Draft Specific Safety Guide "DS490, Seismic Design of Nuclear Installations",
Status: STEP 8, Comments by Member States

COMMENTS BY REVIEWER				RESOLUTION			
Comment No.	**Para. No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
Russia	General	I propose to supplement the document with an Appendix which includes the main (key) terms used in it (Seismic design, Earthquake, Earthquake levels, Seismic (Earthquake) hazard, Seismic resistance systems, or constructions, or components, Seismic margins, Seismic qualification, Frequency of exceedance.		X	Supported and recommend. Glossary section will be added.		
Russia	General	I propose to include the paragraph: Impacts from earthquakes of different levels can cause dependent on such events failures to perform required safety functions by individual structures, or components (single failures), or systems (multiple failures, including common cause failures); their occurrence can lead to serious accidents with damage to nuclear fuel or to the established limits exceedance of a large accidental release. Based on the results of a probabilistic safety analysis for seismic effects (SPSA), the values of a severe accident frequency with damage to nuclear fuel and the values of exceedance of the established limits of a large accidental release are determined. Therefore,				X	CCF considerations are addressed in Section 4 – Plant Layout. SL1 and SL2 earthquake levels to be used in design are defined in Section 3. Moreover, beyond design earthquake is also defined in Section 3 – to be used for assessment of seismic robustness of the design (seismic margins). Severe accidents are out of scope of the Design Safety Guide. Sever Accidents are out of scope. They supposed to be prevented by adequate Seismic Margins (Section 7).

		it is necessary to include in document No. DS 490 the targets for the assessment of the results acceptability obtained from SPSA in order to achieve an acceptable level of safety of a nuclear installation. When performing SPSA, the frequency of occurrence of different levels earthquakes and the corresponding values of the conditional probabilities of dependent items failures (systems, structures, and components) are used as the main quantitative characteristics. Quantitative values of the conditional probabilities of dependent items failures depend on the intensity values of the earthquakes effects and on the seismic resistance characteristics of the items. Quantitative values of the conditional probabilities of dependent system failures depend on the intensity values of the effects of earthquakes, on the characteristics of the seismic resistance of the structures and components included in them, as well as on the technical solutions provided for in the project to protect systems from CCF in the event of earthquakes of the corresponding levels.					
Russia	General	It is necessary to give recommendations, whether to consider joint earthquake-dependent multiple failures of items with different structures or not. And if so, recommendations on the methods				X	This is done in Section 2 para 15A and para. 2.6. Multiple failures induced by seismic events should not occur for severity of the hazard covered by design

		and techniques for performing such analyzes shall be given.					basis. Assessment of seismic design robustness (for beyond design base earthquakes) is covered by Section 7.
Finland	1.6	As background, an important consideration should be noticed on the difference between (i) the seismic design, and (ii) the seismic safety evaluation of nuclear installations, as indicated in the Safety Guide on Evaluation of Seismic Safety for Existing Nuclear Installations, IAEA Safety Standards Series No. NS-G-2.13, [3], published in 2009. Seismic design of a new installation is distinct from the seismic safety evaluation of an existing installation in that seismic design and qualification of structures, systems and components (SSCs) is most often performed at the design stage of the installation, prior to its construction. The methods of seismic safety evaluation and the related criteria may also be used for assessing beyond design basis earthquake of new designs as part of the design process. ~~Seismic safety evaluation is applied only after the installation has been constructed. Of course, exceptions exist,~~ On the other hand, the methods of seismic design are used in the design of new or replacement components after construction of the installation. ~~Conversely, the seismic safety evaluation for assessing beyond~~	The sentence "Seismic safety evaluation is applied only after the installation has been constructed." is too strongly formulated and misleading as introductory text, even though the next sentence provides exceptions.	X	Addressed by Para 1.6. Also, Para 7.1 was modified to reflect this: 7.1. Evaluation of seismic margin is part of the safety assessment of the design….		

		~~design basis earthquake of new designs prior to construction may make use of the criteria applied for seismic safety evaluation.~~					
Russia	1.7.	It is necessary to eliminate inconsistency between clause 1.7. according to which this document provides recommendations on the assurance of the security requirements set forth in document [1] when earthquakes occur for designing seismic resistance of structures and components, and in other clauses it is indicated that these recommendations also apply to nuclear facilities systems.		X	Modified as following: 1.7. The objective of this Specific Safety Guide is to provide recommendations and guidance on how to meet the safety requirements established in Ref. [1, 10 and 11] in relation to the design aspects of a nuclear installations subjected to seismic hazard defined in accordance with the guidance in Ref. [2]. Thus, it gives guidance on a consistent application of methods and procedures currently available according to the state-of-the-practice for seismic analysis, design, testing and qualification of structures, systems and components so that they meet the applicable safety requirements established in Ref. [1, 10 and 11].		
Iran	Para 1.10/Line 2	: nuclear power plants; research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities; storage facilities for spent fuel; facilities for the enrichment of uranium; nuclear fuel fabrication facilities; conversion facilities; facilities for the reprocessing of spent fuel; facilities for the predisposal management of	Based on IAEA safety glossary, nuclear installations mentioned in this para are not complete. Some of them such as conversion facilities, nuclear fuel cycle related research and development facilities are missed. Ref.: INTERNATIONAL ATOMIC ENERGY	X	Refers to IAEA Glossary 2018: nuclear power plants; research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities; storage facilities for spent fuel; facilities for the enrichment of uranium; nuclear fuel fabrication facilities; conversion facilities;		

		radioactive waste arising from nuclear fuel cycle facilities; and nuclear fuel cycle related research and development facilities.	AGENCY, IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection, 2016 Edition, IAEA, Vienna (2016).		facilities for the reprocessing of spent fuel; facilities for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities; and nuclear fuel cycle related research and development facilities.		
Israel	Par. 1.10 Footnote (1)	*(We have included an identical comment in our comments sent a couple of weeks ago to DS498):* Footnote 1, related to paragraph 1.10, does duly explain the specific importance of the use of graded approach for sites at which different types of nuclear installations are collocated. (For example, smaller and less dangerous nuclear installations compared to a high power NPP being operated at the same site). We would like suggest, for the sake of completeness of this footnote, to consider adding to that footnote a sentence mentioning that at such collocated installations site the "down-graded" approach to the "small" and less dangerous installations – has to be applied carefully. That, when taking in consideration the proximity to the "high power NPP" for example, proximity which may result, in case of an accident at the high power installatio, in significantly increased damage - and resulting hazards - to the "small installation", compared to a scenario in which the small nuclear installation is standing alone and not in vicinity to other installations.	Completeness	X	The footnote was modified: “For sites at which nuclear installations of different types are collocated, particular consideration should be given to using a graded approach considering multi-facility aspects (see para 2.6).		

