## Resolution of Public Comments on Draft Regulatory Guide DG-1127, "Combining Modal Responses and Spatial Components in Seismic Response Analysis" (Proposed Revision 2 of Regulatory Guide 1.92)

During the comment period for Draft Regulatory Guide DG-1127, which ended on April 15, 2005, the NRC received comments from Westinghouse (W), Brookhaven National Laboratory (BNL), DST Computer Services S.A. of Switzerland (DST), and James Annett of New Jersey (JA). The following table summarizes the comments, the staff's related responses, and the resultant changes (if any) made to DG-1127 to address the comments.

| Source | Comment | Formal Staff Response | Change to DG-1127 |
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| JA-1 | Consider clarifying how the 100-40-40 rule may be used in conjunction with determining geometric resultant responses using SRSS.<br><br>An example might involve a concern with sliding of foundations, where friction is a concern. For this example 100% of the vertical acceleration is used and a resultant horizontal acceleration determined by SRSS of 40% of the two horizontal accelerations. | The Square-Root-of-the-Sum-of-the-Squares (SRSS) and 100-40-40 methods for combining the effects of three directions of seismic excitation are intended to be applied to structural response quantities, not to the external loading. This is clearly specified in DG-1127. The 100-40-40 method applies only when the response spectra method is used.<br><br>The 100-40-40 method, as defined in DG-1127, has been accepted as an alternative to SRSS for estimating the likely maximum absolute value of an internal response component (e.g., force, moment, deflection, rotation) at a specific location in a structural element, attributable to the combined effect of three directions of seismic excitation (horizontal E-W, horizontal N-S, vertical). The basis for acceptance is a numerical study, which compared the 100-40-40 prediction of maximum response to the SRSS prediction of maximum response, for the complete range of possible ratios of responses R1, R2, and R3. The results demonstrate that the 100-40-40 prediction is essentially equal to or higher than the SRSS | None |

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| | | prediction for all response ratios. In most structural design evaluations, the maximum response to external loads is desired for comparison to codified acceptance criteria.<br><br>The example cited (sliding of foundations where friction forces are important) warrants special design considerations.<br><br>First, the potential for liftoff of the foundation caused by combined vertical and horizontal excitation needs to be considered. If liftoff is expected, a nonlinear analysis of the structural response of the foundation/building on the supporting medium, including liftoff and sliding between the foundation and the supporting medium, is appropriate. The potential for liftoff can be estimated by linear analysis of the foundation/building for each of the three directions of seismic excitation, assuming complete foundation fixity to the supporting medium. After SRSS or 100-40-40 combination of the responses, if the prediction of normal forces at the foundation/supporting medium interface exceed the compressive contact force attributable to deadweight over a significant area of the foundation, then liftoff should be considered.<br><br>In the absence of liftoff, the total contact force between the foundation and the supporting medium times the coefficient of friction between the surfaces defines the horizontal load limit before sliding will occur. The selection of combinations of total contact force and total horizontal force that | |

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| | | may exist simultaneously due to the three-directional seismic excitation is not addressed by either the SRSS or 100-40-40 methods. The critical condition for sliding may exist when none of the responses are at their extreme values, because of the coupling between the contact force and the allowable horizontal force. A conservative approach would be to use the minimum total contact force (deadweight minus maximum vertical force attributable to three directions of seismic excitation), and the maximum total horizontal force attributable to three directions of seismic excitation. If sliding is precluded for this condition, there is no need for further analysis. However, if sliding is indicated by the conservative analysis described above, the analyst may need to conduct a linear time history analysis using three statistically independent seismic excitations [see Paragraph 2.2(2) of DG-1127], and to check for sliding at suitably selected points in time. | |
| DST-1 | My comments concern "Appendix A: General Discussion of the Response Spectrum Method."<br><br>GENERAL COMMENT:<br>I find the formulation ambiguous and I suggest that a more rigorous mathematical approach can lead to improved engineering solutions. | RESPONSE TO GENERAL COMMENT:<br>The material in Appendix A was taken from Section 3.2.2.2, "Linear Methods," of ASCE Standard 4-98, "Seismic Analysis of Safety-Related Nuclear Structures and Commentary," promulgated by the American Society of Civil Engineers (ASCE).<br>The formulation is limited to uniform support excitation, typical for analysis of building structures and equipment, and a very commonly used assumption in the analysis of multi-supported systems (e.g., piping). The intent of Appendix A was to provide an overview, rather than a rigorous general treatment, of modal superposition time | The staff deleted Appendix A to DG-1127 and added a discussion of uniform support motion (USM) vs. independent support motion (ISM) in the Background portion of **Section B, "Discussion."** That discussion includes a statement that RG 1.92 is only applicable to USM, and a reference to the current staff position for |

