MAINE YANKEE ATOMIC POWER COMPANY •

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United States Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Office of Nuclear Reactor Regulation
Division of Licensing
Operating Reactors Branch #3
Mr. Robert A. Clark, Chief

References: (a) License No. DPR-36 (Docket No. 50-309)
(b) USNRC Letter to MYAPCo, dated October 22, 1982

Subject: YAEC-1296P DNBR Limit Methodology for Maine Yankee

Dear Sir:

Enclosure 1 forwards our responses to your three questions on the YAEC-1 CHF correlation in support of the Maine Yankee Cycle 7 reload.

We trust these responses clarify the issues. If you have further questions, please do not hesitate to call us.

Very truly yours,

MAINE YANKEE ATOMIC POWER COMPANY

John H Garrity

J. H. Garrity, Senior Director
Nuclear Engineering and Engineering

AJC:pjp

Enclosure 1 (10 pages)

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cc: Mr. Ronald C. Haynes
Mr. Paul A. Swetland

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Responses to NRC Questions on YAEC-1

Question #1

The nonuniform axial shape data is a composite of data from both a top-peaked and a bottom-peaked axial shape. An F-test of the equality of means and variances of the top-peaked and bottom-peaked data is highly significant, suggesting that the data should not be pooled. What is the justification for pooling the top-peaked and bottom-peaked data?

Response

The goal of the effort associated with developing the YAEC-1 was to determine a DNBR limit that would be quantitatively (95/95) derived. The 95% probability of 95% confidence level limit was to be designed to cover the complete range of operations for 14x14 Maine Yankee fuel. This would include a variety of axial power shapes in addition to many radial power distributions. The five experiments analyzed included two severe top and bottom-peaked axial power shapes (peak to average valves of 1.68) as well as three test sections with uniform axial power. These axial power distributions cover the range of plant operation. The severe top and bottom-peaked cases, however, are more typical of the limiting power distributions near the edge of the allowed operating band. It was our engineering judgment to separate the non-uniform data from the uniform in deriving the 1.17 limit. This was done based on the results of our comparisons of each data set and on the conservative nature of the predictive capability of our correlation with the COBRA code. Therefore, we believe there exists an engineering basis for categorizing the five experiments into two subsets. The DNBR limit of 1.17 was determined from the worst subset.

From a statistical point of view, the two non-uniform axial shapes show differences in means and variances. The F-Test, a basic statistical testing procedure, suggests that this data should not be combined. Therefore, there is a conflict between the engineering and statistical analysis of these experiments. However, when the worst case experiment (#58) is considered alone, the data lead to a 95/95 level DNBR limit of 1.20. We believe this limit can be acknowledged to be conservative, and therefore, in the interest of expediency a DNBR limit of 1.20 would be acceptable to Maine Yankee. However, Maine Yankee reserves the right to introduce a new submittal for limit reduction in the future.

Question #2

The significant difference between the performance of YAEC-1 on top-peaked and bottom-peaked axial shapes admits the possibility that for other axial shapes the performance may be even worse. The use of a tolerance limit implies that a sample was randomly selected from the population of interest. If "axial shape" represents a significant component of variation, and only two axial shapes were sampled, then the correspondence of sampled population and population of interest is highly unlikely. Is there any reason for regarding these two shapes as extremes? If not, what is the justification for the use of tolerance interval for setting the DNBR limit?

Response

The axial shapes analyzed are definitely extremes. Axial shapes with peak to average values of 1.68 are the normal CE design reactor shapes.

Question #3

Provide measured and predicted DNB locations, both axially and radially, for each data point.

Response

The two subsets, uniform and non-uniform axial power shapes, can be used to demonstrate radial and axial location predictive capability. The uniform axial power shape experiments provide the radial locations while the non-uniform axial power shape experiments demonstrate the axial location accuracy. This separation is due to the instrumentation of the various experiments. That is, there are azimuthally placed thermocouples at the exit of the test bundle for the uniform experiments and axially located thermocouples placed in one location radially for the non-uniform experiments.

Uniform

Figures 2.1, 2.3 and 2.5, as designated in YAEC-1296P, graphically present the radial location accuracy. Figure 2.1 shows the experimental radial location of the first indication of DNB. We limited our analysis to the first indication of DNB since this is the parameter most equivalent to minimum DNB, as required in the safety analysis. The prediction from the COBRA model for Test Section 21 is a constant Rod 24, Channel A (designated in Figure 2.1). As shown, the predominate DNB channel is accurately predicted. The rod COBRA calculates, however, is incorrect. Due to the closeness of the power peaking in the rods of interest, the fact that the first indication is incorrect is not considered a significant discrepancy.