Germany	1.12	The structure of this Specific Safety Guide follows the general workflow of seismic design and qualification: – Section 2 describes the specific safety requirements for treating external hazards and seismic actions according to ~~the~~ Ref [1] and provides recommendations of general nature on seismic design aspects.	Clarification (there is more than one recommendation)	X			
Germany	2.7	Special consideration should be given to para 5.21A of ~~the~~ Ref [1], as indicated above, regarding the need to provide in the nuclear installation design an adequate seismic margin for those SSCs ultimately required for preventing ~~an~~ early radioactive release or ~~a~~ large radioactive release in the event of an earthquake level exceeding the ones considered for design purposes~~, assuming that for seismic events there is not possibility to have early warnings and there is a high probability of combination with other hazards (such as fires and floods)~~. To fulfil such requirement, in Section 3 of this Specific Safety Guide, discussions and guidance are provided to determine the beyond design basis earthquake and the categorization of the SSCs to be designed or evaluated against such event, while in other sections ~~is~~ are discussed the applicable performance criteria in such cases.	Our suggestion is to delete this part of the sentence, as the reasons are not conclusive: most of other events at NPPs cannot be predicted, too. And the seismic design should prevent a high probability of the combination with other hazards. Clarification. There is more than one performance criterium	X	Support editorial change in last sentence. The paragraph proposed for deletion was moved in a footnote since for beyond design base earthquake seismic induced fire and flood are credible events.		

Finland	2.10	The design of a nuclear installation ~~is usually~~ should be a very well-structured process, conducted under the rules, procedures and conditions of a proper project management.	?	X	Support change as stated, since this wording offers guidance, whereas former wording stated an opinion (very was deleted / no adjectives)		
Russia	Sect. 3	-	Section 3 does not contain any information about the scale that should be used for measurement of earthquakes of SL-1, SL-2 and BDBE levels.			X	The metrics for seismic hazards results are proved in para 3.9 and 3.10. Seismic hazard results are typically expressed in acceleration. They can be further converted to velocity and/or displacements. The metrics for SL1 and SL2 are defined in sub-section “Determination of the Design Basis Earthquake (DBE)”
Russia	Sect. 3	-	Beyond Design Basis Earthquake (BDBE) is not mentioned in whole section 3 “Seismic categorization for structures, systems and components”. Therefore, there are no requirements for any structure, system or component to be functional during and/or after the occurrence of the BDBE.			X	Beyond Design Basis Earthquake is mentioned in Section 3 sub-section “Beyond design basis earthquake”. BDBE is not used for design. It is used to assess seismic design robustness (seismic margin – See Section 7)
Russia	3.2.	Instead of the term “certification” the term “qualification”, which reflects the meaning of this concept to the fullest extent, shall be used.				X	The word “certification” is not used anywhere in the document!

							Terminology used in Para 3.2 is consistent to the IAEA Safety Glossary.
Finland	3.5	Geological and geotechnical hazards that are of a nature or an intensity which cannot be coped with available engineering solutions should have been excluded during the site selection and evaluation process as recommended in Ref. [2] and [5].	Grammar	X	Replace with: "Some geological and geotechnical hazards may be of a nature for which satisfactory engineering solutions to protect against them have not been identified. In such situations, during the site selection and evaluation process the site should be deemed unsuitable, as recommended in Ref. [2] and [5]. "		
Germany	3.5	Geological and geotechnical hazards that are of a nature or an intensity which available engineering solutions cannot cope with ~~available engineering solutions~~ should have been excluded during the site selection and evaluation process as recommended in Ref. [2] and [5].	Clarification	X	Addressed (see below)		
Russia	3.5.	Since the site is selected and estimated at the stage preceding the design stage of a nuclear facility, it is necessary to provide specific recommendations on the implementation of clause 3.5. which could ensure the site's suitability for the construction of a nuclear facility on it.	When designing a nuclear facility, in accordance with clause 3.4., it is recommended to take into account earthquake impacts associated with the danger of ground movements, and in accordance with clause 3.5. geological and geotechnical hazards, in the event of which it is impossible to ensure the safety of a nuclear facility with acceptable engineering solutions, are recommended to be excluded in the process of site selection and estimation.	X	Addressed – see below.		

			Such geological and geotechnical hazards include (see clause 3.4.), for example, soil liquefaction, slope instability, tectonic and non-tectonic sinking, cavity formation leading to subsidence of the soil.				
Canada	3.6	Thus the seismic design process should consider the following steps: a) defining the design basis earthquakes levels, b) defining seismic categorization, c) selecting applicable standards, d) providing seismically resistant structural systems in accordance with the layout and the functional requirements e) evaluating the seismic demand f) determining preliminary design of structural elements based on codes and standards, providing adequate reinforcement detailing g) verifying that demand does not exceed the seismic capacity defined in preliminary design and adjust if necessary h) assessing that the process above results in adequate margins.	The definition of structural systems and the preliminary design of elements are missing in the draft of 3.6	X	Modified as follow: Thus, the seismic design process should consider the following steps, which highlight the major tasks involved in the design process. Each item will be formalized into many individual sub-tasks for a typical nuclear design of any complexity: a) …same as you proposed”		
Russia	3.6.	It is necessary to indicate the higher priority in the design - whether it is the use of this document recommendations or the requirements of the national regulatory body.				X	The IAEA Safety Standards provides recommendations based on international state of practice. It is the member state decision how to use them.
USA	3.9 / Line 3	… (peak ground acceleration and spectral representation) should be selected. The spectral representation should be a smooth broad band spectra.	The use of smooth broad band spectral representation is one way to account for uncertain-	x	Added to Para 3.9.		

			ties in deterministic evaluations and introduce conservatism in the design.				
Israel	Paragraphs 3.10, 3.19, 3.24, 3.27, 3.32 (11), 3.3 and also probability values in paragraphs 7.6 and 9.6	General remark regarding quantitative values of **annual frequencies - compared with analysis needs - of relevant seismic hazards parameters** (e.g. in mean values hazard curves): Such values, ranging from 10E-2 to 10E-7 (in separate contexts of course), are mentioned in several sections of the present DS (see paragraph numbers in the left column here). It seems to me (and I might be wrong), that it could be useful for the users of this safety standard to "concentrate" these values (in an appendix?) as a general categorizations recommendations summary (in a similar way to Table 9.2).	Clarity and usefulness			X	I understand your comment. Generally, we cannot get consensus for quantitative values. Depending of the context we use a language (e.g. 10^{-4}…10^{-5}). If we try to be more prescriptive as you suggested, we will face large difficulties reaching consensus.
Germany	3.12 Line 1	In addition to the geological, geophysical and geotechnical data and soil properties determined during the site characterization stage mentioned in para 3.7 above, ~~,~~in the pre-construction~~,~~ stage of the nuclear installation project a very detailed programme of geophysical and geotechnical investigations should be carried out to complete and refine the assessment of site characteristics to be consistent with the final layout of buildings and structures and their final location in the site area. ….	Something is missing here in the text and this is our suggestion how the statement may be improved.	X	Done!		

