BW

B&W NUCLEAR TECHNOLOGIES

Rec'd 2/6/90

3315 Old Forest Road
P.O. Box 10935
Lynchburg, VA 24506-0935
Telephone: 804-385-2000
Telecopy: 804-385-3663

January 30, 1990
JHT/90-9

Mrs. Valeria Wilson, Chief
Administration Section
Planning, Program and Management Support Branch
Program Management, Policy Development and Analysis Staff
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: RELAP5/MOD2 Topical Report, BAW-10168P

Dear Mrs. Wilson:

During recent conservations between the NRC, INEL, and the B&W Fuel Company, a potential deficiency in the data supporting the application of the McEligot heat transfer correlation within RELAP5/MOD2-B&W code has been discussed. The attachment to this letter provides additional material, addressing the area of concern, that can be used in evaluating the application of the correlation.

Yours truly,
C J McPhatter
for
J. H. Taylor, Manager
Licensing Services

cc: Gene Hsii, NRC
R. C. Jones, NRC
R. B. Borsum
T. L. Baldwin

T010
1/1

Justification for the Use of the McEligot Heat Transfer Correlation for Reynolds Numbers Less Than 2000

The following supplemental information is being supplied in support of the RELAP5/MOD2-B&W computer code documented in BAW-10168. The topical and other supportive material filed to date do not provide data to support the use of the McEligot heat transfer correlation for Reynolds numbers less than 2000. According to 2.3.3-66 of BAW-10168 the McEligot correlation may be used at Reynolds numbers as low as 800. This leaves a range from 800 to 2000 over which the correlation may be applied but for which the support data had not been supplied. Data within that range has been taken by Oak Ridge and reported in reference 1. Both the data, which extends to Reynolds numbers as low as 1100, and the trend of the data support the extension of the McEligot correlation down to the range at which the natural convection correlation is applied.

The Dittus-Boelter correlation and the McEligot correlation are essentially the same except that the leading normalization factor for McEligot is 10 percent less than Dittus-Boelter and the McEligot coorelation incorporates a gas temperature to wall temperature correction term. The two correlations are:

Dittus Boelter

$$h_{DB} = 0.023\ k_g/D_e\ (Re_g)^{0.8}(Pr_g)^{0.4}\ ,\ \text{and}$$

McEligot

$$h_{Mc} = 0.021\ k_g/D_e\ (Re_g)^{0.8}(Pr_g)^{0.4}(T_g/T_w)^{0.5}\ .$$

Figure 29 of reference 1, reproduced here with the McEligot correlation added as Figure 1, displays data against the Nusselt number reduced by the Prandtl number raised to the 0.4 power. Substituting into the correlations for the heat transfer coefficient they become:

$$Nu_{DB}/Pr^{0.4} = 0.023\ Re^{0.8}\ ,\ \text{and}$$

$$Nu_{Mc}/Pr^{0.4} = 0.021\ Re^{0.8}\ (T_g/T_w)^{0.5}\ .$$

Figure 1 shows the data taken by Oak Ridge for heat transfer to vapor at low Reynolds numbers along with the Dittus-Boelter correlation, the McEligot correlation evaluated at two T_g/T_w ratios, and a convective correlation of the Nusselt number set equal to four times the Prandtl number raised to the 0.4 power. This is the convective correlation selected by Oak Ridge. The convective correlation used in RELAP5/MOD2-B&W sets the Nusselt number itself to 4.0; however, because the Prandtl varies so slightly from one, at these conditions, the two convective treatments are essentially the same.

As can be seen From Figure 1, the McEligot correlation particularly with T_g/T_w at 0.8 (a reasonable number for LOCA toward the end of blowdown) fits through the data quite credibly. The cross over to free convection occurs between a Reynolds numbers of 800 to 900 depending on the gas to wall temperature ratio. Thus it is valid to extend the McEligot correlation downward, Reynolds numbers below its original data base, to the free convection regime.

References:

1. T. M. Anklam, R. J. Miller, and M. D. White; Experimental Investigations of Uncovered-Bundle Heat Transfer and Two-Phase Mixture-Level Swell Under High-Pressure Low Heat-Flux Conditions; NUREG/CR-2456, ORNL-5848; March 1982.