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| | | history analysis and response spectrum analysis (RSA).<br><br>The commenter clearly highlighted the limitations and ambiguities contained in Appendix A. The staff will consider deleting Appendix A from the final RG 1.92, and replacing it with references to more formal treatments of the subject. The staff would consider recommendations for such references.<br><br>As an alternative, the comments will be factored into a revision of Appendix A. Definitions will be clarified and inherent assumptions (e.g., uniform support excitation) will be clearly identified. | ISM analysis. |
| DST-2 | COMMENT #1:<br>My first comment refers to equations (A.1). It is stated that "X=column vector of relative displacements (mx1)." The first question is: relative to what? | RESPONSE TO COMMENT #1:<br>If Appendix A is retained, the definition of X will be clarified. | The staff deleted Appendix A to DG-1127. |
| DST-3 | COMMENT #2:<br>The second question is: exactly what is the meaning of the term $\ddot{u}_g$, defined as the "ground acceleration"? | RESPONSE TO COMMENT #2:<br>If Appendix A is retained, the definition of $\ddot{u}_g$ will be clarified. | The staff deleted Appendix A to DG-1127. |
| DST-4 | COMMENT #3:<br>My next comments refer to equations (A.2) and (A.3). | RESPONSE TO COMMENT #3:<br>If Appendix A is retained, the distinction between m and n will be clarified and the matrix dimension of Φ will be corrected. While n=m only if all modes are | The staff deleted Appendix A to DG-1127. |

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| | We note that X is defined in (A.1) as an (mx1) vector, where m = number of dynamic degree-of-freedom. For equation (A.2) to be coherent, Φ and Y must be (mxm) and (mx1) respectively; that is, they must include all m dynamic degrees of freedom. They cannot be dimensioned as defined by "n = number of modes considered."<br><br>However, both the orthogonality principle, $\Phi^T M \Phi = I$, and the equation (A.3) are valid if Φ is defined as the rectangular matrix whose columns are a subset of the mode shape vectors. Then Φ will be (mxn) and Y will be (nx1), where m = number of dynamic degrees-of-freedom and n = number of modes considered. | retained, only roughly half of the modes are considered usable, and the intent of the procedures outlined in the RG is to minimize the number of modes that need to be calculated. Therefore, n<<m will be the typical case. | |
| DST-5 | COMMENT #4:<br>(Because of its length and the number of symbols and/or equations used, Comment #4 is not reproduced here.) | RESPONSE TO COMMENT #4:<br>The Appendix A presentation is limited to uniform support excitation. If Appendix A is retained, this will be clearly stated. | The staff deleted Appendix A to DG-1127. |
| DST-6 | COMMENT #5:<br>(Because of its length and the number of symbols and/or equations used, Comment #5 is | RESPONSE TO COMMENT #5:<br>The Appendix A presentation is limited to uniform support excitation. If Appendix A is retained, this will be clearly stated. | The staff deleted Appendix A to DG-1127. |