Iran	Para 3.12/Line 2 Page 11	3.12. In addition to the geological, geophysical and geotechnical data and soil properties determined during the site characterization stage mentioned in para 3.7 above, pre-construction, …	In this Para and after "above", an additional "," exists. It shall be omitted.	X	Done !		
Finland	3.13 a)	As result of the geological, geophysical and geotechnical investigations conducted at the site area and at the location of the buildings and structures of the nuclear installation as described above, the following data should be basically available: a) Static and dynamic soil properties: e.g., unit weight (γ) and/or density (δ), strength capacity in drain and/or undrained conditions, low-strain shear wave (vs) and primary wave (vp) velocities, variation of shear modulus (G) and damping ratio as a function of shear strain levels, with their variation in depth with indication of the types of soil and rock encountered until the bedrock level. Adequate number of soil profiles should be developed. The profile is usually defined as horizontal~~ly~~ layers of ground, with best estimate (mean) values of layer … ..	Please clarify the last sentence. Please replace horizontally by horizontal or add missing words. Is the intention to emphasize that sediment layers may be folded strata. Also these could be modelled with horizontal layers.	X	Done !		
USA	3.13 a)/ Line 6	The profile is usually defined as horizontally layers of ground, with best estimate (mean) values of layer thickness, shear wave velocity, unit weight and the shear modulus and damping ratio as function of shear strain level. The	Agree that the subgrade media profiles are usually defined as horizontal layers of ground. The proposed sentence is intended to be cautionary statement for cases with highly complex subgrade media.	X	Support amendment.		

		use of horizontally layered soil profiles should be justified by the results of site investigations or sensitivity studies.					
Canada	3.14	Type 1 sites: V_s> 1500 m/s Type 2 sites: 1500 m/s > V_s> 300	The document should be consistent with IAEA TECDOC on Soil-Structure Interaction. 1 100 m/s is too low for hard rock site knowing that EPRI document required site 2000 m/s > V_s response analysis for			X	If DS490 is consistent with Safety Guide 3.6, then the TECDOC should be made consistent with this, not the other way around. The point on low value and EPRI is covered in a general way by footnote 7. No change needed to DS490. However, I agree with comment that the Vs value as stated is rather low!
Germany	3.16	Seismic site response analysis should be performed for soil types 2 and 3 ~~while soil type 1 is usually considered as a hard rock site6~~. Soil type 1 is normally considered a rock site and a soil response analysis is not required if it can be demonstrated that negligible effect on modifying the control seismic motion. Type 3 sites (soft soil conditions) require detailed studies and site response analysis as described in Ref. [5].	Duplication with the next sentence.	X	Done !		
Iran	Para 3.16/Line 2, Para 5.24/Line 3, Para 6.7/Line 2 & 4	3.16. Seismic site response analysis should be performed for soil types 2 and 3 while soil type 1 is usually considered as a hard rock site[6]. 5.24. Lateral boundaries should also be located at sufficient distance so that the structural response is not significantly af-	In these sections, the numbers of footnotes in the text shall be superscript.	X	O.K.		

		fected by these boundaries. Minimum distances to the soil-foundation interface depend on the type of boundary being selected (elementary[22], viscous, transmitting or domain reduction method conditions). 6.7. Seismic qualification of active components should include the qualification of structural integrity[26]					
Canada	3.17	The second approach is to conduct a site response analysis ~~compatible with the~~ using the seismic input provided on the bedrock. A site response analysis will be conducted for detailed and specific geochemical and dynamic characteristics of the soil and rock layers at the site area.	The site response analysis is performed using the seismic input provided on the bedrock. The seismic input on the bedrock is the input data for site response analysis of the soil above the bedrock.	X	I think there is value in adding the words, but amended as below: " … using the seismic input provided at bedrock or some other specified horizon in the soil/rock column under the site. A site response analysis should be conducted that is compatible with the …"		
Finland	3.19 4)	Starting with the seismic hazard curves and associated response spectra obtained at the bedrock outcrop layer, calculate site amplification factors through convolution of the bedrock hazard curves for each spectral frequency of interest, so that they should mimic the characteristics of the ~~principle~~ principal contributors to the de-aggregated seismic hazard, including diffuse seismicity;	Misprint	X	Agreed		
Canada	3.19 5)	Note that the final design ground motion could be developed with seismic margins beyond this level	The last sentence of 3.19 5) should be modified as many member states use UHRS as	X	Comment is correct. Suggest following additional text.		

			is.		"Note that the final design ground motion could be developed with seismic margins beyond this level <u>to ensure that sufficient uncertainties have been considered".</u>		
Germany	3.19	If the second approach is utilized, a step-by-step procedure should be applied as follows to determine the final seismic vibratory ground motion at the site including all parameters (spectral representations and time histories, in horizontal and vertical directions) at the specified control point location(s), usually the free field ground level, competent rock, or foundation level: ….	Definition for "competent rock" is missing. We did not find what is mean. Delete?	x	Competent rock is replaced by engineering rock. Definition of engineering rock will be added in Definition Section (It will be consistent with DS507 – revision of SSG-9).		
Pakistan	Page 14, para 3.21, line 3	The SL-2 design earthquake level should be associated with the safety requirements ……… motion for which certain structures, systems and coomponents of the nuclear installation should <u>**be designed to**</u> remain functional during and after the ……….. safety requirements	To maintain consistency with para 3.22, and make sentence more clear the proposed words may be added.	X	Reads better as amended.		
Canada	3.22	The SL-1 earthquake level should be associated, mainly, to operational and licensing requirements and corresponds to a less severe, more probable earthquake with respect to SL-2 level which could reasonably be expected to occur and to affect the nuclear installation during its operating lifetime. For this level of ground motion structures, systems and components necessary for continued operation should be designed to	In the current draft there is no difference in requirements between SL-1 and SL-2			X	Post earthquake inspection is needed for making decision to shut down or continue operation (according to applicable operating procedures). It is true that up to SL-1 no damage is expected but some malfunctions/alarms cannot be ruled out. So appropriate inspection should be conducted.

		remain functional and complying with the safety objective, without the necessity for shutdown of the plant and inspection.					Operator response is addressed in Section 8 "Seismic instrumentation and response to an earthquake event" There are many SSCs not seismically qualified and therefor malfunctions of such SSCs cannot be ruled out.
Russia	3.22	«The SL-1 earthquake level should be associated, mainly, to operational and licensing requirements and corresponds to a less severe and more probable earthquake with respect to SL-2 level. *Earthquake of SL-1 level* could reasonably be expected to occur and to affect the nuclear installation during its operating lifetime and for which those structures, systems and components necessary for continued operation should be designed to remain functional and complying with the safety objective».	Existing text may lead to the ambiguity of interpretation. Since the phrase "…which could reasonably be expected to occur and to affect the nuclear installation during its operating lifetime…" could be related to SL-2 earthquake level	X	Support change. Re-word as follows: "The SL-1 earthquake level should be associated with operational and licensing requirements, and corresponds to a less severe and more probable earthquake than the SL-2 level. Earthquake of SL-1 level could reasonably be expected to occur and to affect the nuclear installation during its operating lifetime. Those structures, systems and components necessary for continued operation should be designed to remain functional and compliant with relevant safety objectives"		
Canada	3.23	The SL-2 design earthquake level is defined based on the results and parameters obtained from the seismic hazard assessment, as indicated in para 3.7 above, and according to specific criteria established by the regulatory authorities to achieve a certain target level for its annual frequency of exceedance. The SL-2 level should be characterized by both horizontal and vertical vibratory	In the last sentence it is enough to say "at the control point defined by the seismic hazard assessment."	X	Accepted with deletion of "anchored to a peak ground acceleration (i.e., at zero period of the response spectrum)		

