AREVA

July 5, 2005
NRC:05:040

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Additional Information for the Review of BAW-10243(P), Revision 0, "Statistical Fuel Assembly Hold Down Methodology"

Ref. 1: Letter, James F. Mallay (Framatome ANP) to Document Control Desk (NRC), "Request for Review and Approval of BAW-10243(P), 'Statistical Fuel Assembly Hold Down Methodology,' NRC:04:053, September 21, 2004.

Ref. 2: Letter, Jerald S. Holm (Framatome ANP) to Document Control Desk (NRC), "Response to a Request for Additional Information Regarding BAW-10243(P), Revision 0, 'Statistical Fuel Assembly Hold Down Methodology,' NRC:05:027, April 15, 2005.

Framatome ANP requested the NRC's review and approval of topical report BAW-10243(P), Revision 0, "Statistical Fuel Assembly Hold Down Methodology" in Reference 1. A response to a request for additional information was provided to the NRC in Reference 2. This letter provides additional information to support that response.

Framatome ANP considers some of the material contained in the attachments to be proprietary. The affidavit submitted with the original topical report satisfies the requirements of 10 CFR 2.390(b) to support withholding of the information from public disclosure.

Sincerely,

Ronnie L. Gardner

Ronnie L. Gardner, Manager
Site Operations and Regulatory Affairs
Framatome ANP, Inc.

Attachment

cc: M. C. Honcharik
Project 728

T007

FRAMATOME ANP, INC. An AREVA and Siemens company
3315 Old Forest Road, P.O. Box 10935, Lynchburg, VA 24506-0935
Tel.: 434 832 3000 - Fax: 434 832 3840 - www.areva.com

Supplemental Information Supporting the Responses of April 15, 2005 for the Request for Additional Information

Statistical Fuel Assembly Hold Down Methodology BAW-10243P

The Monte Carlo propagation of uncertainties requires the uncertainties, to be treated, be realistically described in order to establish a realistic figure of merit for protection, in this case for the protection against fuel assembly lift off. This supplemental information includes the following, as applied in the Statistical Fuel Assembly Hold Down Methodology –

1) *a description of the basis for the propagation and estimation of uncertainties,*

2) a description of the treatment of various uncertainties,

3) representative data for some uncertainties, and

4) a Monte Carlo Propagation illustration.

Basis (Principles)

Basis for Propagation of Uncertainties

- The propagation of several distributions results in a normal distribution even if non-normal (uniform) distributions are included in this propagation.
- Uncertainties from sources other than data can be estimated in several ways. A more conservative treatment of any uncertainty is the one that results in the larger derived standard deviation or half range. Thus uncertainties derived from sources other than data must be justified as to the appropriate type of treatment.
- The spread of the distribution (resulting from the propagation) is the major determinate of the resulting figure of merit (minimum hold down force). Thus, for any given propagation statepoint, individual values either above or below the mean contribute equally to the overall variance.
- A protection level of 95 percent for any given variable uncertainty is the standard requirement in Monte Carlo Propagation of uncertainties.

Basis for Estimating Uncertainties in the Absence of Data

- The standard deviation of a normal distribution can be estimated from its range and protection level. In the following, the variable, X, is assumed normal with a symmetric half range of 6.0 (X = 100 +/- 6.0)
- A normal distribution plus or minus two sigma includes in excess of 95 percent of the population (the standard for Monte Carl Propagation). Here the example standard deviation of X is estimated as 6.0/2.0 = 3.0 and X is propagated as N[100,3.0]. This type of propagation is usually applicable to derived variable uncertainties such as bypass leakage flow.

- A normal distribution plus or minus three sigma covers in excess of 99 percent of the population. This type of propagation is usually assumed to apply to absolute variable uncertainties such as dimensional tolerances. Here the example standard deviation of X is estimated as 6.0/3.0 = 2.0 and X is propagated as N[100,2.0]. Note that this is a less strict estimation of the effective standard deviation than in the case of the 95 percent protection above and is allowed because of the absolute limits on the dimension. This type of estimation is also discussed in Reference 2, page 5-31.

- A uniform distribution describes the uncertainty of a controlled variable (such as temperature controlled by a thermostat). A uniform distribution propagates with an effective standard deviation of 58.33 percent of its half range. Here the example variable is propagated as U[100,6.0]. This propagation is effectively the same as a propagation of N[100,3.5].

Application

Using the principles discussed above, the distributions and values of various types of uncertainties can be estimated.

Variable Uncertainties with Data

- If data are available for a variable, they are checked for normality with either the D prime test from Reference 1 (50 or more data) or the W test (from 3 to 50 data) from Reference 2.

- If the data passes a normality test, the uncertainty is propagated as normal with the measured mean and standard deviation. Thus if measured data for a variable, X, was normal and resulted in a mean of 100 and a standard deviation of 2.5, X would be treated as normal with a standard deviation of 2.5 (N[100,2.5]).

