SAN ONOFRE UNITS 2 AND 3

DOCKETS 50-361 and 50-362

RESPONSE TO NRC QUESTION 221.19

NON-PROPRIETARY VERSION

APRIL 25, 1979

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QUESTION 221.19 (4.4) (RSP)

It is our understanding that San Onofre 2 and 3 will use fuel assemblies with support grids which are thicker and higher than comparable grids for the 16x16 fuel design in ANO-2. Also the grid spacing has been increased relative to the grid spacing for ANO-2 by using one less grid for the bundle. The new San Onofre 2/3 fuel design is not presently described in the FSAR. The effect of these changes in grid design may be to reduce the critical heat flux for San Onofre fuel relative to that for ANO-2 and other plants which use the same grid design as ANO-2. Therefore, provide data to justify the use of the CE-1 CHF correlation for San Onofre or propose another, acceptable, correlation for use on San Onofre 2 and 3.

The test for the effects of bundle corners on CHF which have been discussed informally with CE and SCE are not appropriate to satisfy the data needed to justify the use of the CE-1 CHF correlation for San Onofre.

RESPONSE

There is a substantial body of information which justifies the use of CE-1 for the San Onofre 2 & 3 fuel assemblies. The relevant information is summarized below.

Table 1 presents dimensional data for the spacer grids of interest. [The spacer] 3.5 grid positions for Arkansas and San Onofre 2 & 3 fuel assemblies are shown in Figure 1.

A number of CHF tests conducted by CE justify the applicability of CE-1 to the San Onofre 2 & 3 fuel. The

tests were conducted in the Medium Pressure Heat Transfer Flow Loop at the Chemical Engineering Research Laboratories of Columbia University. References 1 and 3 provide a description of the test facility, basic test section hardware, and the procedures for testing and data handling.

Evidence that CE-1 is applicable for the axial grid spacing of 15.7" planned for San Onofre 2 & 3 fuel is provided by data obtained with the even larger spacing of 17.4". The bundle used in the test was a 16x16 type, 21 rod bundle (5x5 array with 4 rods replaced by CEA guide tube). Heated length was 7 feet. Uniform axial and nonuniform lateral power distributions were used. Spacer grids were representative of the Arkansas/HID-1 design. Except for the grid spacing, the test bundle was similar to the 16x16-type, 21-rod bundle used to obtain some of the CE-1 source data (reference 1). Figure 2 presents the results obtained using the CE-1 correlation and the C-E design subchannel analysis code, TORC (reference 2), to predict CHF for comparison with the measured values. The results given in Figure 2 show that CE-1 predicts CHF satisfactorily for 17.4" spacing, a spacing larger than the 15.7" spacing of the San Onofre 2 & 3 fuel.

The CHF test results discussed previously were obtained with a uniform axial power distribution. The nonuniform axial power distribution tests were conducted only for 14.2" grid spacing. However, detailed analysis of the CHF data obtained with the nonuniform axial power, 16x16 type bundles with 14.2" spacing showed that CE-1 used with the F factor (design method)

substantially underpredicts the measured CHF values (reference 3). Table 2 illustrates this with information excerpted from reference 3. The results given in Table 2 show that CE-1 underestimates the measured CHF values by approximately 25%. Those tests were conducted with an axial grid spacing of 14.2", but it is extremely unlikely that the large margin of conservatism shown by those results could be eliminated by increasing the grid spacing by 1.5" to 15.7".

It is the position of C-E that the above information justifies the application of CE-1 for fuel assemblies with grids similar to those tested and with grid spacing of 15.7" as planned for the San Onofre 2 & 3 fuel. The remaining concern involves the potential effect of grid design changes.

[ ] 3,5

The following paragraphs discuss C-E CHF test results which address the questions of effect of increase in the height and thickness of the grid strips.