		ground motion response spectra, anchored to a peak ground acceleration (i.e., at zero period of the response spectrum) and at the control point defined by the seismic hazard assessment.					
Russia	3.24.	It is indicated in clause 3.24. that for an earthquake of the SL-2 level, it is recommended to choose the average value of the annual frequency of exceedance from the range of $1x10^{-3}$ - $1x10^{-5}$ $year^{-1}$. For the selected value of the annual frequency of exceedance, determined using seismic hazard curves, it is recommended to calculate seismic reserves. Notes. 1) Since document No. DS 490 contains recommendations for ensuring the seismic resistance of systems, structures and components, seismic resistance reserves should be considered as additional reserves. 2) It is necessry to note that for the similar average values of the annual frequency of exceedance, determined with the use of seismic hazard curves, different sites can be characterized by different values of exposure intensity, for example, the values of peak horizontal accelerations of the surface soil layer may differ by several times. Therefore, in document No. DS 490 it is necessary to present specific recommendations, such as what value of the annual frequency of exceedance (for example, $1x10^{-3}$, $1x10^{-4}$, $1x10^{-5}$ $year^{-5}$)				X	This para. does not recommend using an average between 10^{-3} and 10^{-5} but identifies that MSs typically choose a value from this range (higher frequency values could be used for other nuclear installations than NPPs - see section 9). Minimum seismic margin is addressed in Section 7. We cannot use quantitative values in IAEA Safety Standards because of consensus process but we show typically values used by MSs (in footnotes or using language e.g. …..)

		shall be determined for an SL-2 earthquake, in relation to which additional reserves of seismic resistance shall be determined in the design.					
Russia	3.24	«If a probabilistic approach was used for the seismic hazard assessment, and according to current regulatory practice in Member States, the SL-2 level corresponds typically to a level with *an annual frequency of exceedance in the range of 10^{-3} to 10^{-5} (mean values) per reactor».*	1) "Annual frequency of exceedance" is more appropriate term; 2) Expressions "1 x" are redundant; 3) "Per year" at the end is redundant, since we are talking about annual frequency.	X	Support change as stated (delete per reactor).		
Russia	3.24	-	There is an expression in the last sentence which says: «the SL-2 should be calculated with due consideration of additional margins and rounding aspects». However, it remains unclear what exactly should be calculated.	X	See amended footnote 10.		
Germany	3.26	The design basis earthquake level should include adequate design conservatism. ~~by considering~~ This conservatism is necessary to account for the uncertainties associated with peak ground acceleration and spectral shape, based on results of the seismic hazard assessment.	The current formulation seems to invert relation between uncertainties and conservatism. 'Considering uncertainties' is just that: acknowledge in the design that there is lack of information. This can be done conservatively or not. Therefore, it seems better to make the clear statement that conservatism is necessary.	X	O.K.		
Russia	3.27	«The SL-1 earthquake design level corresponds typically to a level with an *annual frequency of exceedance in the range of 10^{-2} to 10^{-3} (mean values) per reactor»*.	1) "Annual frequency of exceedance" is more appropriate term; 2) Expressions "1 x" are redundant;	X	Support change as stated (delete per reactor).		

			3) Expressions "/yr" are redundant, since we are talking about annual frequency. 4) "Per year" at the end is redundant, since we are talking about annual frequency.				
Germany	3.28	Regardless of the exposure to seismic hazard at the specific site, a new nuclear installation should be designed at least for a minimum earthquake level. In thisat regard, considering (i) the advances on the developments of new design of nuclear installations, (ii) the uncertainties in the seismic hazard assessment, and (iii) the effectiveness in terms of cost and technical provisions of providing a high level of assurance against the seismic hazards from the conception phase of the installation, the minimum level for seismic design should correspond to a peak ground acceleration of 0.10g, and not less than values established by the national seismic codes for conventional facilities., these values to be considered at the free field ground surface, or foundation level as appropriate. In addition, this requirement leads to a generally more robust design of the nuclear installation, which increases the safety margin also with regard to other dynamic loads. …..	The arguments i) and ii) are also valid for sites with higher seismic risks. Especially uncertainties might be of less relevance at sites with very low seismic risk in comparison to sites with higher seismicity.	X	O.K.		
Japan	3.28. Last sentence	... For plant structures, systems and components sensitive to low frequency motions (eg. SSCs on isolators), as well as high frequency motions, time histories/	In recent years, concern about the influence of high frequency motion is increasing as in EPRI Technical REPORT	x	Sentence with low frequency content (base isolation) was moved to para 3.21 (was not appropriate to para 3.28 talking about minimum SL-2		

		response spectra should be examined and, if necessary, modified to take these effects into account.	(3002009429) "Advanced Nuclear Technology: High-Frequency Seismic Loading Evaluation for Standard Nuclear Power Plants".		level). Your comment is accepted and implemented to the modified para 3.21.		
Japan	3.29.	In addition to the two earthquake levels defined and determined for design purposes, as indicated in the previous sub-section, an earthquake level exceeding the ones considered for design purposes should be ~~defined~~ considered as required in Refs. [1, 2, and 3]. For this earthquake level, noted as the Beyond Design Basis Earthquake (BDBE), the design should:	Appropriate expression. Safety guides provide recommendations and guidance on how to comply with the safety requirements, so “should be defined …” statement is not suitable here.	X	O.K.		
Russia	3.29.	Clause 3.29 a) shall be read as follows: To provide sufficient seismic reserves for systems, structures and components (SSC) in order to confirm the required low target values of core damage frequencies of early or large accidental release. To provide adequate seismic margin for SSCs to ensure required low value of core damage, early and large radioactive release frequency of nuclear installation.		X	I can’t see anything here that undermines the existing wording. So, agree with comment, but no change needed.		
Russia	3.29/c)	-	It is unclear, which DBE values are considered in this sentence: «Demonstrate that cliff edge effects are avoided within the uncertainty of the determined DBE values».	X	Suggest following amendment: “Demonstrate that cliff edge effects are avoided within the uncertainty associated with the definition of the SL-2 ~~determined DBE~~ values”		