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| DST-7 | COMMENT #6:<br>To end my comments on a positive note, based on the formulation in the attached document, I derive an alternate form for the solution.<br><br>(Because of the length and the number of symbols and/or equations used, Comment #6 is not reproduced here.) | RESPONSE TO COMMENT #6:<br>It is the staff's understanding that the commenter is proposing an alternative approach to the Gupta and Lindley-Yow methods. If this is the case, the staff would be interested in an example of the proposed method (e.g., piping model BM3 from NUREG/CR-6645). | None<br><br>Note: The commenter provided additional information to the staff. The information provided will require in-depth staff evaluation before it can be considered for possible inclusion in a subsequent revision of RG 1.92. |
| BNL-1 | The importance of the "residual rigid response" is not sufficiently emphasized. See the NUREG/CR-6645 recommendations for both response spectrum analysis (RSA) (Recommendation 6) and mode superposition time history analysis (Recommendation 7). The term "significant" used in the DG is very vague and subject to broad interpretation. It is less prescriptive than the current guidance in the SRP. The current guidance in the SRP can lead to a 10% underprediction of support forces, as discussed in NUREG/CR-6645. The "residual rigid response" should always be calculated and algebraically combined with the in-phase components of the amplified | The staff did not formally respond to this BNL comment; however, the staff did consider this comment in developing the final version of RG 1.92, Revision 2. | The staff revised Regulatory Position C.1.4 in Revision 1 of RG 1.92, to include additional discussion regarding the importance of including the residual rigid response of missing mass modes for both response spectrum analysis and modal superposition time history analysis. |

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| | modal responses in RSA. In mode superposition time history analysis, the "residual rigid response" time history should always be included as an additional response mode and algebraically combined with the amplified modal response time histories, at each instant in time. | | |
| BNL-2 | Rev. 2 to RG 1.92 needs to include a note that Regulatory Position 1.4 replaces or supercedes the procedure in SRP 3.7.2, Appendix A, for calculating the missing mass contribution to total response. There is an error in the SRP equations. This was pointed out to the staff during the NUREG/CR-6645 effort. Appendix I of NUREG/CR-6645 contains the correct equations for implementing the SRP 3.7.2, Appendix A, procedure. | The staff did not formally respond to this BNL comment; however, the staff did consider this comment in developing the final version of RG 1.92, Revision 2. | Appendix A to the final Revision 2 of RG 1.92 is reproduced from Appendix I to NUREG/CR-6645 and contains the correct equations for implementing the procedure set forth in Appendix A to SRP 3.7.2. However, Revision 2 of RG 1.92 does not reference Appendix A to SRP 3.7.2.<br><br>Note: The draft revision (1996) of Appendix A to SRP 3.7.2 corrected the noted error. |
| BNL-3 | There is no discussion of direct integration time history analysis as an alternative to mode superposition time history analysis, nor any reference to the comparisons and | The staff did not formally respond to this BNL comment; however, the staff did consider this comment in developing the final version of RG 1.92, Revision 2. | None.<br><br>Revision 2 of RG 1.92 recognizes direct integration time history analysis as an alternative to |

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| | recommendations included in NUREG/CR-6645, Appendix E. | | mode superposition time history analysis in the Background portion of **Section B, "Discussion."**<br><br>Revision 2 of RG 1.92 does not reference Appendix E to NUREG/CR-6645, because the staff considered the comparison of direct integration results to modal superposition results presented in Appendix E to be outside the scope of RG 1.92. |
| BNL-4 | Generally, DG-1127 includes the recommendations of NUREG/CR-6645, Section 5.2, for combining modal responses. One exception is the NUREG/CR-6645 recommendation (Recommendation 3) that, if the "closely spaced modes" methods of RG 1.92, Rev. 1, were going to be retained, their applicability should be limited to damping ratios of 2% or less. A second exception is the NUREG/CR-6645 recommendation (Recommendation 5) that the use of Method 1(as defined in NUREG/CR-6645) should be strongly discouraged or identified | The staff did not formally respond to this BNL comment; however, the staff did consider this comment in developing the final version of RG 1.92, Revision 2. | None.<br><br>The staff determined that the level of conservatism achieved by using Revision 1 of RG 1.92 is acceptable. Therefore, it is still acceptable to use the methods delineated in that revision, with the exception that the "residual rigid response of the missing mass modes," as described in Regulatory Positions C.1.4 and C.1.5, should be included in all analyses submitted in support of licensing decisions, after |