[ ] 3,5

The test used an electrically heated 25 rod bundle simulating the corner region of four adjacent 16x16 fuel assemblies positioned such that the gap between them would be a minimum (see Figure 3). The test section had a 7' uniformly heated length and a nonuniform lateral power distribution as shown in Figure 3. A typical spacer grid is shown in Figure 4; the test grid geometry is identical to that of the HID-1 spacer grids which will be

used in the San Onofre 2 & 3 fuel assemblies. Axial spacing of the grids was 14.3".

Figure 5 shows a comparison of the measured values of CHF and predictions made using the TORC subchannel analysis code and the CE-1 correlation. Clearly the measured values are substantially higher than the predicted values, showing that the presence of the perimeter strips increases CHF in the subchannels on and near the periphery of the fuel assembly.

[ ] 3,5

CONCLUSION

It is the position of C-E that the available information provides sufficient justification for the use of CE-1 for predicting margin to CHF in San Onofre 2 & 3 fuel assemblies, and that no additional data are required.

REFERENCES

1. "Critical Heat Flux Correlation for C-E Fuel Assemblies with Standard Spacer Grids, Part I-Uniform Axial Power Distribution", CENPD-162-P-A and CENPD-162-A, September 1976.

2. "TORC Code, A Computer Code for Determining the Thermal Margin of a Reactor Core", CENPD-161-P and CENPD-161, July, 1975.

3. "Critical Heat Flux Corrleation for C-E Fuel Assemblies with Standard Spacer Grids, Part II - Nonuniform Axial Power Distribution", CENPD-207-P and CENPD-207, June 1976.

TABLE 1

16x16 SPACER GRID CHARACTERISTICS

	Arkansas[1]	San Onofre Units 2 and 3[1] Six HID-1	Four HID-2	16x16 Test Bundles[2]
Grid Spacing, in.	14.8	15.7		14.2 - 17.4
Perimeter Strips: Thickness, in.	[redacted]			3,5
Height, in.				
Interior Strips Thickness, in.				
Height, in.				

(1) All reactor fuel assemblies include an inconel spacer grid at the beginning of the heated length. That grid is not included in this summary.

(2) Reinforced spacer grids were used with all the 12 1/2 ft. test bundles. Reinforcement of the grids was necessary to provide adequate support for the heater rods against the high electromagnetic attractive forces which occur at high test section power levels. The method of reinforcing the grids and the justification for the use of the CHF data obtained with reinforced spacer grids are discussed in Reference 1.

(3) When used with the test grids.

TABLE 2

CE-1 CHF Prediction for Nonuniform Axial Power 16x16 Type Bundles with a 12.5' Heated Length and Standard Grids at 14.2" Spacing

	Axial Flux Shape	
	1.46 Symmetric	1.47 Top Peak
Number of CHF Data	107	106
Mean of Ratio of Measured and Predicted CHF	1.236	1.254
Standard Deviation of Measured and Predicted CHF	0.122	0.083

Figure 1.