Russia	3.30	«Therefore, during the seismic design of a new nuclear installation, two different *types* of earthquake levels should be determined: (i) one *type*, noted as DBE and constituted by the SL-2 and SL-1 levels, as defined in paras 3.20 to 3.28 above, for which adequate seismic margin should be provided by the design to avoid cliff edge effects, and (ii) *the second type*, noted as BDBE which aims to verify that adequate margins exist to comply with the safety requirements indicated in paragraph above».	P. 3.30 says about "two different sets of earthquake levels". However, according p. 3.29 and p. 3.32, the BDBE level is only one.	X	Could be made more explicit by slight amendment to para. 3.29 first sentence: "Therefore, during the seismic design of a new nuclear installation, two different sets of earthquake levels should be determined: (i) one set, noted as DBE and constituted by the SL-2 and SL-1 levels, as defined in paras 3.20 to 3.28 above, (ii) an additional earthquake level for assessing the seismic design robustness is defined as BDBE which aims to verify that adequate margins exist to comply with the safety requirements indicated in paragraph above."		
Japan	3.32.	The determination of the BDBE and the associated loading conditions can be done by: a) Defining the BDBE earthquake level by a factor times the SL-2 earthquake level[11]. b) Defining the BDBE earthquake level based on considerations derived from the probabilistic seismic hazard assessment[12]. 3.32A. In the case where the uncertainty associated with the hazard curve is large, it may be impracticable to define the BDBE. In such a case, a method alternative to defining the BDBE may be applied based on, for example, intensive geological survey and	Addition of a paragraph. Although it is understandable that defining two levels is ideal as a formulation, in practical, there are cases where it is difficult due to large uncertainty to define the Beyond Design Basis Earthquake. Since safety guides provide recommendations and guidance on how to comply with the safety requirements, the case mentioned above should be described and an alternative method in such case should be also described.			X	BDB analysis considers the uncertainties implicit in the seismic hazard and seismic response analyses. Moreover, the recommended ways for defining BDBE is based on international state of practice also reflected also in the IAEA Safety Standard NS-G-2.13 covered by a) and b). Intensive geological survey and analyses with engineering judgment is included in PSHA process.

		analyses with engineering judgment.					
Canada	3.33	The BDBE level should be characterized by both horizontal and vertical vibratory ground motion response spectra, anchored to a peak ground acceleration (i.e., at zero period of the response spectrum) and at the control point defined by the seismic hazard assessment.	In the last sentence it is enough to say "at the control point defined by the seismic hazard assessment."	X	O.K.		
Russia	3.38	«Physical barriers designed to protect the installation against the effects of external events other than seismic events (e.g. fires or floods) should remain functional and maintain their integrity after an *BDBE* earthquake level».	According to p. 3.29 c) which says, that for the BDBE level design should provide adequate seismic margin for those SSCs ultimately required for preventing core damage and mitigating an early radioactive release or a large radioactive release.			X	I think text is ok as is. Seismic design includes conservatism that is evaluated in Seismic Margin Assessment (safety analysis of the design) using different criteria as used in the design process (See section 7).
Pakistan	Page 17, Para 3.39, line 2	For any item in Seismic Category 1, appropriate acceptance criteria[12] should be established through the acceptable values **(limit states)** of design parameters indicating, for example, functionality, leak tightness, maximum distortion and/or deformation, maximum stress level, etc. of **different structural systems**	Acceptable values refers to different limit states values of a certain design parameter (e.g. Allowable drift, rotation etc). These limit state values are different for different structural systems and hence may be mentioned in the sentence.	X	Initially thought this was ok. But are all acceptance criteria expressed as "limit states"? The structural ones might be classed in that way, and the term is widely used in structural analysis and in limit state codes, but for functional criteria, is this naming convention still appropriate? I don't think it is. Also, not all SSCs are structural systems, so I would delete that additional text. I would amend as follows: "For any item in Seismic Category 1, appropriate acceptance criteria[12] should be established through the acceptable values **(e.g. performance targets or limit states)**		

					of design parameters indicating, for example, functionality, leak tightness, maximum distortion and/or deformation, maximum stress level, etc. of ~~**different structural systems**~~		
Russia	3.41/b)	«Items not included in Seismic Category 1 (particularly items under (b) and (c) in para. 3.37) that are required to prevent or mitigate plant accident conditions (originated by postulated initiating events other than earthquakes) for a period long enough that there is a reasonable likelihood that an *SL-1* earthquake may occur during that period».	The likelihood that an SL-2 earthquake may occur during the period of NPP operation is insignificant.	X	3.41 b was modified: b) Items not included in Seismic Category 1 that are required to mitigate plant design extension conditions.		
Canada	3.42	The items of nuclear installations included in Seismic Category 2 should be designed to withstand the effects of a SL-2 earthquake level without structural failure.	The difference between requirements for Category 1 and 2 should be provided. For Category 1 functionality for Category 2 Structural integrity.	X	The difference between Cat 1 and 2 is provided in Para 3.37 to 3.41. According to Para 3.45 Table 1 Seismic categories 1 and 2 applies for either structural integrity, or leak tightness or functionality, or their combinations, as applicable. Table 1 was amended to make this clear.		
Russia	3.42	Clause 3.42 shall be supplemented with the requirements on the earthquake intensity during and (or) after which the elements of category 2 seismic resistance shall continue to function.	It is not specified during what time and (or) after an earthquake effect of what intensity, the elements of category 2 seismic resistance shall remain operational (continue to function).			X	This appears to be asking for a more prescriptive guidance. This level of details belongs to project specific guidelines.
Russia	3.42	«The items of nuclear installations included in Seismic Category 2 should be designed to withstand the effects of a *SL-1* earthquake level».	If the items of nuclear installations included in Seismic Category 2 should be designed to withstand the effects of a SL-2 earthquake level, there is no			X	According to Para 3.45 Table 1: Both SL-1 and/or SL-2 should be used as prescribed by applicable regulations and nuclear codes.

			reason for introducing seismic categorization.				The scope of qualification will be different between SC-1 and SC-2.
USA	3.42 / Line 2	…withstand the effects of a SL-2 earthquake level. Alternatively, technical basis demonstrating that spatial interactions will not impede or affect any of the safety functions required to be performed by the Seismic Category 1 items should be provided.	Adding an alternative for consideration, for cases where it might be possible to demonstrate that the spatial physical interaction will not result in adverse effects (e.g. a very light item falling into a very robust and massive item).	X	Useful amendment.		
Germany	3.43	Seismic Category 3 should be the group constituted by all items that are not in Seismic Categories 1 and 2.	Clarification	X	O.K.		
Germany	3.44	The items of nuclear installations included in Seismic Category 3 should be designed as a minimum in accordance with national practice for seismic design of non-nuclear applications ~~and, therefore, for facilities at conventional risk~~. However, for some items in Seismic Category 3 ~~which~~that are important to the operation of the installation, it may be reasonable to select a more severe seismic loading, corresponding to the SL-1 level, if defined, and more stringent acceptance criteria than the ones for conventional facilities in national practice, based only on operational needs. Such an approach will minimize the need for plant shutdown, inspection and restart, thus allowing the installation to continue to operate after an earthquake occurrence.	Why is level SL-1 not mentioned here? We understood that it is exactly the purpose of SL-1 to ensure the safe operation of the plant.	X	Support changes. Some editorials added.		