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| | as unacceptable. | | official issuance of Revision 2. |
| BNL-5 | While the NUREG/CR-6645, Appendix F, procedure for determining $f_2$ has been included as Appendix B in DG-1127, there is no mention that $f_2$ is a function of the damping ratio. In using this procedure, a unique $f_2$ needs to be calculated for each damping ratio of interest. The numerical example in NUREG/CR-6645, Appendix F, illustrates this. | The staff did not formally respond to this BNL comment; however, the staff did consider this comment in developing the final version of RG 1.92, Revision 2. | The staff revised Appendix B to DG-1127 to indicate the dependance of $f_2$ on the damping ratio. |
| BNL-6 | As the author of NUREG/CR-6645, I find the editorial changes that were made to the text of NUREG/CR-6645, in developing DG-1127, generally to be a step backwards in clarity of presentation and readability. Perhaps an independent assessment of both presentations by typical users of RG 1.92 would be useful. | The staff did not formally respond to this BNL comment; however, the staff did consider this comment in developing the final version of RG 1.92, Revision 2. | As appropriate, the staff modified the text of DG-1127 to improve its clarity and readability. Nonetheless, the author of NUREG/CR-6645 understandably believes his original presentation is better. No independent assessment was conducted. |
| W-1 | Lindley-Yow's method has a limited range of validity that precludes a consistent application to all structures and components of a given plant or within a given project scope. | Addressed by Response E in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>**Regulatory Position 1.3.2 has been revised to include additional guidance for applying the Lindley-Yow method. The low-frequency limitation can be circumvented by setting the rigid response coefficient, α, to zero for all frequencies below the** | The staff revised DG-1127, consistent with the formal response to Westinghouse.<br><br>In particular, the staff revised Regulatory Position C.1.3.2 and added Regulatory Positions C.1.4.2 and C.1.5.2. |

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| | | frequency of the first spectral peak. For frequencies at or above the first spectral peak, α is equal to the ZPA divided by the spectral acceleration. In the Lindley-Yow method, $f_{ZPA}$ is the equivalent of $f_2$ in the Gupta method (i.e., α=1 for $f \geq f_{ZPA}$). In applying the Lindley-Yow method, there is a very significant analysis simplification if the fundamental frequency of the structure, syste, or component (SSC) being analyzed is ≥the frequency of the first spectral peak. This is described in NUREG/CR-6645, Sections 2.2.1, 2.3.2, and 2.4.3. Regulatory Positions 1.4.2 and 1.5.2 have been added to Revision 2 of RG 1.92, to incorporate this guidance. | |
| W-2 | Gupta's method requires the determination of two attributes for each response spectrum, namely the "highest significant frequency" $f_l$ and the so-called "rigid frequency" $f_2$ that "may not be uniquely determined' (as stated in page 12 of DG-1127). The author himself has proposed and published several versions of the best fit equations and formulas to calculate approximate values of the $f_l$ and $f_2$ bounds (see Ref. 6).It would be very difficult for a non-expert user to apply the method in a consistent and reliable manner in several practical cases listed hereafter. | Addressed by Responses B, C, D, and K in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>(Response B)<br>The staff acknowledges that some judgement is needed in selecting $f_2$ for use in Gupta's method. A sensitivity study of Gupta's method for different assumed values of $f_2$ is included in Chapter 4 of NUREG/CR-6645. The results are compared to time history results, as well as results obtained using the Lindley-Yow method. Appendix H to NUREG/CR-6645 presents results obtained by Professor Gupta using his current recommendation for estimating $f_2$ (i.e., the frequency at which the spectral accelerations for different damping values converge) Appendix F to NUREG/CR-6645 describes a straightforward, response-based method to determine $f_2$ during the generation of | The staff revised DG-1127, consistent with Response K.<br><br>The staff also revised Regulatory Position C.1.3.1 to clarify the selection of $f_1$ for use in Gupta's method for single-peaked spectra, multi-peaked spectra, and broad-banded spectra.<br><br>In addition, the staff deleted Figures 1 and 2 from DG-1127 and added new Figures 1, 2, and 3. |

