framatome

Response to Request for Additional Information - ANP-10337 Supplement 1

ANP-10337
Supplement 1Q1NP
Revision 0

Topical Report

July 2019

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	All	Initial Issue

Contents

List of Figures

Nomenclature

Acronym	Definition
DGE	Deformable Grid Element

INTRODUCTION

The United States Nuclear Regulatory Commission (NRC) provided a request for additional information (RAI) regarding the topical report ANP-10337PA Supplement 1P-0 (Reference 1) in Reference 2. A total of 11 questions were received from the NRC.

The following sections provide the responses to NRC questions 1, 2, 3, 8, and 11. The responses for the remaining questions will be provided in a subsequent report.

1.0 RAI 1

Question:

Section 2.1 describes applicability requirements that must be met in order to use the DGE for a candidate grid design. The NRC staff understands that, based on the discussion within the remainder of the topical report, Framatome intends to maintain the same acceptance criteria for permanent grid deformation from ANP-10337P-A. In some cases, the available testing data for a candidate grid design may not cover the full range of permanent grid deformations up to and including the acceptance criteria from ANP-10337P-A. What limitations, if any, will be placed for use of the DGE in cases where test data is not collected to the full extent of the permanent grid deformation limits?

Response:

The Deformable Grid Element (DGE) benchmark analysis is performed by comparing the response of the DGE for a simulated progressive dynamic impact test against the experimental results of a progressive impact test. The benchmark analysis is limited to the range of residual deformations measured in the dynamic impact test. No extrapolation beyond the measured residual deformations is made when benchmarking, validating, or using the DGE. In the case where the residual deformations measured in the impact test is less than the acceptance criteria for permanent deformation defined in ANP-10337PA, the range of application for the DGE will be limited to the range of residual deformations measured in the dynamic impact test.

2.0 RAI 2

Question:

Section 4.1 discusses how the DGE is computationally modeled within the ANP-10337P-A analysis codes. Describe how the DGE is implemented in the CASAC code as a user-defined element. Describe how the DGE implementation is controlled within the Framatome software QA program.

Response:

The DGE is implemented in CASAC through the user defined element capability. The CASAC program passes information such as nodal displacement, velocities, and forces of the connected degrees of freedom between the user element and the main CASAC solver. The user defined element also includes a set of state variables for storing and updating the calculated residual deformation. The user element must be compiled with the main CASAC program to be active.

The source code and the compiled CASAC executable necessary to implement the DGE are controlled by internal Framatome procedures, which comply with the quality assurance requirements of 10 CFR Part 50, Appendix B. The Framatome procedures define the validation and verification process to confirm that the DGE and the overall CASAC code are functioning properly. The source code for the DGE is compiled with the approved version of CASAC (currently v5.4) as a stand-alone executable. Upon official release of the software, the executable file is stored on a network drive, the DGE source code is placed in Framatome's archiving system, and the software is added to a controlled list of internally approved engineering software. If a revision to the DGE source code is needed, the validation, verification, and release procedures are repeated. Revisions to the DGE source code would adhere to the limits and conditions #3 of the base topical report, i.e. changes to the constitutive models and equations would require NRC approval.

3.0 RAI 3

Question:

The acceptance criteria defined in Section 2.1 appear to be envisioned to be generically used in determining whether the DGE can be used to describe a candidate spacer grid design. How are these criteria sufficient to provide assurance that a candidate grid design will always behave consistently with the DGE model? If additional testing is performed during the design phase for a new spacer grid design to confirm the expected behavior under a variety of conditions (e.g., random impacts), summarize any additional tests beyond those needed to provide the DGE parameters that would be performed to provide confirmation of the expected behavior.

Response:

The intention of Section 2.1 is not to list the acceptance criteria for the use of the DGE itself. Rather, Section 2.1 defines the behaviors that must be satisfied for a spacer grid design to be compatible with the methodology defined in the supplemental topical report. These necessary behaviors are the same as those defined in Limits and Conditions (L&C) #1 of ANP-10337PA because these behaviors must be satisfied to support a deformation-based analysis methodology. In the base methodology of ANP-10337PA, [

] whereas the supplemental topical report [

]

Regarding the DGE, the general framework for the constitutive equations and physical behaviors of the element itself were developed in conjunction with the criteria of Section 2.1. Specifically, the element does not make allowance for [ ] Thus, if the spacer grid design demonstrates the necessary behavior, the spacer grid is consistent with the DGE model.

During the spacer grid design and development phase, additional testing protocols are used to confirm the acceptance criteria of Section 2.1 are met. Progressive impact tests and [ ] confirm that the spacer grid [ ] confirm the [ ] These tests are not intended to define DGE input parameters, but are designed to demonstrate that the acceptance criteria are met. These additional tests, i.e. in addition to the standard progressive impact test, are performed to validate a new spacer grid design. These additional tests are not required for every design variant (e.g. array) within a single family of a spacer grid design unless the standard progressive test indicates a substantial departure in reference behavior.