Finland	Table I in section 3.	Table I implies that non-safety classified SSC should always be Seismic Category 3. However, if the only credible interaction of an item with safety classified items is collapse due to an earthquake, it may be sensible to classify it as non-safety classified and Seismic Category 2. A comment or a footnote should be added to Table I.	Example of correspondence of seismic categories with the safety classes defined in Ref. [6] is given in Table 1. The inclusion of an item in a seismic category should be based on a clear understanding of the functional requirements that should be ensured for safety considerations during or after an earthquake. According to their different functions and their functional safety categories, parts of the same system may belong to different seismic categories. Tightness, degree of damage (e.g., fatigue, wear and tear), mechanical or electrical functional capability, maximum displacement, degree of permanent distortion and preservation of geometrical dimensions are examples of aspects that should be considered and determined as input for the seismic designers to allow them to establish the limiting acceptable conditions.			x	Non-safety classified SSC are not always in SC-3. Items interacting with SC-1 will be classified as SC-2 according to Para 3.41 a).
Pakistan	Page 21, Para 4.6, bullet b)	b) Steel or reinforced concrete moment-resisting frames, specially detailed to provide ductile behavior. **However, for safety class 2 and 3 (seismic category 1) structures, adequate stiffness should be ensured to limit Interstory deformation, such that cracking can be minimized.**	Para 4.6 line 3 states that Specially detailed reinforced concrete moment resisting frame can be used for any seismic Category. This is very general statement since large ductility / inter-story deformation in not desirable in the safety class 2 and 3 structures. The proposed additional sentence may be added as a footnote.	X	Accepted as a new bullet with the following modification: For safety class 2 and 3 (seismic category 1) structures, adequate stiffness should be provided to limit deformation, to avoid excessive cracking or displacement that may affect the attached equipment		

Pakistan	Page 21, Para 4.7	b) Intermediate Moment Resisting Frame System	This is also one of the structural systems also prohibited by ASCE 43-05 and should also be included in para 4.7			X	We do not have a definition for intermediate Moment Resisting Frame Systems. Ordinary moment-resisting frame systems covers all frames not meeting the ductility criteria. So, the intend of ASCE 43.05 is met.
USA	4.9 / Line 1	Structures in Seismic Category 1 ~~can~~ should be designed to exhibit ~~nonlinear~~ linear behavior. Limited nonlinear behavior may be permissible, provided that their acceptance criteria…	Seismic Category I in some member states including the US are designed to exhibit linear behavior under SL-2/SSE earthquake levels. Non-linear behavior may be permissible for higher earthquake levels or for the SSE level evaluations involving geometric nonlinearities (sliding and uplift evaluations)	X	Accepted with some modifications: Structures in Seismic Category 1 should be designed to exhibit linear behaviour. Limited nonlinear behaviour may be permissible, provided that their acceptance criteria are met. Ductile behaviour is needed for developing adequate seismic margins.		
Pakistan	Page 21, Para 4.10, bullet b)	Structures in Seismic Category 2 ~~**can**~~ **should** also be designed to exhibit nonlinear behavior. Detailing of structural members, particularly joints and connections, should be consistent with the ductility level required to comply with the acceptance criteria.	The use of “can” in the para 4.10 gives an impression that considering non-linear behaviour is optional. However, in the later sentence it is emphasized that detailing should be consistent with the ductility level. If the defined acceptance criteria (limit state) is beyond elastic limit then non-linear analysis should be performed and can’t be optional.	X	Accepted with modification: Structures in Seismic Category 2 should be designed to exhibit nonlinear behaviour especially for developing adequate seismic margin capacity. Detailing of structural members, particularly joints and connections, should be consistent with the acceptance criteria		
USA	4.12 / Line 1	~~The possibility of~~ The global stability of the structure for overturning and lateral sliding during the earthquake ~~of structures~~ set ~~on waterproofing material (especially if wet)~~ should be assessed. Effects of waterproofing material (especially if wet), if any, should be	Some member states, including the US require a global stability evaluation regardless of the use or non-use of waterproofing material.	X	This would be normal design practice anyway. Changes supported.		

		considered in the evaluation of lateral sliding.					
Russia	4.18-4.25	This subsection should be amended with the following paragraph: application of seismic protection shall be economically feasible.				X	Disagree. Economic feasibility is not the objective of a safety standard.
Russia	4.18	This paragraph should be amended or an additional paragraph should be included: Seismic isolation shall not result in increase of the structure response under any other specific external impacts (except for seismic ones) in case these impacts are determinative.				X	Already covered by 4.22 g). No changes are needed.
Canada	4.22	4.22. The design of isolation systems should consider the following: (e) Qualification conditions of isolators should be consistent with the anticipated operating environmental conditions	The temperature but also the humidity.	X	Agreed.		
Canada	4.23	The substructure, the isolator pedestals (plinths) and the common footing (lower basemat), should be designed to resist not only gravity and seismic loads, but also the moments induced by the lateral displacements of the isolator system, including P-□ effects. The design of the lower basemat should take into account the effect of wave propagation.	The lower basemat is very flexible structure and sensitive to wave propagation.	X	Agreed.		
Germany	4.26.A New para	Mechanical equipment (e.g. pumps, valves) should be seismically qualified if functionality during and/or after an earthquake is required (see Section 6).	Our suggestion is to include new para. Even if the anchorage might be the crucial part for mechanical equipment, seismic qualification is needed	X	Para 4.26 was modified as following: “Seismic qualification of mechanical equipment depends		

			for active components. Hence such a recommendation needs to be included as for electrical equipment.		on seismic categorisation (Section 3 Sub-section "Seismic categorization for structures, systems and components")….		
Poland	4.27 b), 4.30 a), etc.	"natural frequencies"	It is proposed to add clarification or explanation of the "natural frequencies" phenomena. From the guide it is unclear are those "natural frequencies" of the structure or equipment related to resonance effect, or not. Also it should be explained how to determine structure, equipment or SSC's "natural frequencies" during design process and how to ensure that constructed and build structures and SSC's "natural frequencies" will be as considered in the design. At least determination of SSC's natural frequencies should be pointed as one of the necessary step in seismic design. This issue poorly mentioned just in 6.21 but in the context of already designed and build component seismic qualification.			X	Natural Frequency is a common used terminology in structural dynamics. Natural frequencies depend of the mass, stiffness distribution and boundary conditions. This topic is well explained in any text book on structural dynamics. This level of details is out of scope of the present draft safety guide.
Poland	4.30 c)	"elephant foot buckling"	Meaning of the term "elephant foot buckling" is unclear. It is proposed to avoid usage of slang terms in such document as a guide, or at least explanation / note should be added with clarification of this phenomena.			X	This is not a slang language is well established technical language describing one of the failure modes of the vertical storage tanks. Anyway, this term will be explained in the Definition section that will be added as suggested by other MS comments.