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| | | seismic response spectra from time history analysis results. This method is described in Appendix B to Revision 2 of RG 1.92, and Appendix F to NUREG/CR-6645 is referenced for more detail.<br><br>The staff notes that setting $f_2 = f_{ZPA}$ in Gupta's method is always acceptable, since $f_{ZPA}$ is an upper bound for $f_2$.<br><br>The staff considers that there is sufficient guidance for knowledgeable analysts to make an appropriate selection of $f_2$ for Gupta's method. Specification of $f_2$ in the updated regulatory guidance strictly for simplicity is contrary to the staff's intention to provide greater flexibility to licensees and applicants, to utilize improved methods for modal response combination. The staff will assess the appropriateness of the selected $f_2$ value as part of its regulatory review of licensee and applicant submittals.<br><br>(Response C)<br>The revised RG1.92 will not specifically address the selection of appropriate $f_1$ and $f_2$ values for the RG1.60 ground spectrum. RG1.60 was last revised approximately 30 years ago, and the staff guidance on design-basis seismic ground response spectra is potentially subject to revision. RG1.165 currently presents an alternative to RG1.60.<br><br>The selection of $f_1$ and $f_2$ for the current RG1.60 spectral shape is only necessary for RSA of an SSC that is directly subject to this ground motion. | |

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| | | The methods identified in Regulatory Position 1.3.1 provide guidance for selecting the appropriate values of $f_1$ and $f_2$.<br><br>(Response D)<br>Building structures are typically analyzed by time history analysis because the time-dependent responses at locations within the structure are needed to generate in-structure response spectra. When applying Gupta's method to in-structure RSA analyses using newly generated in-structure response spectra, the method of Appendix B, can be implemented to determine the value of $f_2$ as a function of % critical damping.<br><br>Appropriate values of $f_1$ can be determined from revised guidance in Regulatory Position 1.3.1 for single-peaked spectra, multi-peaked spectra, and broad-banded spectra.<br><br>(Response K)<br>See W-7 comment below for text of Response K. | |
| W-3 | Similar reason is already invoked in the DG-1127 itself for eliminating the influence of another physical parameter of the seismic input, namely the finite duration of the strong motion mentioned in Section 1.1.2-(2) ($t_D$ in previous version of the draft Revision 2 - DG-1108) because 'the duration value was often arbitrary selected.' | The NRC's formal response to Westinghouse, dated November 16, 2005, noted that the staff has revised Regulatory Position C.1.1.2 to restore the original Rosenblueth equation, as presented in DG-1108. | The staff revised Regulatory Position C.1.1.2 to restore the original Rosenblueth equation, as presented in DG-1108. |

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| W-4 | The use of refined methods for calculating the response in the medium-to-high frequency range seems in contradiction with the simplification of the response spectrum check in the post-earthquake evaluation criteria of Regulatory Guide 1.166 (Ref. 2). The Regulatory position C 4.1 - Response spectrum check -requires to compare the real spectral accelerations with the OBE response spectrum accelerations only between 2 and 10 Hz, and ignores the spectral accelerations above 10 Hz that are considered as non damaging to the nuclear power plant structures and components. The implementation of the proposed methods will also require significant modifications to the existing computer codes used for the seismic analysis of structures, components and piping.<br><br>While the programming of new algorithmic formulas is a one-time effort, the definition of new attributes of the response spectra input will have a repetitive impact on the cost of new projects and will introduce a degree of uncertainty in the use of existing | Addressed by the introductory paragraphs in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>**The staff notes that modal response combination methods accepted in Revision 1 of RG1.92 are still considered acceptable, with the single stipulation that all modes with frequencies $\geq f_{ZPA}$ must be included in the solution by using the "residual rigid response of missing mass modes" approach. In its comments, Westinghouse identified this as a significant improvement to regulatory guidance.**<br><br>**The staff has also determined that there is no need to perform any backfit for prior analyses that did not incorporate this refinement.**<br><br>**Having established this as a starting point, the staff considers Revision 2 of RG 1.92 to be "forward looking." In anticipation of an increase in new license activities, the staff desires to provide updated guidance on acceptable modal response combination methods.** | None. |

