Commonwealth Edison Company
1400 Opus Place
Downers Grove, IL 60515

ComEd

September 8, 1995

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attn: Document Control Desk

Subject: Additional Information Regarding Commonwealth Edison Company's Request to Increase the Interim Plugging Criteria for Byron Unit 1 and Braidwood Unit 1
NRC Docket Numbers 50-454 and 50-456

Reference: September 7, 1995, Commonwealth Edison Company Meeting with the Nuclear Regulatory Commission Regarding the Hydrodynamic Load Model

At the reference meeting Commonwealth Edison Company (ComEd) discussed with the Nuclear Regulatory Commission (NRC) the hydrodynamic load models that were submitted to the Staff in support of Byron and Braidwood's request to increase the interim plugging criteria (IPC) to 3 volts. During this meeting the Staff requested more information regarding the calculation of crossflow resistance in the ComEd RELAP model. Enclosed is the requested information.

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If you have any questions concerning this, please contact this office.

Sincerely,

for Denise M. Saccomando
Nuclear Licensing Administrator

cc: D. Lynch, Senior Project Manager-NRR
R. Assa, Braidwood Project Manager-NRR
G. Dick, Byron Project Manager-NRR
S. Ray, Senior Resident Inspector-Braidwood
H. Peterson, Senior Resident Inspector-Byron
H. Miller, Regional Administrator-RIII
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Estimation of Crossflow Resistance Terms for RELAP5 Model

A review of the Westinghouse TRANFLO input/output indicated that the TRANFLO model employed a special connector type at several locations in the D4 model. This connector type is a crossflow junction, and employs a correlation to determine the flow resistance due to crossflow through the tubes. This application leads to a variable flow resistance being applied that has a functional dependence on mass flow rate through the connection. This crossflow model is applied at the TRANFLO connectors 35, 36, 39, 47, 48, 52, 54, 56, and 58. Physically these areas correspond to the entrance from the downcomer to the tube bundle, the preheater areas, and the curved section of the U-tubes near the top of the bundle. To approximate this resistance in RELAP, the Zukauskas correlation as presented in "Nuclear Systems I" Kazimi/Todreas on page 390 was used. This provided an independent check of the pressure drops developed by TRANFLO.

The method of implementing the crossflow resistance was to take the pressure drop predicted by the correlation and convert it into an equivalent K value to be added to a junction local loss coefficient (for a junction near the crossflow location). To facilitate comparison with TRANFLO generated values, the flow rates from a TRANFLO output at .57 seconds were used, along with the tube pitch, crossflow length and area, and tube size, also taken from the input "echo" of the TRANFLO results. This approach provided a crossflow resistance based on reasonably high flow rates. Since this results in the lowest K-value, due to the dependence of K value on Reynolds number (for the Zukauskas correlation, the f factor increases with decreasing Re), it represents a conservative estimate of the crossflow resistance effects.

The actual values used were calculated via a MATHCAD file. This file is attached on the following pages. As can be seen, the Zukauskas correlation compares favorably with the TRANFLO calculated pressure drops. As stated above, the most appropriate way to handle this effect would be to employ a K-value that varied with the flow rate. The use of a single point value derived at high Reynolds number flows will provide a reasonable prediction of the crossflow effects, but remain on the conservative side by predicting less pressure drop at lower flowrates.

Calculation of Crossflow Resistance Term

The crossflow resistance of the tube bundle needs to be accounted for, particularly at the U-bend portion of the tubes. This will be handled by calculating a K value to be added to the separator inlet loss coefficient, using a correlation by Zukauskas obtained from p390 of "Nuclear Systems I" Kazimi/Todreas. The values for crossflow length and area are taken from the TRANFLO output previously provided.

$g := 32.2$

$\rho := 45.5$ Density of fluid

$\mu := 19.7 \cdot 10^{-7} \cdot g$ viscosity of sat liq at 1000 psi

$D := .1234$ hydraulic dia from TRANFLO INPUT

$G := \frac{11000}{36.39}$ Mass flux from TRANFLO Output at .57 sec

$S := \frac{.0885}{\left(\frac{.75}{12}\right)}$ $S = 1.416$ Tube lattice aspect pitch over dia

$Re := G \cdot \frac{D}{\mu}$ $Re = 5.88 \cdot 10^{5}$ Reynolds number needed to obtain f

$f := 0.24$ f-factor from figure

$Z := 1$ square lattice, no Z correction

$N := \frac{4.25}{.0885}$ number of rows of tubes, estimate by crossflow junction length/pitch

$DP := \frac{f \cdot N \cdot G^2}{2 \cdot \rho \cdot 144 \cdot g} \cdot Z$ DP at estimated flow

$DP = 2.496$

At a flow of 11000 lb/sec the expected dp is about 2.5 psi. This compares with the TRANFLO generated dp of 2.84 at .57 seconds. Now need to convert this dp into a K value to be added to the separator inlet.

$A_{sep} := 22.01$ $W := 11000$

$K := \frac{DP \cdot A_{sep}^{2} \cdot 144 \cdot g \cdot 2 \cdot \rho}{W^2}$

$K = 4.216$

This is added to the losses associated with the junction between 102 and 135-5.

Similarly for the entrance to the tube bundle

$g := 32.2$

$\rho := 45.5$

$\mu := 19.7 \cdot 10^{-7} \cdot g$

$D := .1234$

$$G := \frac{2600}{1.559}$$

$$Re := G \cdot \frac{D}{\mu} \qquad Re = 3.244 \cdot 10^{6}$$

$$S := \frac{.0885}{\left(\frac{.75}{12}\right)} \qquad S = 1.416$$

$f := 0.24$

$Z := 1$

$$N := \frac{1.107}{.0885}$$

$$DP := \frac{f \cdot N \cdot G^{2}}{2 \cdot \rho \cdot 144 \cdot g} \cdot Z$$

$DP = 19.788$

At a flow of 2600 lb/sec the expected dp is about 19.7 psi. This compares with the TRANFLO generated dp of 18 at .57 seconds. Now need to convert this dp into a K value to be added to the downcomer inlet.

$A_{in} := 5.7356$

$W := 2600$

$$K := \frac{DP \cdot A_{in}^{2} \cdot 144 \cdot g \cdot 2 \cdot \rho}{W^{2}}$$

$K = 40.633$

This is being added to the junction between the downcomer and the entrance regions to the tube region 112-5 to 100.

Similarly for connector 52

$g := 32.2$

$\rho := 45.5$

$\mu := 19.7 \cdot 10^{-7} \cdot g$

$D := .1234$

$G := \frac{830}{4.2478}$

$Re := G \cdot \frac{D}{\mu}$ $\qquad Re = 3.801 \cdot 10^{5}$

$S := \frac{.0885}{\left(\frac{.75}{12}\right)}$ $\qquad S = 1.416$

$f := 0.24$

$N := \frac{4.0729}{.0885}$

$Z := 1$

$DP := \frac{f \cdot N \cdot G^{2}}{2 \cdot \rho \cdot 144 \cdot g} \cdot Z$

$DP = 0.999$

At a flow of 830 lb/sec the expected dp is about 1 psi. This compares with the TRANFLO generated dp of 1.038 at .57 seconds. Now need to convert this dp into a K value to be added to the preheater junctions.

$A_{in} := 4.2478$

$W := 830$

$K := \frac{DP \cdot A_{in}^{2} \cdot 144 \cdot g \cdot 2 \cdot \rho}{W^{2}}$

$K = 11.045$

This value will be used for connector 56 as well as connector 54/58 due to similarity.In the RELAP model these junctions are in volume 133 and the entrance to 133.