Poland	4.31	Grey cast iron and PVC are examples of brittle materials.	It is proposed to add definition of PVC in the list of the abbreviations.	X	PVC will be included in the Definition section (added as suggested by other MSs comments)		
Germany	4.31 c)	c) Vertical supports should not be excessively spaced. Guidelines from established national and/or international design codes should be followed;	We suggest to add national design codes as well	X	Support change.		
Germany	5.4 Line 1	(Version 1) Structural response should be calculated using ~~linear~~ equivalent linear static analysis, linear dynamic analysis~~, complex frequency response analyses~~ (in time or frequency domain) or non-linear dynamic analysis. (Version 2) Structural response should be calculated using ~~linear~~ equivalent linear static analysis, linear dynamic analysis (in time or frequency domain), non-linear static (“pushover”) analysis ~~,complex frequency response analyses~~ or non-linear dynamic analysis.	It not fully clear what is meant by “non-linear analysis”. If only dynamic (time-history) non-linear analysis is allowed, we propose Version 1 of the text. If also non-linear static (“pushover”) analysis, we propose Version 2 of the text.	X	Version 2 accepted with the following addition: …according to applicable guidelines, codes and standards.		
Germany	5.4 (b)	…. b) The analysis model should adequately represent the behavior of the structure under the seismic action, considering realistic distribution of the mass, ~~the inertial~~ stiffness and damping ~~distribution~~ of the structure;	It is unclear what is meant by “the inertial stiffness”.	X	Support change.		
Russia	5.4 (c)	This paragraph should be deleted as the information on the analysis model is contained in par. 6.12c.				X	5.4 c) talks about seismic SSI analysis and consideration of uncertainties related to soil dynamic properties

							since 6.12 c talks about seismic demand to be used in Seismic Qualification Process.
USA	5.5 / Line 1	~~It is common practice~~ The structural response can be calculated based on ~~to apply~~ the application of two ~~the~~ horizontal and one vertical components of seismic input simultaneously, provided that ~~In this case,~~ the components of the seismic input ~~should~~ are demonstrated to be statistically independent.	The section titled Structural Response, starting with paragraph 5.4, mentions several acceptable analysis methods including linear equivalent static analysis, linear dynamic analysis, complex frequency response analysis, and non-linear analysis. The proposed markups are intended to generalize the discussion of the application of the seismic input components in the context of the analysis methods, for some of which it may not be a common practice to apply the components of seismic input simultaneously.	X	Reasonable changes.		
Germany	5.11	For complex structures, the analyst should consider separation of the ~~seismic~~ ~~model~~ computational model into main structures and substructures. …	Clarification	X	Accept change but keep “seismic”.		
Iran	Para 5.15/ Line 1	5.15. The in-structure response spectra, typically used as the seismic input for linear …	Because there is the definition of in-structure response spectra and difference between it and floor response spectrum in footnote 24, it does not need to repeat "floor" here.	X	O.K.		
Russia	5.15a	It is necessary to correct the error in the English and Russian texts of Clause 5.15A. of the IAEA document "Nuclear Power Plant Safety: design", SSR-2/1, (Rev / 1), 2016 [1], as well as in clause 5.15A. of document No. DS 490,				X	SSR 2/1 Rev 1 is not open for revision It is not possible to make changes to SSR-2/1 Rev 1 (out of scope) within revision process of NS-G-1.6/DS490

		stating it in the revisions given below. 5.15A. Items important to safety shall be designed and located, with due consideration of other implications for safety, to withstand the effects of hazard or to be protected, in accordance with their **significance** to safety, against hazards and against common cause failure mechanisms generates by hazards. 5.15A. The items important to safety shall be designed and placed taking into account their safety **significance** so as to withstand the **hazards** and the common cause failures caused by them.					
Iran	Para 5.16/ Line 1	5.16. In order to in-structure response spectra be used as design seismic input for the structures, systems and components housed by …	This statement is incomplete and "in-structure response spectra" shall be added after "In order to".	X	Accepted		
Iran	Footnote 21/ Page 32		In this footnote, the definition and main application of Soil-Structure Interaction have been stated while it is better to bring this statement in pervious pages, such as page 3 or 13, where "Soil-Structure Interaction" has been used earlier.			X	Fair point but this footnote provides additional explanation directly relevant to points being made here. However, I think definition of terms section would be useful at the end, as a reference, in addition to abbreviations section.
Iran	Para 5.17/ Line 1	5.17. When consideration of soil-structure interaction (SSI) effects is required (see clause 5.2), …	Consideration of soil-structure interaction effects in analysis has been referred in para 5.2.	X	Change clause to para.		
Russia	5.17 (d)	The side walls of water pools in the NPP buildings are thick enough so the interaction between				X	The large mass of the water should be properly modelled. The hydrodynamic effects could be relevant for

		the fluid and the structure (FSI) should not be taken into account.					the SSI response as well as for the spent fuel racks or other safety significant items located in the pool.
Russia	5.18	It is necessary to write "should be taken into account" instead of "shall be taken into account", and the final decision on consideration of non-linear behavior shall be made depending on the type and homogeneity of the soil foundation. Otherwise this paragraph contradicts par. 5.28 where application of frequency-independent rigidity and attenuation in soil determined for elastic behavior of the soil is permitted.				X	There is no SHALL statement in Para 5.18 or any other paragraphs except quotation of requirements from Section 2.
Germany	5.20 Line 3	…. Direct methods are applicable to (equivalent) linear idealizations and are commonly used in case of ~~they are the only alternative for~~ nonlinear idealizations of the soil-structure system. Sub-structuring methods divide the soil-structure interaction problem into a series of simpler problems, solve each problem independently, and superpose the results. Sub-structuring methods are typically used in case of linear SSI analysis ~~should be limited to (equivalent) linear idealizations, since they rely on superposition.~~	Direct methods are NOT "the only alternative for nonlinear idealization of the soil-structure system". There are several sub-structuring methods which can be used in case of non-linear SSI analyses (e.g. Green's functions in wave-number time domain, dynamic stiffness transformation to time domain, scaled boundary finite element method in time domain, etc.). For more info, see for example Ref. Wolf (1988) "SSI Analysis in Time Domain".	X	Seems to be a reasonable change.		
Iran	Para 5.21/ Line 3	5.21. Uncertainties in the SSI analyses should be considered, either by the use of probabilistic techniques or by bounding deterministic analyses which cover the expected range of variation of	In this line, "including," has been repeated.	X	O.K.		