Figure 2.3 presents the experimental DNB first indications for Test Section 36.1. The COBRA model again provides a constant indication, Rod 18, Channel A (designated in Figure 2.3). As in the previous experiment, Channel A is the predominate DNB experimental channel. This experiment also shows the only experimental DNB first indication in a non-matrix channel for the three experiments discussed in YAEC-1296P.

Figure 2.5 is the final presentation of the uniform experiments, Test Section 38. In this case, the COBRA model indication varies between Rods 20 and 21. Because of this variation, symbols describing the three possible combinations of data are utilized. These symbols are described on Figure 2.5. For this experiment, the COBRA channel indication does not provide as accurate a prediction as the previous uniform experiments. However, the prediction of a matrix subchannel as the limiting subchannel remains a valid calculation when compared to the experimental results.

In short, the change to the CE cold wall factor has altered the COBRA channel location prediction from a cold wall subchannel to a matrix subchannel. The experimental data for first DNB indiction shows an overwhelming number in the matrix subchannel (98 vs. 1 - eliminating Test Section 21 since it has no cold wall).

This provides an excellent confirmation of the YAEC-1 cold wall factor accuracy. Additionally, it should be noted that the M/P values calculated in COBRA are consistently conservative, i.e., M/P is greater than 1.0.

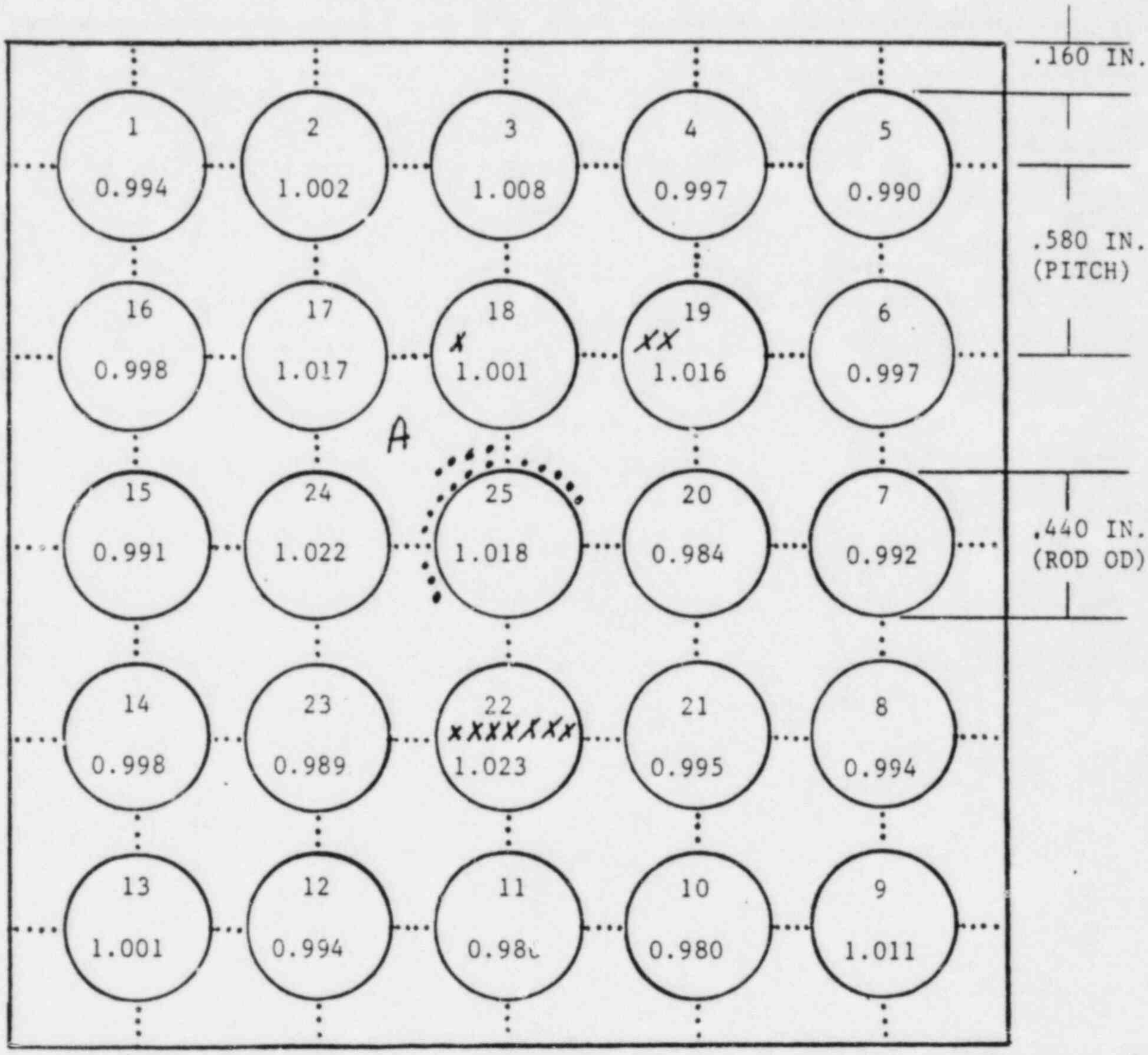
Non-Uniform

The results of the axial indication analysis are shown in two tables. The YAEC-1 consistently predicts DNB at a higher heat flux location, i.e., lower in the channel than the experimental data. It should be noted that Test Section 60, which is the more inaccurate of the two experiments, is calculating very conservative M/P values. This degree of conservatism would be expected to continue in the safety analysis applications.