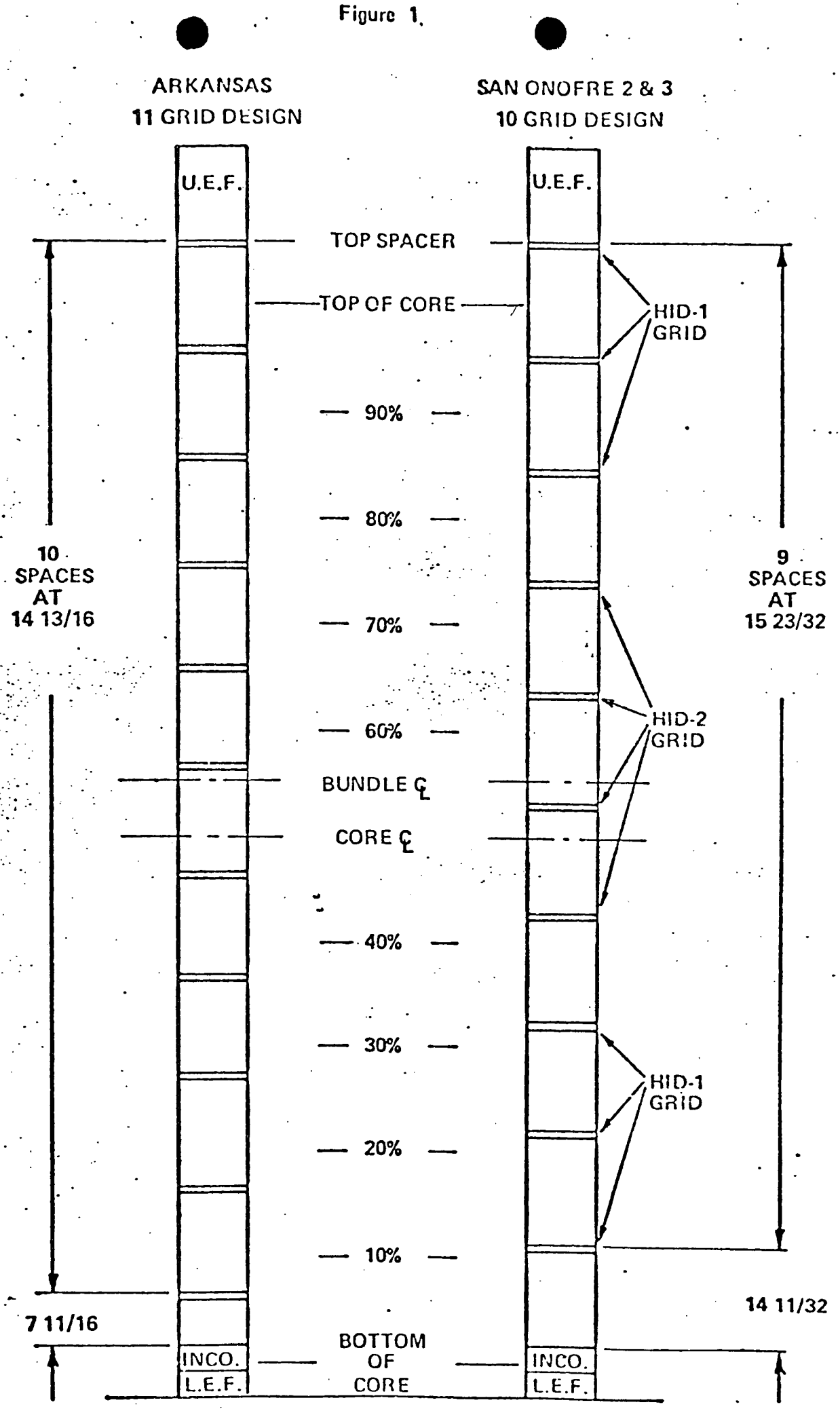

ARKANSAS
11 GRID DESIGN
SAN ONOFRE 2 & 3
10 GRID DESIGN
U.E.F.
U.E.F.
TOP SPACER
TOP OF CORE
HID-1
GRID
90%
80%
10
SPACES
AT
14 13/16
70%
9
SPACES
AT
15 23/32
HID-2
GRID
60%
BUNDLE ℄
CORE ℄
40%
30%
HID-1
GRID
20%
10%
7 11/16
14 11/32
INCO.
L.E.F.
BOTTOM
OF
CORE
INCO.
L.E.F.

Figure 2

MEASURED AND PREDICTED CRITICAL HEAT FLUXES FOR A 16 x 16-TYPE BUNDLE WITH C-E STANDARD SPACER GRIDS AT 17.4" AXIAL SPACING