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| | spectra input in analysis revisions or plant upgrade projects | | |
| W-5 | Based on the discussion above, it is recommended to provide further guidance or even a set of generic parameters $f_l$ and $f_2$ as a pragmatic approximation to cover the following practical cases:<br>coarse broadened design spectra made of steps and plateaus that were used in older design specifications of nuclear equipment;<br>envelope of several floors response spectra for piping systems supported at different structures, leading to multiple peaks and multiple values of $f_1$ and $f_2$;<br>spectra broadened by +/- 15% in frequency that may distort the graphical determination of $f_l$ and $f_2$.<br><br>Based on some of Dr. Gupta's publications, these generic parameters are likely to be in the 2–10 Hz range for $f_l$ and in the 6–33 Hz range for $f_2$. The generic values should be selected within these ranges and declared acceptable for cases a), b) and c) above. As a minimum the | Addressed by the introductory paragraphs; Responses B, C, D, and K; and closing paragraph in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>(Introductory Paragraphs)<br>See W-4 comment for text of the introductory paragraphs.<br><br>(Responses B, C, D)<br>See W-2 comment for text of Responses B, C, and D.<br><br>(Response K)<br>See W-7 comment below for text of Response K.<br><br>(Closing Paragraph)<br>A licensee or applicant still has the option to utilize techniques that are accepted in Revision 1 of RG1.92, with the single addition of the missing-mass effect. This may be the appropriate approach for any new analysis using old design bases. As previously noted, Revision 2 is "forward looking." Some of the concerns Westinghouse has raised should not be as significant for new design. | The staff revised DG-1127, consistent with Response K.<br><br>The staff also revised Regulatory Position C.1.3.1 to clarify the selection of $f_1$ for use in Gupta's method for single-peaked spectra, multi-peaked spectra, and broad-banded spectra.<br><br>In addition, the staff deleted Figures 1 and 2 from DG-1127 and added new Figures 1, 2, and 3. |

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| | frequencies $f_l$ and $f_2$ should be provided for the concrete example of the broadband design response spectra provided in Regulatory Guide 1.60 (ref. 5).<br><br>Besides the RG 1.166 mentioned earlier, there are other examples where a fixed frequency range was used as an approximation of an entire distribution of a system dependent parameter. This is the case for the ZPA frequency cutoff that is generally taken as 33 Hz irrespective of the actual spectra. This is also the case for the frequency dependent damping ratio of piping systems per the ASME Code case N-411 (Ref. 3) where the fixed transition zone bounds of 10 Hz to 20 Hz are used for all piping systems.<br><br>In conclusion, the use of scientific refinements will not bring the expected improvement in analysis results accuracy if the new input parameters cannot be determined in an accurate and rigorous manner. This is particularly critical for the response spectrum analysis of piping systems with broadened envelope spectra commonly used in the nuclear | | |