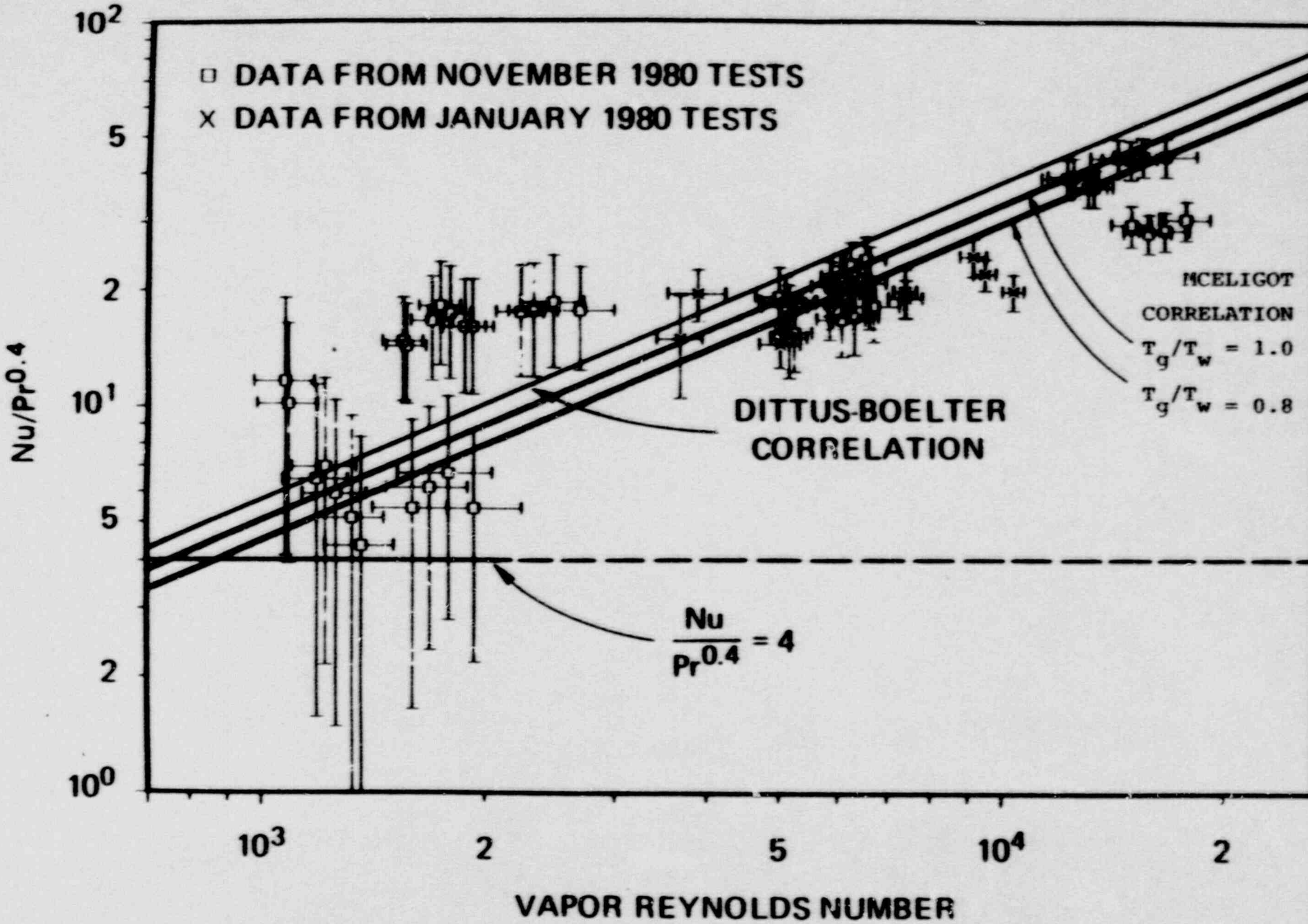

Fig. 1 . $Nu/Pr^{0.4}$ vs vapor Reynolds number; all vapor properties evaluated at vapor temperature.