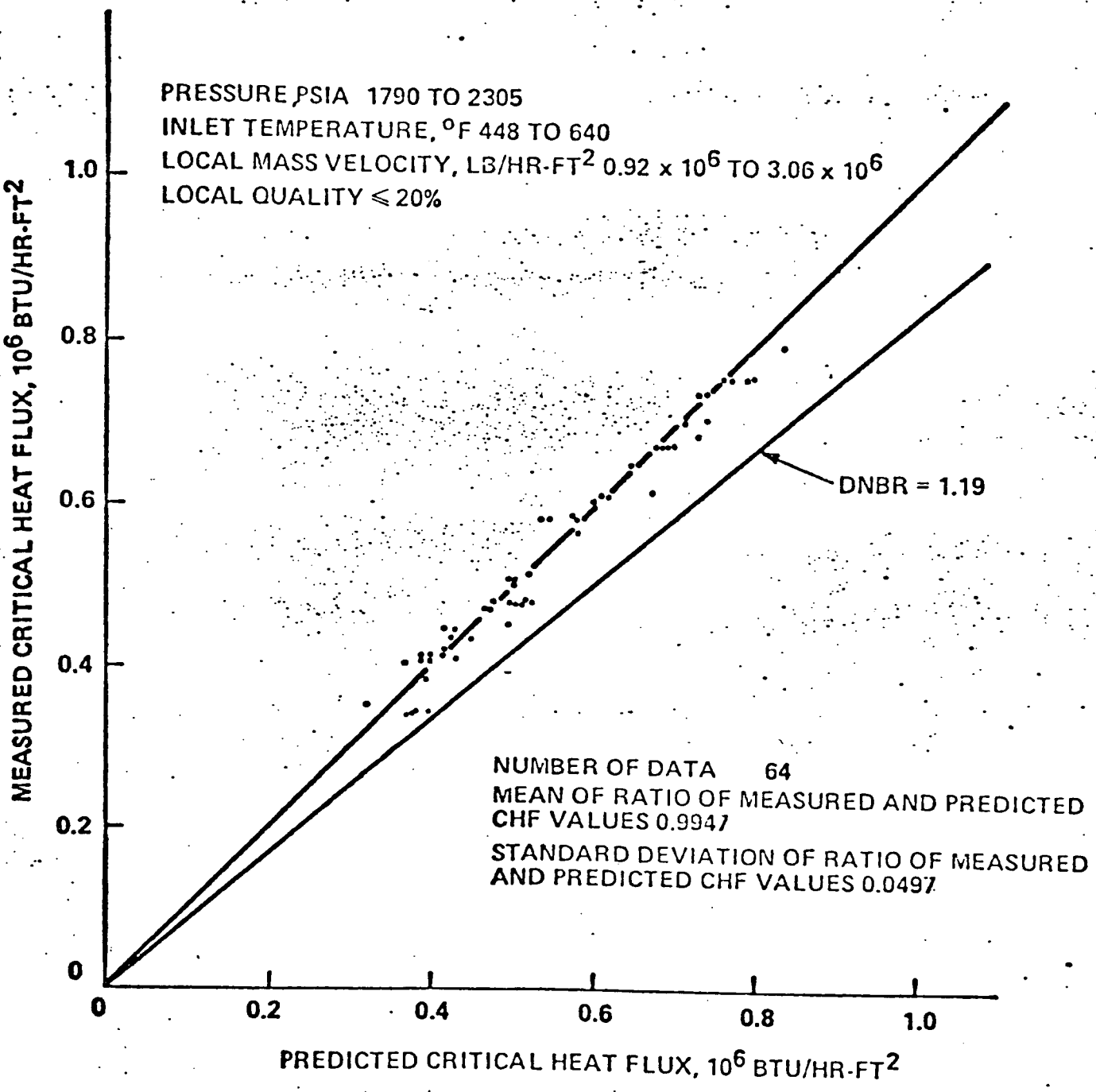


Figure 3

LATERAL GEOMETRY AND ROD POWER DISTRIBUTION

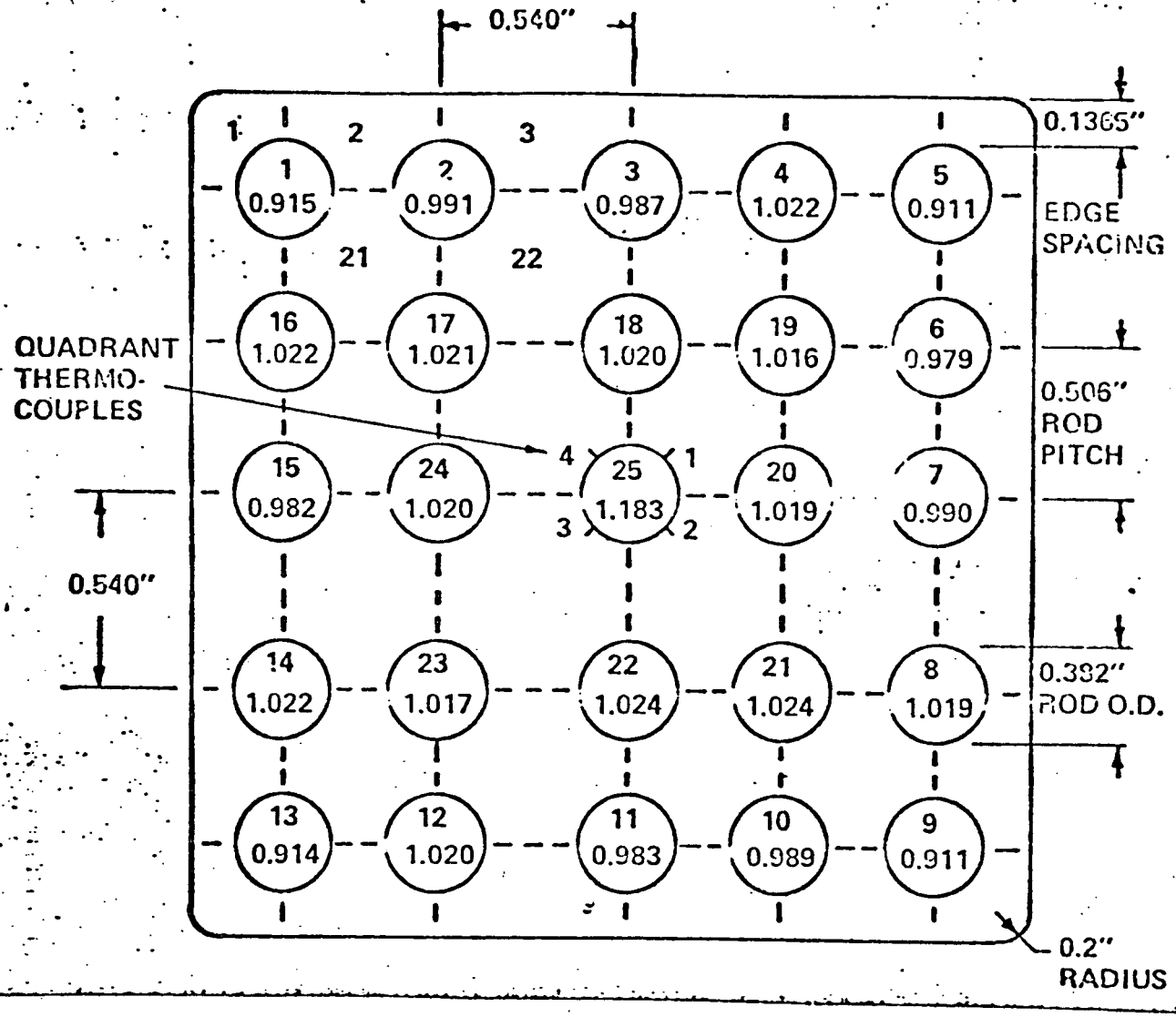