- If the data fails a normality test, the measured standard deviation is penalized by the ratio of the effective uniform distribution above to that of the 95 percent protection normal distribution (3.5/3.0). Thus if measured data for a variable, X, failed the normality test, the standard deviation of 2.5 would be increased 2.92 (2.5*(3.5/3.0)) and X would be propagated as N[100,2.92].

Variables Uncertainties without Data

- Dimensional Tolerances without data are essentially "go-no go" specifications. The upper and lower bounds are never exceeded. The standard deviation can thus be estimated by assuming the 99 percent normality criterion above. Thus if X = 100 +/- 6.0, X would be treated as N[100,2.0]. This is the least restrictive treatment of variables without data.

- Other Individual Variables without data (unless they are control variables) must be treated at the more restrictive 95 percent level above. An example of this type of variable uncertainty would be a nominal, maximum and minimum weight. Thus if X = 100 +/- 6.0, X would be treated as N[100,3.0]. This is the usual treatment of variables without data.

- Derived Variable Uncertainties are the result of an engineering analysis (uncertainties on core bypass fraction, spring set, etc.) and usually include the effects of several sub variables. These uncertainties generally correspond to the standard 95 percent protection criterion. Unless a different protection level of distribution is specified, they are treated as normal plus or minus two sigma. Thus if X = 100 +/- 6.0, X would be treated as N[100,3.0].

- Control Variable Uncertainties arise when system action is initiated when either the upper of lower limit is reached. Examples are temperature (a thermostat) and pressure (a pressurizer). Since the value "drifts" between two extremes with equal probability, they are treated as uniform plus or minus their half range uncertainty. Thus if X = 100 +/- 6.0, X would be treated as U[100,6.0]. (Note that this uniform treatment is equivalent to a normal propagation of N[100,3.5] which is a 16.7 percent increase in the standard deviation derived in the case of 95 percent protection with a normal distribution.)

- Skewed, Biased or Uneven Uncertainties can sometimes be specified for each of the above uncertainty types. In this case, the derived standard deviation (normal distribution) or half range (uniform distribution) is the larger of the two calculated from the specifications. Thus X = 100 +6.0/-3.0, X as a dimension would be treated as N[100,2.0] (the standard deviation being 6.0/3.0 at 99% protection), X as a derived variable would be treated as N[100,3.0] (the standard deviation being 6.0/2.0 at 95% protection), and X as a control variable would be treated as U[100,6.0] (using the larger half range which propagates as N[100,3.5]).

References

1. "American National Standard Assessment of the Assumption of Normality," ANSI N15.15, American National Standards Institute, 1974.

2. Dan Lurie and Roger Moore, Applying Statistics, NUREG-1475, USNRC, 1994.

Representative Data

Spring Constant Uncertainty is developed from [ ] data by fitting a [ ] order polynomial in spring depression. Its distribution is normal around its predicted value with a standard deviation of [ ] percent of the predicted value.

DESCRIPTIVE STATISTICS AND D PRIME TEST

Hydraulic Lift Resistance Uncertainty is developed from [ ] form loss coefficient data again fit to a polynomial. The measured to predicted values are normal around [ ] with a standard deviation of [ ] percent of the predicted value.

DESCRIPTIVE STATISTICS AND D PRIME TEST

Fuel Assembly Height Uncertainty is estimated (in the topical report) from its mechanical dimensional specification of [ ]. It is treated as [ ]. Actual data show this to be [ ].

DESCRIPTIVE STATISTICS AND D PRIME TEST FOR NORMALITY

Free Spring Height Uncertainty is estimated (in the topical) from its mechanical dimensional specification of [ ]. It is treated as [ ]. Actual data show this to be [ ].

DESCRIPTIVE STATISTICS AND W TEST FOR NORMALITY

Monte Carlo Propagation – An Illustration

To illustrate the statistical propagation behavior, a sample propagation of 7 distributions discussed above is provided. The distributions means and standard deviations will be normalized to one and their relationship will be assumed to be [ ]. A code fragment following the results illustrates the model.

The model results in the following statistics.

```
************************************************************
****        DESCRIPTIVE STATISTICS AND D PRIME TEST      ****
************************************************************
```

[

]

COMPARING UNIFORM AND NORMAL DISTRIBUTIONS

Here we examine and confirm the models for uniform and normal distributions. Let Variable, X = 100 +/- 6

SUMMARY

RESULTING UNIFORM PROPAGATION

```
*************************************************************
****        DESCRIPTIVE STATISTICS AND D PRIME TEST      ****
*************************************************************
```

RESULTING NORMAL 2 SIGMA (95%) PROPAGATION

```
************************************************************
****       DESCRIPTIVE STATISTICS AND D PRIME TEST      ****
************************************************************
```

RESULTING NORMAL 3 SIGMA (99%) PROPAGATION

```
************************************************************
****       DESCRIPTIVE STATISTICS AND D PRIME TEST      ****
************************************************************
```