3K Designated NEDE-24326-1-P Material Which May Not Change Without Prior NRC Staff Approval

[*This Appendix presents the necessary NEDE-24326-1-P (Reference 3.9-6 or 3.11-2) material for identifying the material by italics which may not change without prior NRC Staff approval.*]*

3K.1 General Requirements for Dynamic Testing (4.4.2.5.1†)

(a) [***Mounting*** *– Specimens to be tested will be mounted in a manner that adequately simulates the installed configuration or as described in the applicable GE mounting documentation.* Mounting will be specified in the Product Performance Qualification Specification (PPQS).

(b) ***Monitoring*** *– Sufficient monitoring equipment will be used to evaluate the performance of the specimen before, during, and after the test. Monitoring product is used to allow determination of applied vibration levels and equipment responses. The location of monitoring sensors* shall be specified by the PPQS and *will be documented in the test report.*

When required by the PPQS*, the response of the product will be measured using accelerometers. When required* by the PPQS*, the accelerometers shall be located at a sufficient number of locations on the product to define the mode shapes and/or frequencies which would be required to allow dynamic qualification of individual safety-related components and devices, to support analytical extrapolation of test results, or to verify frequency requirements.*

(c) ***Exploratory Tests*** *– Exploratory vibration tests may be performed on the product to aid in the determination of the test method that will best qualify or determine the dynamic characteristics of the product. If it can be shown that the equipment is not resonant at any frequency within the expected frequency range, it may be considered a rigid body and tested according to methods and procedures discussed in Subsection 4.4.2.5.6† or analyzed according to the methods of Subsection 4.4.4.1.4.5†.*

If the product contains a single resonance or multiple resonances, one of the methods outlined in Subsection 4.4.2.5.3† will be used to qualify the product t by test.

The exploratory test may be performed in the form of a low-level, continuous sinusoidal sweep at a rate no greater than 1 octave per minute over the frequency range equal to or greater than that to which the equipment is to be qualified. All resonances will be recorded for use in determining the test method to be used or the dynamic characteristics of the equipment. If the configuration of the product is such that critical natural frequencies cannot be ascertained, dynamic qualification will be accomplished by testing by the Response Spectrum method as

* See Subsection 3.10.

† Refers to section numbers of NEDE-24326-1-P.

specified in Paragraph 4.4.2.5.3.6†. An acceptable alternative qualification method is a fragility test as described in Subsection 4.4.2.5.7†.

(d) ***Dynamic Event Aging Tests*** *– The dynamic tests simulate the effect of five (5) upset events* and in-service hydrodynamic loads having a long duration in order to simulate dynamic event aging followed by one (1) faulted event.† The dynamic tests are performed on aged products unless otherwise justified.*]‡

There are two hydrodynamic loads that have long durations: Safety Relief valve (SRV) and Chugging. The first step in considering these long duration hydrodynamic loads is to obtain Required Response Spectra (RRS) data for the worst SRV and for Chugging events. These spectra should not include any other loads. Having obtained the appropriate RRS's, the duration of SRV testing is determined by multiplying the number of SRV actuations by 0.5 second. The number of SRV actuations is given in Table 3.9-1.*f*

Chugging tests will have a 15 minute duration.

Since Chugging is a post LOCA phenomena, Chugging will only be applied to equipment which is required to function post LOCA. SRV will be applied to all equipment located in areas where hydrodynamic loads exist.

The test sequence to be used when addressing long term hydrodynamic loads will be:

(1) Vibration aging (if required)

(2) SRV cycles (duration as above)

(3) 5 Upset events* (0.5 SSE**+ hydrodynamic) (30 seconds each)

(4) 1 Faulted event (SSE + hydrodynamic) (30 second duration)

(5) Chugging (15 minute duration)

[*Since most testing will be biaxial rather than triaxial, the above sequence and durations will be applied twice with the equipment being rotated 90 degrees on the table between the two tests.*]‡

[*The Test Response Spectra (TRS) will envelop the RRS as specified in 4.2.2.a(6)*††.]‡

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* *Upset Event - 0.5 SSE (in lieu of the OBE specified by NEDE-24326-1-P), or alternatively, as described in Subsection 3.7.3.2.*

† *Faulted Event - The SSE combined with appropriate hydrodynamic loads*.

‡ See Section 3.10.

f Table 3.9-1 to be used in lieu of the SRV actuations specified by NEDE-24326-1-P.

** 0.5 SSE to be used in lieu of the OBE specified by NEDE-24326-1-P.

†† Refers to section numbers of NEDE-24326-1-P.

For SRV tests, the TRS will be examined to assure that motion cycles are equal to or greater than 3X the number of SRV actuations.

(e) [***Loading*** *– Dynamic tests will be performed with the product subjected to nominal operating service conditions. If significant, normal operating loads such as electrical, mechanical, pressure, and thermal will be included. Where normal operating loads cannot be included in the dynamic tests, supplemental analysis will be used to qualify the product for those effects.*]*

3K.2 Product and Assembly Testing (4.4.2.5.2†)

(a) [*Products will be tested simulating nominal operating conditions.‡*]* The product shall be mounted on the shaker table as stated in Paragraph 4.4.2.5.1(a)† . If the product is intended to be mounted on a panel, the panel will be included in the test mounting.

Alternatively, the response at the product mounting location may be measured in the assembly test as specified in Paragraph 4.4.2.5.1(a)†. Then the product will be mounted directly to the shake table, with the dynamic input being that which was determined at the product mounting location.