Figure 4

HID-1 SPACER GRID, SIMULATING THE CORNER REGION OF 4 ADJACENT 16 x 16 ASSEMBLIES

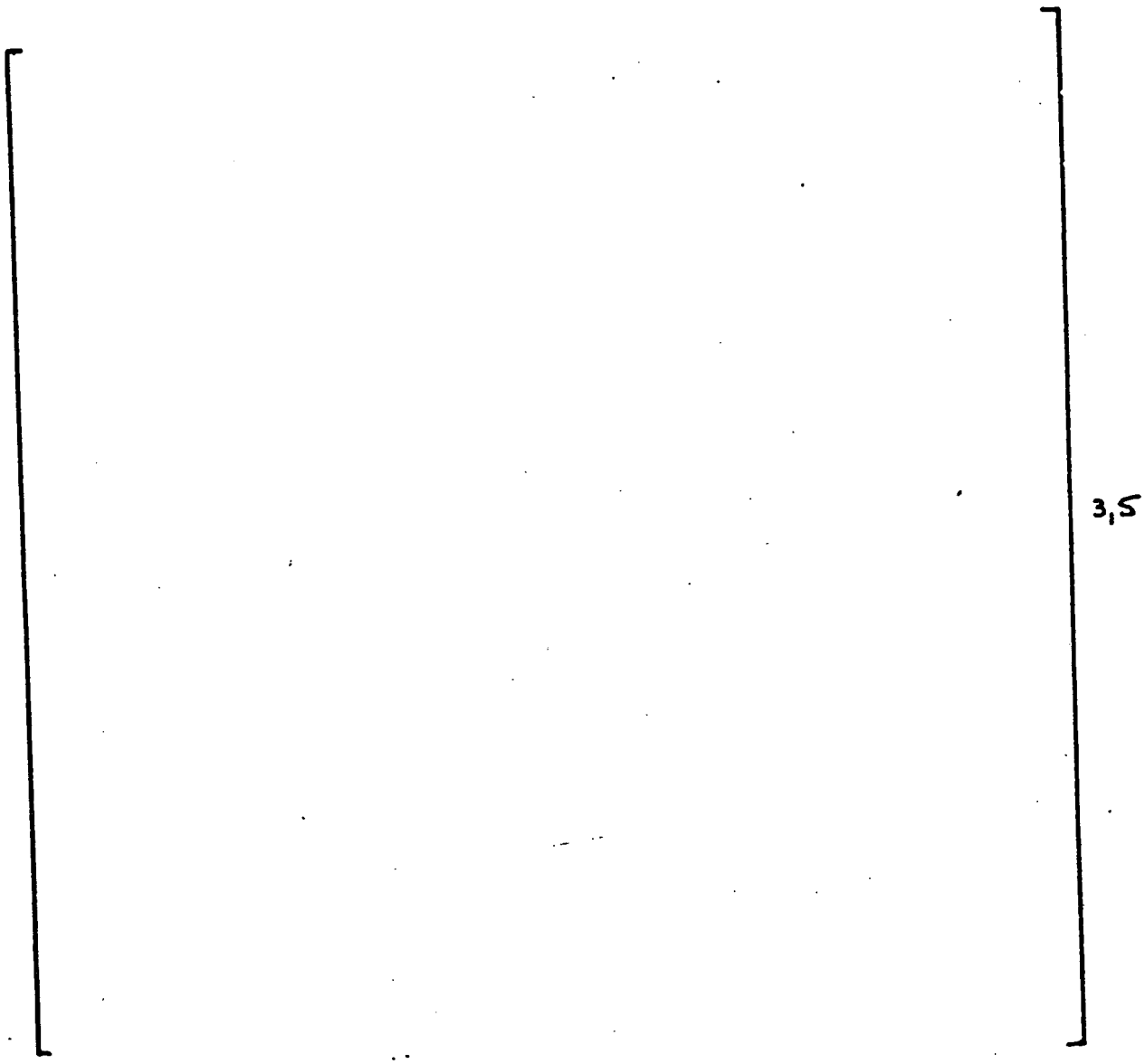