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| | industry. For this type of application to piping design, the only pragmatic solutions seem to be:<br>defining fix values for the $f_l$ and $f_2$ parameters (potentially subject to restrictions to be spelled out in an Appendix);<br>allowing further simplification by collapsing the $f_l/f_2$ transition range into a single step transition at $f_{ngid}$ /2 (or $f_{ZPA}$ /2) as previously allowed in ASCE 4-86 Standard (Ref. 4). Even if that option has been removed in the newer edition ASCE 4-98, it may still provide a sufficient approximation for piping systems analysis. | | |
| W-6 | Algebraic combination has been implemented in the three piping analysis codes used in the past ten years by Westinghouse in several projects of seismic requalification or upgrades of nuclear plants in European countries, including Switzerland, Spain and Slovenia. It uses an algebraic white-noise modal combination rule (GAC) developed by P. Mertens (Ref. 7) that has been reviewed and approved by the Swiss Safety | Addressed by Response A in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>The staff did not critically review Mertans' method or evaluate it in NUREG/CR-6645. Moreover, the staff does not intend to reference Mertans' method in Revision 2 of RG 1.92; however, this does not preclude its use. A licensee or applicant may submit a technical evaluation, comparing Mertans' method to the "complete quadratic combination" (CQC), and the staff would review such submissions for acceptability. | None. |

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| | Authority (Ref. 8). That method is listed in NUREG/CR-6645 as reference 5, but not evaluated. It yields coupling factors similar to Der Kiureghian's CQC method with a damping dependent frequency range for closely spaced modes. Some results obtained with that method are presented and discussed in a paper on snubber elimination project in a Spanish nuclear power plant (Ref. 9). | | |
| W-7 | The definition of $f_l$ as "the highest significant motion frequency" should be improved. Figure 2 shows a series of plateaus El F, that are typical for acceleration peaks broadened by +/- 15% per Regulatory Guide 1.122 requirements. The "highest significant motion frequency" should rather be the mid-point of the EF plateaus (in logarithmic scale). It is recommended that the response spectrum curves (broadened and unbroadened) be used in Figures 1 and 2 for a non-ambiguous representation of $f_l$ and $f_2$. The Figure 1 from previous DG-1 108 might be used for that purpose. | Addressed by Response K in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>The staff has revised the figures and Regulatory Position 1.3.1 to clarify the selection of $f_1$ for use in Gupta's method, for single-peaked spectra, multi-peaked spectra, and broad-banded spectra.<br><br>For unbroadened, single-peaked response spectra, typical of calculated in-structure response spectra at a specific location, the definition of $f_1$ is straightforward, and DG-1127, Eqn. 7.2, applies. However, this is somewhat academic for design analysis. If the spectra are broadened ±15% to account for analysis uncertainty, $f_1$ is the highest-frequency point on the broadened plateau. This is consistent with the basis for broadening (i.e., the actual frequency of the spectral peak may not be the calculated frequency). | The staff revised DG-1127, consistent with Response K.<br><br>The staff also revised Regulatory Position C.1.3.1 to clarify the selection of $f_1$ for use in Gupta's method for single-peaked spectra, multi-peaked spectra, and broad-banded spectra.<br><br>In addition, the staff deleted Figures 1 and 2 from DG-1127 and added new Figures 1, 2, and 3. |

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| | | For broad-banded ground response spectra, $f_1$ is the highest frequency at which there is significant amplification of the PGA (ZPA). Typically, beyond $f_1$ the spectral acceleration rapidly decreases toward the PGA (ZPA).<br><br>For broad-banded in-structure response spectra, typical of a spectral envelope of multiple locations, f1 is defined in the same manner as for broad-banded ground response spectra. There is no technical basis for assuming a different value.<br><br>For the case of unbroadened, multi-peaked response spectra, $f_1$ is the highest frequency at which a spectral peak occurs. After broadening of the spectral peak, f1 is the highest-frequency point on the broadened plateau. | |
| W-8 | For the specific case of piping systems analyses with broadened envelope response spectra, it is recommended that fixed values of fl and f2 be provided in an appendix, or alternatively that the use of a single step frequency (at the minimum of $f_{rigid}$ /2 and $f_{ZPA}$) be permitted. | Addressed by Responses B, C, and D in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>See W-2 comment for text of responses B, C, and D. | None. |
| W-9 | The analysis of relatively stiff buildings using conservative time histories may show amplification at frequencies above 33 Hz. Existing guidance suggests that | Addressed by Response J in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>The staff interprets this comment as a critique | None. |