3K.3 Multiple-Frequency Tests (4.4.2.5.3†)

(a) **General** – [*When the dynamic ground motion has not been strongly filtered, the mounting location retains the broadband characteristics. In this case, multi-frequency testing is applicable to dynamic qualification.*]*

(b) **Response Spectrum Test** – Testing shall be performed by applying artificially generated input excitation to the product, the amplitude of which is controlled in 1/3 octave or narrower bands. [*The excitation will be controlled to provide a test response spectrum (TRS) which meets or exceeds the required response spectrum (RRS). The peak value of the input excitation equals or exceeds the zero period acceleration (ZPA) of the RRS.*]*

3K.4 Single- and Multi-axis Tests (4.4.2.5.4†)

[*Single-axis tests may be allowed if the tests are designed to conservatively reflect the dynamic event at the equipment mounting locations or if the product being tested can be shown to respond independently in each of the three orthogonal axis or otherwise withstand the dynamic event at its mounting location.*

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* See Section 3.10.

† Refers to section number of NEDE-24326-1-P.

‡ In addition, dynamic coupling between interacting equipment will be considered.

If the preceding considerations do not apply, multi-axis testing will be used. The minimum is biaxial testing with simultaneous inputs in a principal horizontal axis and the vertical axis. Independent random inputs are preferred, and, if used, the test will be performed in two steps with the equipment rotated 90° in the horizontal plane for the second step. If independent random inputs are not used (such as with single frequency tests), four tests would be run; first, with the inputs in phase; second, with one input 180° out of phase; third, with the equipment rotated 90° horizontally and the inputs in phase; and, finally, with the same equipment orientation as in the third step but with one input 180° out of phase.]*

3K.5 Single Frequency Tests (4.4.2.5.6†)

[*If it can be shown that the products, as defined in R.G.1.92 has no resonances, or only one resonance, or if resonances are widely spaced and do not interact to reduce the fragility level in the frequency range of interest or, if otherwise justified, single frequency tests may be used to fully test the product.*]*

3K.6 Damping (4.4.2.5.7†)

[*The product damping value used for dynamic qualification shall be established. See Section 3.5 of IEEE-344*†.‡]*

3K.7 Qualification Determination (4.4.3.3†)

[*In order for equipment to be qualified by reason of operating experience, documented data will be available confirming that the following criteria have been met:*

(a) the product providing the operating experience is identical or justifiably similar to the equipment to be qualified;

(b) the product providing the operating experience has operated under all service conditions which equal or exceed, in severity, the service conditions and performance requirements for which the product is to be qualified; and

(c) *the installed product must, in general, be removed from service and subjected to partial type testing to include the dynamic and design basis event environments for which the product is to be qualified.*]*

3K.8 Dynamic Qualification by Analysis (4.4.4.1.4†)

(a) The analytical procedures described in this section may be used for dynamic qualification of products.

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* See Section 3.10.

† Refers to section numbers of NEDE-24326-1-P.

‡ *Also see subsections 3.7.3.8.1.7, 3.9.2.2, 3.9.3 and 3.10.2.*

(b) Many factors control the design of a qualification program. Paragraphs 4.2.2.c(3)* and 4.2.2.d(1)* provide general guidelines on dynamic analysis techniques. Analytical techniques and modeling assumptions will, when possible, be based on a correlation of the analytical approach with testing or operating experience performed on similar equipment or structures. [*Analysis may be used as a qualification method for the following conditions:*

(1) *if maintaining structural integrity is the only required assurance of the safety function,*]†

(2) if the response of the equipment is linear or has a simple nonlinear behavior which can be predicted by conservative analytical methods, or

(3) if the product is too large to test.

3K.9 Required Response Spectra (4.4.4.1.4.6.2*)

(a) [*The required response spectra that define the dynamic criteria for the location(s) of the product under consideration are to be given in the PPQS. If the equipment under consideration is attached to the structural system at more than one location, then the dynamic analysis performed takes into consideration the different response spectra at the different support locations. The effect of multiple support attachment points or multiple locations of the particular product can also be accounted for by selecting a single spectrum which will effectively produce the critical maximum responses due to different accelerations existing at different points.*]† This may be conservatively accomplished by enveloping the response spectra for the different applicable locations. Alternatively, actual multi-support excitation effects may be taken into account by performing a multi-support excitation analysis.

3K.10 Time History Analysis (4.4.4.1.4.6.3*)

Time history analysis will be performed when conditions arise invalidating the response spectrum method of analysis due to nonlinear phenomena, or when generation of in-equipment response spectra or a more exact result is desired. To integrate or differentiate, the analysis will be done by an applicable numerical integration technique. The largest time step used in the analysis will be 1/10 of the period of the highest significant mode of vibration of the equipment. [*The dynamic input will be the time history motion at the equipment support location.*]† For products supported at several locations, the responses will be determined by simultaneous excitations using appropriate time history input at each support location. The scaled time interval will be varied as per Paragraph 4.4.2.a(6)‡. If the product frequency is within the range

* Refers to section number of NEDE-24326-1-P

† See Section 3.10.

of the supporting structure, then a time interval will be chosen such that the peak of the response spectrum shall be at the product resonance frequency. The total time interval range will be provided with the time history.

‡ Refers to section number of NEDE-24326-1-P.