FIGURE 2.1

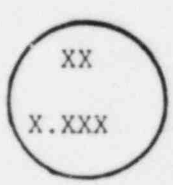
RADIAL GEOMETRY AND POWER DISTRIBUTION

TEST SECTION NUMBER 21



: Experimental Location with Azimuthally placed Thermocouples

x Experimental Location with only one Thermocouple



-----------HEATER ROD NUMBER

-----------NORMALIZED POWER FACTOR

FIGURE 2.3

RADIAL GEOMETRY AND POWER DISTRIBUTION

TEST SECTION NUMBER 36.1

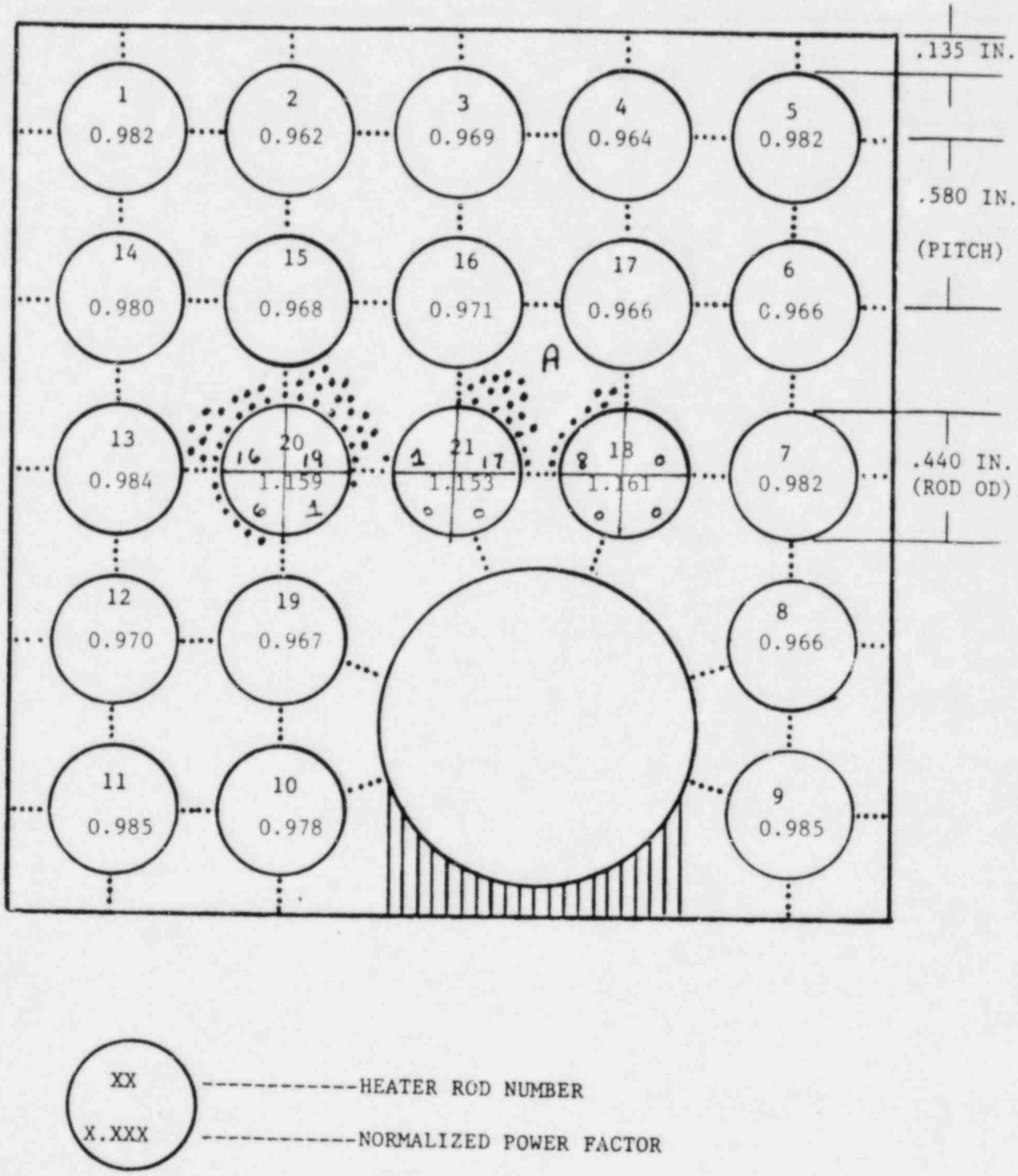
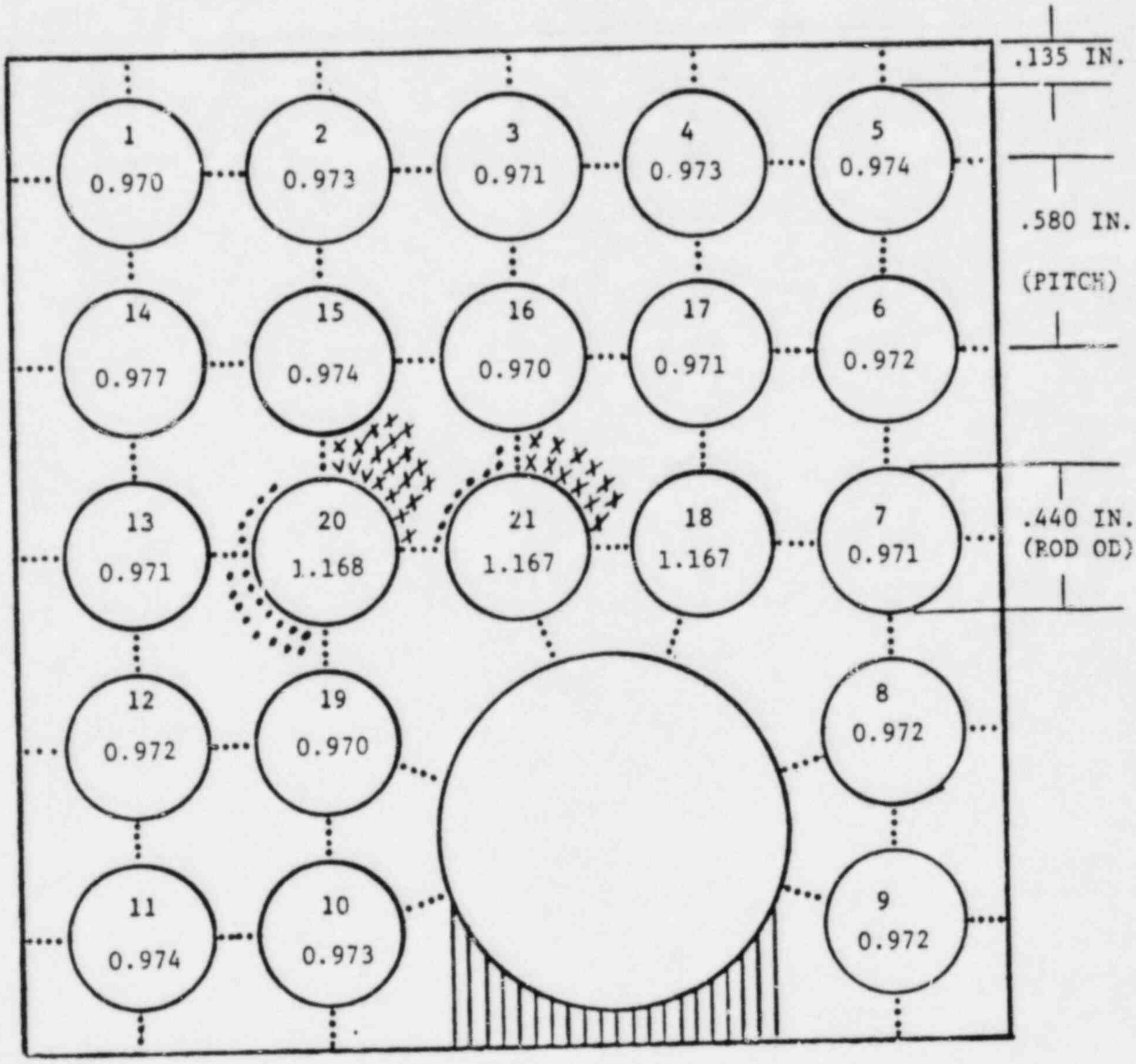