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| | 33 Hz may be used as a cutoff and amplification at frequencies above 33 Hz is negligible. The Regulatory Guide should identify that the ZPA does not need to be taken greater than 33Hz and that $f_2$ can also be limited to 33Hz. | of poor selection of conservative time histories. If the design ground response spectrum has no frequency content above 33 Hz, then the time history used to match the design ground response spectrum should also be deficient in frequency content above 33 Hz. The revised RG1.92 will not address corrections to alleviate inadequate selection of time histories. A licensee or applicant would need to address such a situation on a case-by-case basis. The staff would assess this as part of its regulatory review of licensee and applicant submittals.<br><br>There is also a current concern that near-field earthquakes, which tend to have higher-frequency content, may not be adequately considered in development of the site-specific, design-basis ground response spectrum. Therefore, future guidance in this area may not retain the long-standing assumption that 33 Hz is the upper limit for frequency content. | |
| W-10 | II.2 Regulatory Position Section 1.1.1<br><br>(A) The third sentence should be changed to:<br><br>"The definition of modes with closely spaced frequencies is a function of the *equipment* critical damping ratio: | Addressed by Response H in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>Adding the word "equipment" to the phrase "critical damping ratio" in Regulatory Position 1.1.1 may cause readers to misunderstand the intent of the guidance because it does not apply only to "equipment." Rather, this guidance applies to RSA of all SSCs. The intent of this comment was not clear to the staff. | None. |

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| | (1) (2) For *equipment* damping ratios….” | | |
| W-11 | II.2 Regulatory Position Section 1.1.1<br><br>(B) Guidance should be added for structures and components with variable modal damping, like piping systems with frequency dependent damping per ASME Code Case N-411 (Ref.3) or multi-material structures with variable composite modal damping ratios. It is suggested that the closely spaced modes criteria (1) and (2) be reformulated as a function of the average damping ratio for each mode pair. | Addressed by Responses F and G in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>RSA damping of piping systems according to Code Case N-411 promulgated by the American Society of Mechanical Engineers (ASME) is accommodated by both the DSC and CQC modal response combination rules. See NUREG/CR-6645, Sections 2.1.4 and 2.1.6. The definition of $C_{ik}$ admits specification of a unique critical damping ratio for each mode. There is no need to address N-411 damping in the revised RG1.92.<br><br>The selection of a suitable damping ratio for an SSC composed of two or more materials with different damping characteristics is a subject for RG1.61, which is currently scheduled for revision. This will not be addressed in the revised RG1.92. | None |
| W-12 | 11.3 Regulatory Position Section 2.1-(2)<br><br>The special case of a vertical axisymmetric structure, such as a containment vessel, should be added to the 100-40-40 spatial combination method. For this case the seismic input should be applied as a two-dimensional input in the worst horizontal | Addressed by Response I in the NRC's formal response to Westinghouse, dated November 16, 2005:<br><br>The staff notes that, as specified in Regulatory Position 2.1, the SRSS and 100-40-40 methods for combining the effects of three directions of seismic excitation are intended to be applied to structural response quantities, and not to the external loading. | None. |

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| | direction plus the vertical direction, leading to a specific 100-40 spatial combination method in local cylindrical axes. | The 100-40-40 method, as defined in Regulatory Position 2.1, has been accepted as an alternative to SRSS for estimating the likely maximum absolute value of an internal response component (e.g., force, moment, deflection, rotation) at a specific location in a structural element, attributable to the combined effect of three directions of seismic excitation (horizontal E-W, horizontal N-S, vertical). The basis for acceptance is a numerical study, which compared the 100-40-40 prediction of maximum response to the SRSS prediction of maximum response, for the complete range of possible ratios of responses R1, R2, and R3. The results demonstrate that the 100-40-40 prediction is essentially equal to or higher than the SRSS prediction for all response ratios.<br><br>RG1.92 does not address specific SSCs or combinations of external loading components. | |