4.0 RAI 8

Question:

Provide engineering drawings, CAD files, material property information, and any other information necessary to describe the grid design used in the example problem sufficiently to perform a structural dynamic analysis of the grid. If possible, provide the CAD files in a file format readable by Solidworks. Include details such as the connection of the grid to the guide tubes and guide tube design information that is relevant to the grid compressive behavior.

Response:

The relevant engineering drawings and CAD files will be transmitted to the NRC separately from this RAI response.

The spacer grid design used in the example problem was the GAIA intermediate spacer grid. In addition to the information provided with the engineering drawings, the following information is necessary to perform a structural dynamic analysis of the grid:

- The guide tube segments [ ] The guide tube segments have dimensions of [ ]
- In BOL conditions, no modifications are made to the grid cell size.
- In simulated EOL conditions, [ ]

- The spring hull [

]

5.0 RAI 11

Question:

In Section 5.4, a 95 percent confidence limit based on the experimental data for deformation, translated to the analytical model, appears to be intended as a substitute for the traditional 95 percent confidence limit on maximum load strength. However, the model itself is not directly based on the experimental mean under all conditions. Rather, the model is tuned so that a covariance analysis can demonstrate that the model is a reasonably good fit to the experimental data. The 95 percent confidence limit is subsequently applied to the results from the piecewise linear fit represented by the model. Under the given procedure, a model could be developed that would underpredict the average behavior of the experimental data under some conditions. Discuss how the proposed procedure will be consistent with the concept that for a given population of spacer grids modeled by the DGE, no more than 5 percent of them will exceed grid deformation limits when the model calculates that the deformation limit is reached.

Response:

The goal of the DGE benchmark analysis is to define the model input parameters such that the DGE model will accurately reproduce the experimentally measured response of the spacer grid. The benchmark analysis attempts to reproduce the average tested behavior, but some difference between the average and the DGE output is expected. The ANCOVA analysis ensures that the difference between the two data sets is not statistically significant. However, it is possible that a DGE model, validated by an analysis of covariance, will under predict the average tested behavior of the spacer grid.

To account for any under prediction and ensure that spacer grid does not exceed the deformation limits at the 95% confidence level, [

]

Figure 5-1 illustrates this procedure.

Section 5.4 will be modified to reflect this response and Figure 5-1 of this response will be added to the topical report as Figure 5-1. A markup page is provided.

Figure 5-1: Illustration of Correction in Case of DGE Under Prediction

[ ]

6.0 ADDITIONAL INFORMATION

The equation for the calculated F statistic on page B-7 is incorrect. In the version submitted for review, the following equation is presented:

[ ]

The equation should instead be:

[ ]

[ ] A markup for page B-7 is provided.

The sample problem will be corrected to address this error, and any resulting changes Appendix B and C will be noted in the next RAI response transmittal.

7.0 REFERENCES

1. ANP-10337PA, Revision 0, Supplement_1P, Revision 0, “Deformable Spacer Grid Element”, September 2018.
2. Letter, Jonathan Rowley (NRC) to Gary Peters (Framatome Inc.), “Request for Additional Information Related to Topical Report ANP-10337P, Revision 0, Supplement 1P, Revision 0 “Deformable Spacer Grid Element” Framatome, Inc. (EPID: L-2018-TOP-0037), May 15, 2019.

8.0 MARKUP PAGES

5.4 *Experimental Uncertainty and 95% Confidence Limit*

Based on the discussion in Section 4.6, the deformable grid element is benchmarked to [

] To comply with the requirements of SRP 4.2, a 95% upper confidence limit must be calculated based on the variability of the experimental data. The 95% upper confidence limit for a multivariable regression is calculated from the following equation:

$$Y_{95\ UCL} = Y_{pred} + t_{n-k-1,95\%}\sqrt{MSres X_0^T (X^T X)^{-1} X_0}$$

Where Y_{pred} is the value predicted by the regression at X_0,

$t_{n\text{-}k\text{-}1}$, 95% is the critical value of the t-distribution for n-k-1 degrees of freedom and a 95% confidence interval,

X_0 is the matrix of desired regressors,

X is the model matrix containing the experimental data,

MSres is the mean squared residual from the regression of the experimental data.

The matrix of desired regressors, X_0, ~~can be~~is found by [

] Then, the 95% upper confidence of the regression at that particular X_0 can be calculated.

If a sensitivity factor, as defined in SRP 4.2 Appendix A.II.3, is needed for the residual deformation, then the Ypred in the calculation of the 95% upper confidence limit shall include the necessary sensitivity factor.

The 95% UCL residual deformation is the quantity for comparison against the maximum permissible residual deformation.

5.5 *Seismic Sensitivity Analysis*

The sensitivity of the horizontal model results to variations in seismic input motion is studied per the recommendation in Section 4.2 Appendix A of NUREG-0800 (Reference 4) and Section 7.5 of Reference 1. In the case of the deformable grid element, the quantity of interest is the spacer grid residual deformation rather than any impact force.

Figure 5-1: Illustration of Correction in Case of DGE Under Prediction

[ ]