FIGURE 2.5

RADIAL GEOMETRY AND POWER DISTRIBUTION

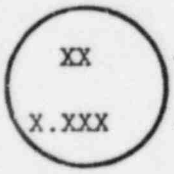
TEST SECTION NUMBER 38



• Experimental Indication

x Predicted Indication

v Agreement Between Experiment and Prediction



------------HEATER ROD NUMBER

------------NORMALIZED POWER FACTOR

TABLE 1

TEST SECTION 58

Measured Rod	Predicted Rod	Measured Location (Inches)	Predicted Location (Inches)
16	16	140.1	120.0
16	16	122.7	126.0
16	16	140.1	120.0
16	16	140.1	120.0
16	16	140.1	120.0
16	16	122.7	120.0
16	16	122.7	120.0
16	16	122.7	120.0
20	16	140.1	120.0
20	16	140.1	120.0
20	16	140.1	120.0
20	16	140.1	120.0
17	16	140.1	120.0
17	16	140.1	120.0
16	16	122.7	120.0
16	16	122.7	120.0
16	16	122.7	120.0
17	16	122.7	120.0
16	16	122.7	120.0
16	16	122.7	120.0
16	16	122.7	120.0
16	16	122.7	120.0
17	16	140.1	126.0
17	16	140.1	126.0
17	16	140.1	120.0
17	16	140.1	126.0
16	16	122.7	120.0
16	16	122.7	120.0
16	16	122.7	120.0
16	16	122.7	120.0
17	16	140.1	120.0
16	16	122.7	120.0

TABLE 1

TEST SECTION 58

(continued)

Measured Rod	Predicted Rod	Measured Location (Inches)	Predicted Location (Inches)
16	16	122.7	120.0
16	16	122.7	120.0
17	16	140.1	126.0
17	16	140.1	126.0
17	16	140.1	126.0
17	16	140.1	126.0
17	16	140.1	126.0
17	16	140.1	126.0
17	16	140.1	126.0
17	16	140.1	126.0
16	16	122.7	120.0
17	16	140.1	120.0
17	16	122.7	120.0
17	16	140.1	120.0
17	16	140.1	120.0
17	16	140.1	126.0
16	16	122.7	120.0
16	16	122.7	120.0
17	16	140.1	120.0

TABLE 2

TEST SECTION 60

Measured Rod	Predicted Rod	Measured Location (Inches)	Predicted Location (Inches)
20	18	70.45	72.0
21	18	87.85	72.0
21	18	105.25	72.0
20	18	53.05	72.0
21	18	87.85	72.0
21	18	105.25	72.0
18	18	87.85	72.0
21	18	87.85	72.0
21	18	105.25	72.0
18	18	87.85	72.0
21	18	105.25	72.0
20	18	70.45	72.0
20	18	70.45	72.0
20	18	70.45	72.0
20	18	70.45	72.0
20	18	70.45	72.0
20	18	70.45	66.0
20	18	70.45	72.0
20	18	87.85	72.0
20	18	87.85	72.0
21	18	70.45	72.0
21	18	105.25	72.0
21	18	105.25	72.0
18	18	70.45	78.0
21	18	87.85	72.0
21	18	105.25	72.0
21	18	87.85	72.0
21	18	87.85	72.0
21	18	87.85	72.0

TABLE 2

TEST SECTION 60

(continued)

Measured Rod	Predicted Rod	Measured Location (Inches)	Predicted Location (Inches)
21	18	105.25	72.0
21	18	105.25	78.0
21	18	105.25	78.0
21	18	105.25	78.0
21	18	105.25	78.0
21	18	105.25	78.0
21	18	87.85	78.0
21	18	105.25	72.0
21	18	105.25	72.0
21	18	105.25	78.0
21	18	105.25	78.0
20	18	87.85	72.0
21	18	105.25	72.0
21	18	105.25	72.0
20	18	87.85	72.0
20	18	87.85	72.0
20	18	87.85	72.0
21	18	105.25	72.0
21	18	87.85	72.0
21	18	105.25	72.0
21	18	105.25	72.0
20	18	105.25	78.0
21	18	105.25	72.0
21	18	105.25	78.0
21	18	105.25	78.0
21	18	105.25	78.0
21	18	105.25	72.0
21	18	105.25	78.0