RAI-25 S02

RAI-25 S01, part "a" asked the applicant to describe the criteria used to determine whether a parameter is a "Leading Parameter." In its response, dated June 13, 2011, the applicant stated that "Leading Parameters" are those that are compared to separate effect test data. This explanation is inadequate. Please clarify the following in your response:

i) How "Leading Parameters" are chosen, and

ii) The relationship between candidate parameters, relevant parameters, and "Leading Parameters."

Response to RAI-25 S02:

i) [

]a,c

A description of how the Leading Parameters are chosen is demonstrated in the following example:

A model validation against separate effect test (SET) is performed, as shown in Figure 1. Here the x-axis represents the calculated values and the y-axis represents the corresponding experimental values.

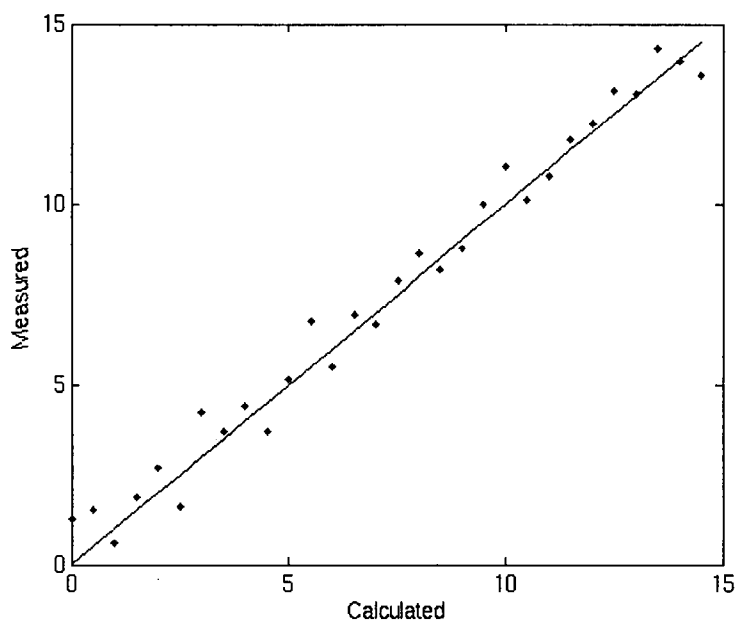

Figure 1 – Example of model validation against measurements data from separate effect test

An evaluation of model uncertainties from a validation against the SET is performed by calculating the average bias and standard deviation for parameter X (model output) as:

$$m = \frac{\sum_{i=1}^{n}\left(x_{measured,i} - x_{calculated,i}\right)}{n}$$

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(\left(x_{measured,i} - x_{calculated,i}\right)^2 - m^2\right)}$$

[

]a,c

To account for both experimental and model uncertainty, a model validation against separate effect test (SET) is performed. The calculated results are compared to experimental data that carries an uncertainty themselves (experimental uncertainty) as shown in Figure 2.

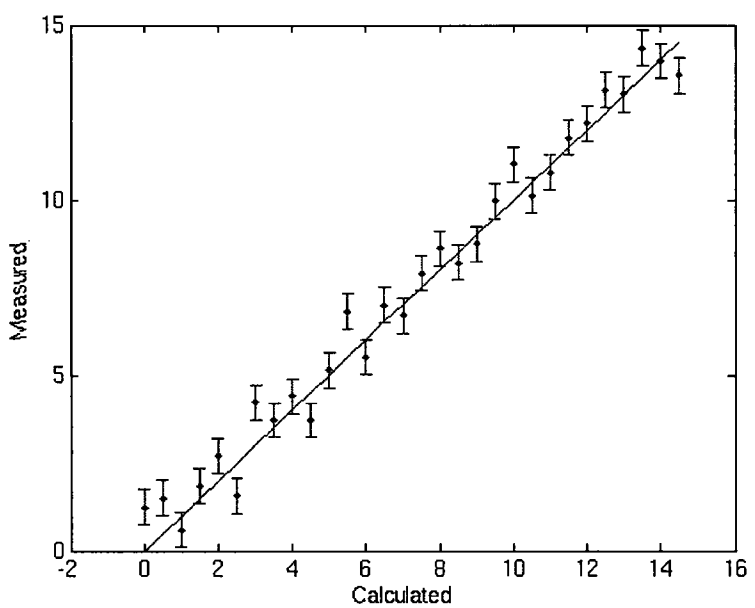

Figure 2 – Example of model validation against measurements data from separate effect test, where measured data carries an experimental uncertainty

Calculating the average bias and standard deviation as in the first example, and applying this uncertainty [ ]a,c.
To consider both the experimental and model uncertainties, a different method is applied [ ]a,c, namely the method of creating the envelope of 2-dimensional uncertainties (described in Section B-7.2 in WCAP 16747-P-A). The uncertainty interval [ ]a,c increases as a consequence of combining two different uncertainty sources. [ ]a,c

This Leading Parameter is one of the uncertainty input parameters (an example of a list of uncertainty input parameters is Table 8-3 in the LTR). It is sampled according to its defined distribution function, together with other parameters, in a Monte Carlo analysis to evaluate the uncertainty in figures of merit, such as MCPR, PCT and others, as demonstrated in Section 8 in the LTR.

ii) Candidate Parameters are all code input and modeling parameters needed to simulate the high ranked phenomena identified in the PIRT.

Relevant Parameters are the parameters selected from the list of Candidate Parameters, having a significant influence on figures-of-merit. The selection process is described in RAI-23.S01 and demonstrated in an example below.

Relevant Parameters may conceptually be seen as all input and modeling parameters that have a significant influence on figures of merit. A relevant modeling parameter carries the uncertainty resulting from the comparison to SET data.

Leading Parameters are Relevant Parameters for which the uncertainty resulting from comparison to the experimental database (SET) is combined with the model uncertainty.

The relation between these sets of parameters (Candidate, Relevant and Leading) and the process of how they are defined is illustrated on Phenomenon H8, Steamlines.

The steamline model provides two important model outputs:

1) Transport time of pressure wave through the steam lines
2) Steam lines frictional pressure drop

[ ]a,c

The Steam lines friction model is described by Equation 1:

$$\Delta p_{fric} = \left(\frac{4L}{Dh} C_f\right)\frac{w^2}{2\rho} \qquad \text{Equation 1}$$

All terms in Equation 1 are Candidate Parameters for the steam line friction pressure drop model. Their definitions are provided in Table 1.

Table 1: List of Candidate Parameters for steam line friction pressure drop model

a,c

[ ]

Pipe geometry (length and hydraulic diameter), steam mass flow rate and steam properties are candidate input parameters, while the Fanning friction factor is a candidate modeling parameter. This factor is calculated according to an empirical correlation.

[ ]a,c

Table 2: List of Relevant Parameters for steam line friction pressure drop model

a,c

[ ]

[ ]a,c

The uncertainty in parameter M accounts for model uncertainties. [ ]a,c

[

]a,c

All of these parameters are included in the uncertainty analysis performed to evaluate the uncertainty in analysis output such as MCPR.

Table 3: List of Relevant Parameters for steam line friction pressure drop model

a,c

References:

1. Moody, L.F.,"Friction factors for pipe flow", Transactions of the ASME 66 (8), 1944

[1] Leading Parameter as it accounts for both model and experimental uncertainty