50.46, which identifies the ECCS acceptance criteria, has been revised to extend the applicability of the criteria to fuel that is clad with ZIRLO™ cladding. Consequently, no exemptions to 10 CFR 50.46 or Appendix K thereto are needed to apply the criteria to the new analyses.

## 2.2 CLADDING MATERIAL-RELATED MODELS IN THE TXU ELECTRIC LOCA METHODOLOGIES

The current NRC-approved TXU Electric ECCS performance evaluation models are TXU's version of Framatome ANP, Inc.'s (Framatome) SEM/PWR-98 (References 1 and 2) for LBLOCA and TXU's version of Framatome's EXEM PWR Small Break Model (References 5 and 6) for SBLOCA.

### 2.3.9 METAL-WATER REACTION

Westinghouse also demonstrated that the use of the Baker-Just model for the calculation of the metal-water reaction rate, which is a required feature of Appendix K Evaluation Models, is conservative for ZIRLO™. (See Section 5.2.1, page 33 of Reference 3 and Figure 5.-5 in Section 5.2.1, page 42 of Reference 3, which shows ZIRLO™ reaction rates are lower that those of Zircaloy-4 cladding). Although Westinghouse developed a new model in order to take advantage of improved behavior for ZIRLO™, the TXU Electric Evaluation Models conservatively continue to use the Baker-Just model for ZIRLO™ as well as for Zircaloy-4 for both large and small break LOCAs, consistent with CE's approach (Reference 4).

### 2.3.10 CLADDING GROWTH AND CREEP

This section deals with the impact of cladding creep and axial growth on LOCA analysis only. While these effects can be very important for fuel design, that scope remains the responsibility of the fuel vendor. Fuel design considerations (e.g., fatigue, corrosion, most implications of creep and growth, etc.) are not required for ECCS Evaluation Models and therefore are not within the scope of this report.

Cladding creep and axial growth do not have a significant impact on LOCA limits for CPSES because they affect cladding dimensions over time, i.e., they affect the initial conditions for the accident but not the accident progression itself. For this reason, cladding creep and axial growth need to be addressed only for RODEX2. None of the other codes in either the small

or large break LOCA methodologies include creep or axial growth models. Furthermore, cladding creep and axial growth have little or no effect on beginning of life LOCA analyses, which have historically been the most limiting for CPSES. Therefore, the cladding creep and axial growth models in RODEX2 need not be as elaborate as the vendor's fuel ZIRLO™ - specific models (e.g. PAD 4.0) which are used for fuel design applications. Thus, the cladding creep and axial growth Zircalloy-4 models in RODEX2 were changed in a manner similar to what was done by Westinghouse to model ZIRLO™ in PAD 3.4 (Reference 10) for LOCA applications.

2.3.10.1 Implementation in RODEX2

The first change made in RODEX2 was to apply a factor [ ]$^{a,c}$ to the ZIRLO™ to Zircaloy-4 clad creepdown ratio. As described in Section B.3.1 of Reference 3, the [ ]$^{a,c}$ factor is justified in Figure B-1 of Reference 3 which shows data for the North Anna plant indicating that the ZIRLO™ to Zircaloy-4 creepdown ratio is well approximated by a [ ]$^{a,c}$ . This factor was used in PAD 3.4 to obtain quantitative predictions of other ZIRLO™ creepdown data. These quantitative comparisons verify that a ZIRLO™ total in reactor creep ratio of [ ]$^{a,c}$ relative to the Zircaloy-4 creep model gives a good prediction of the North Anna ZIRLO™ creepdown data, with a measured to predicted ratio of [ ]$^{a,c}$. A predicted to measured plot is shown as Figure B-2 of Reference 3.