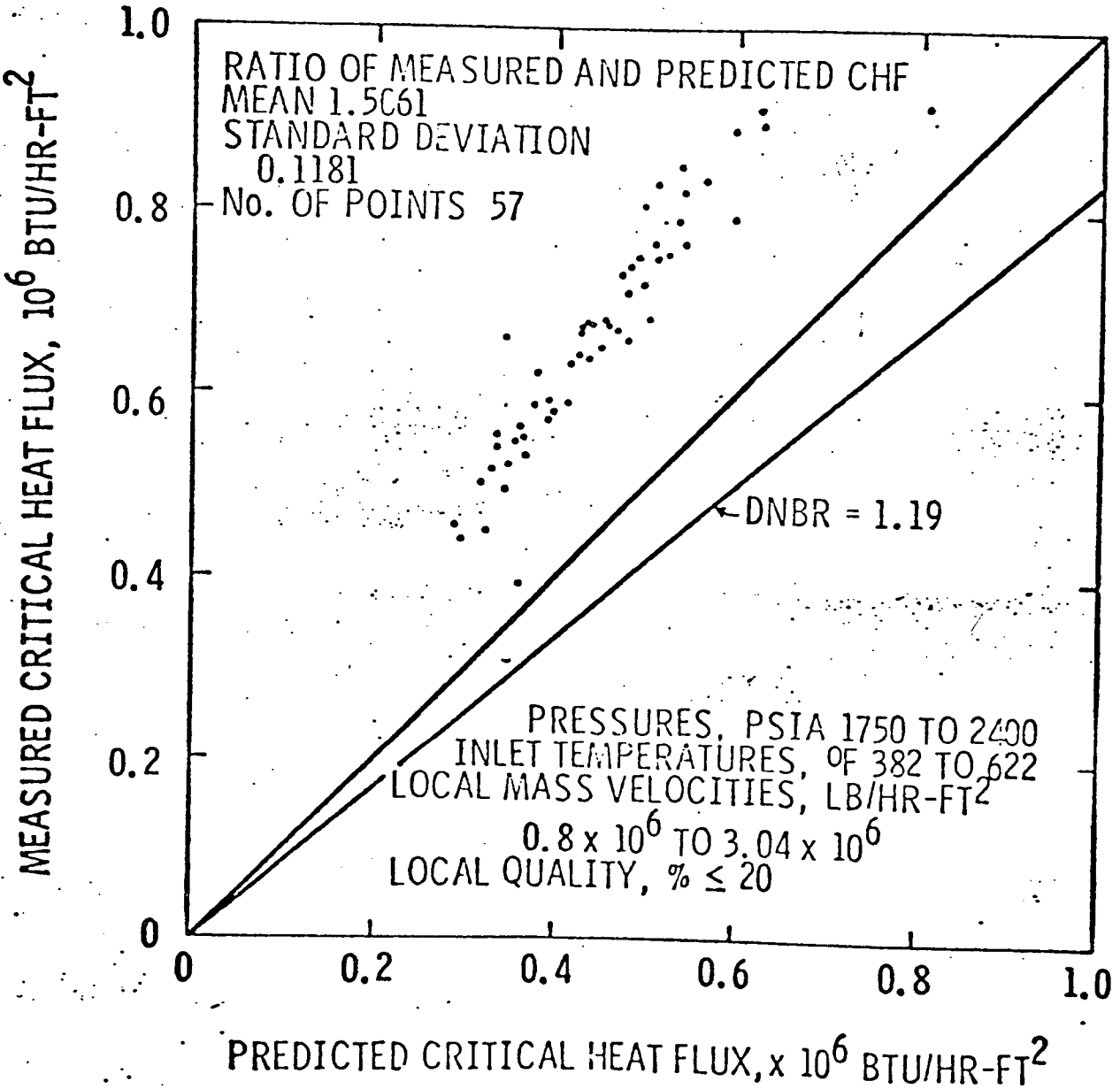


Figure 5

MEASURED AND PREDICTED CRITICAL HEAT FLUXES FOR A 16 x 16 TYPE BUNDLE REPRESENTING THE CORNER REGION OF 4 ADJACENT FUEL ASSEMBLIES



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