The second change was to apply a factor [ ]$^{a,c}$ to the ZIRLO™ to Zircaloy-4 clad irradiation growth ratio. As described in Section B.3.2 of Reference 3, Westinghouse obtained

clad growth data for BR-3 and North Anna ZIRLO™ rods. The data were evaluated for comparison with the PAD 3.4 Zircaloy-4 clad growth model. The ratio of the ZIRLO™ rod growth data to the Zircaloy-4 rod growth model is plotted versus fluence on Figure B.3 of Reference 3. That figure shows that although there is scatter in the ZIRLO™ - to - Zircaloy-4 rod growth ratio, the ZIRLO™ growth is uniformly less than the Zircaloy-4 growth, and there is no clear trend in the [ ]$^{a,c}$. Based on this data, the ZIRLO™ rod growth model for fuel performance was considered to be approximately [ ]$^{a,c}$ of the Zircaloy-4 growth model.

The RODEX2 Zircaloy-4 creep rate equation is given in Reference 2 (Section 3-5.1):

$$\epsilon_g = \epsilon_{g\ th\ cr} + \epsilon_{g\ irr\ cr}$$

where,

{ }

and,

{ }

Both $k_{th}$ and $k_{irr}$ are constants. Based on the ZIRLO™ to Zircaloy-4 creep ratio discussed above, [ ]$^{a,c}$, it is necessary to adjust the creep rates in the RODEX2 model above as follows:

$k_{th,Zirlo} = (0.8)^{1/2} \cdot k_{th,Zircaloy}$ and,

$k_{irr,Zirlo} = 0.8 \cdot k_{irr,Zircaloy}$

Note that [ ]$^{a,c}$ is an overall factor that applies to thermal as well as to irradiation creep (Reference 9). From Table 3.9 of Reference 2, the following constants then need to be changed in RODEX2 to represent ZIRLO™ creep rates:

Figure 2.3

Zircaloy-4 Heat Capacity

a, b, c

Figure 2.4

ZIRLO™Heat Capacity

a, b, c

Figure 2.5

Thermal Conductivity - 1

[ ] a, b, c

Figure 2.6

Thermal Conductivity - 2

a, b, c

Figure 2.7

Thermal Conductivity - 3

a, b, c

Figure 2.8

Thermal Expansion - 1

a, b, c

Figure 2.9

Thermal Expansion - 2

a, b, c

Figure 2.10

Modulus of Elasticity - 1

[ ] a, b, c

Figure 2.11

Modulus of Elasticity - 2

[ ] a, b, c

Figure 2.12

Poisson's Ratio

a, b, c

Figure 2.13

Clad Emissivity

a, b, c

Figure 2.14

ZIRLO™ NUREG-0630 Burst Temperature Model

as Implemented in TXU Electric's Methodologies

[ ]a, b, c

Figure 2.15

ZIRLO™ Burst Temperature Model versus Hoop Stress

as Implemented in TXU Electric's Methodologies

a, b, c

[ ]a,c

Where, [ ]a,c loading in gm/in, [ ]a,c is the fraction of the He produced by the boron (n,α) reaction which is released to the fuel rod void volume. Both are design inputs provided by the fuel vendor (Westinghouse). [ ]a,c is the fractional depletion of the boron coating, which is given by:

[ ]a,b,c

The actual number of moles of He produced can be obtained by multiplying the calculated moles/in by the length of the coated region of the fuel [ ]a,c. This [ ]a,b,c is also a design input provided by the fuel vendor (Westinghouse).

It would be a simple matter to modify RODEX2 to internally calculate and add this amount of He. However, instead of modifying this code, TXU Electric has elected to correct the number of moles calculated by RODEX2 by adding the He moles calculated manually (or by a utility code) using the above formulae and to input the corrected number of moles into the next steps (codes) in the LOCA methodology. This approach was tested by making two runs with the PAD 3.4 code. In the base case (case 9 in Table 4.1), the nominal values for the coating variables were input, and the code was allowed to calculate all fuel rod initial conditions which were then fed into the rest of the LBLOCA methodology. The PCT was then calculated. In the test case (case 6 in Table 4.1), the coating variables were set to zero, as they would be in