		analysis parameters affecting response, including soil properties.					
Germany	5.24	Lateral boundaries should also be located at sufficient distance so that the structural response is not significantly affected by these boundaries. Minimum distances to the soil-foundation interface depend on the type of boundary being selected ~~(elementary22, viscous, transmitting or domain reduction method conditions).~~	The bracket contains very specific details, which are not needed and can hardly be understood in the context of this safety guide. If the bracket shall remain, all four expressions need to be explained.	X	O.K.		
USA	5.25/ Line 2	… frequencies of interest in the structural response, including consideration of component and equipment frequencies.	Component and equipment may have fundamental frequencies of vibration outside the frequency range of interest for the building structure.	X	Accepted with modification: …including consideration of component and equipment frequencies whenever these might influence the structural response.		
Canada	5.26	SSI by direct methods can be used for linear and non-linear analyses.	This statement should be added.			x	Already covered by Para 5.20
Turkey	5.26.c. Footnote 23	'Rigid boundary' refers to the interface between the foundation and the soil being rigid. Validity of the rigid base assumption, wherever it is employed, should be shown with a sensitivity analysis prior to the performance of the calculations.	Licensing experience in Turkey has shown that considering the foundations NPP buildings as rigid or flexible bases must be done carefully, as these assumptions depend on the foundation thickness and the properties of the underlying soil. Consequently, these factors may also change the response of the structure obtained at different levels.	X	O.K.		
USA	5.27/ Line 3	… flexible volume methods and substructure subtraction methods). Technical justifications (e.g. adequate transfer functions over the frequency range of interest, and verification against analysis results from flexible volume	The subtraction method makes a simplification with respect to the treatment of the excavated soil volume that may lead to limitations in the applications of the subtraction method and potential errors	X	O.K.		

		method using reduced size computer models) should be provided to demonstrate the adequacy of SSI analysis based on the sub-structure subtraction method.	induced in computed foundation compliance functions and transfer functions.				
Canada	5.29	SSI by sub-structuring methods unsung superposition can be used for liner analyses only.	This statement should be added			X	Already addressed by Para 5.20
USA	5.29 c) / Line 1	…, 'small' buildings or underground structures (e.g. tunnels) located …	The proposed edits are intended to expand the assessment of potential SSSI effects on adjacent items other than the building structures.	X	Agreed.		
Russia	5.31	Editorial note. The following should be stated: "....demonstrate three-dimensional (spatial) behavior".		X	Agreed. Amend as follows: "a three-dimensional analysis should therefore be performed to properly characterize this three-dimensional (spatial) behavior"		
Canada	5.34	Seismic Capacity should be put under Seismic Design (Chapter 4) not under Seismic Analysis.	Seismic analysis is performed with the goal to calculate seismic demand. Seismic design is performed to achieve seismic capacity able to withstand the design demand and with detailing able to withstand beyond design demand.	X	Agree. Consider moving to Section 4..		
USA	5.34 / footnote 25	Seismic capacity is the highest seismic level for which required adequacy has been verified, expressed in terms of the input or response parameter at which the structure or the component is verified to perform its required safety function. ~~with high confidence of low probability of failure.~~	The proposed edits are intended to avoid different definitions of the high confidence of low probability of failure capacity (e.g. seismic margin capacity described in DS 490 Section 7, "Margin to be Achieved by the Design")	X	Support this change. (the whole subsection Seismic Capacity was moved to Section 4 Seismic Design)		
Iran	Para 5.35/ Line 1	5.35. For Seismic Category 1 and 2 structures, systems and components, acceptance criteria for load combinations, should…	Because load combination is applicable for structures, systems and components, it has to be considered here.			X	Load Combinations is typically specified in applicable design codes and standards and this is covered by Para

							5.35. (all Sub-section Seismic Capacity is moved to Section 4 Design).
Pakistan	Para. 5.38	Appropriate ageing considerations should guarantee the long term safe performance of structures, systems and components …….. Main ageing mechanisms such as radiation embrittlement, fatigue, corrosion, creep, shrinkage and pre-stress losses should be taken into account.	An important aging parameters "shrinkage" in structures is missing			X	Creep and shrinkage are a time dependent phenomena typically for concrete material. They are not degradation mechanisms. Creep and shrinkage effect are attenuated with time and normally they are considered in the initial design (e.g. for pre-stressing losses).
Poland	6.2/1st sentence	The in-structure design spectra should be used as input for seismic qualification.	1. It is unclear if "in-structure design spectra" is the same as "design response spectra" (see 5.4) or "in-structure response spectra" (see 4.27) or is something different. Proper clarification should be provided regarding "design spectra" or usage of the term should be unified in the entire guide. 2. Another aspect is that the meaning of the term "spectra", which is widely used in the guide, is poor explained. Provided footnote 14 is hardly understandable and does not explain the physics of the process the result of which and will be the "spectra". Spectra is a function of some parameter. It is unclear which parameter (vibration, ground motion frequency, load force fluctuation period etc.) is considered in one or another case. "Design", "Response" or "In-	X	Design Response Spectra in 5.4 means DBE or SL2. In-structure Response Spectra are used by Structural Nuclear Engineers to evaluate seismic demand for items located in the structures. This terminology is common for structural nuclear engineers. Response Spectra or Spectrum is well defined in any text book on structural dynamics. This will be addressed in a definition of terms section suggested by other MSs.		

			structure" are not the physical parameters, just applied terms. Additional clarification or definitions regarding all kinds of "spectra" used in the guide should be added to the guide.				
Russia	6.9	The following is stated in this paragraph: "the advanced means of analysis (programs) enable to use highly sophisticated numerical models with limits of applicability, and thus verification of these programs shall be performed by calculations according to alternative programs". Paragraph 6.9 should be amended: "performance of the alternative calculation is not mandatory in case the analytical program has passed certification in the regulatory bodies".				X	Disagree. Good scientific/ engineering practice dictates that results should be checked and verified anyway. The analysis models need to be validated. Certification of codes does not alter this, but obviously use of such codes can start from a presumption that they are likely to be correct. However, all software has limitations and at the very least the checks should confirm that programs have not been used outside of these limits.
Germany	6.11 Line 4	… Seismic demand is then computed using an appropriate analysis (including numerical) method and /or numerical analysis, ~~and~~ combined with the demand from other applicable actions.	Although some analytical methods can be applied, most commonly numerical analysis is needed.	x			
Germany	6.12 Line 1	(Version 1) The seismic demand on SSCs may be computed using ~~linear~~ equivalent linear static analysis, linear dynamic analysis (in time or frequency domain), ~~complex frequency response methods~~ or non-linear dynamic analysis, depending on the relevance of the particular component and on the national practice.	It not fully clear what is meant by "non-linear analysis". If only dynamic (time-history) non-linear analysis is allowed, we propose (similar as our comment to para 5.4) Version 1 of the text. If also non-linear static ("pushover") analysis, we propose Version 2 of the text.	X	Agreed as per comment for para. 5.4.		

		(Version 2) The seismic demand on SSCs may be computed using ~~linear~~ equivalent linear static analysis, linear dynamic analysis (in time or frequency domain), ~~complex frequency response methods~~ non-linear static ("pushover") analysis or non-linear dynamic analysis, depending on the relevance of the particular component and on the national practice.					
Russia	6.12	The words "linear spectrum theory" should be inserted after the words "linear equivalent static analysis".				X	Not sure I've ever heard of linear spectrum theory before. Linear equivalent static analysis is a reasonably well understood term and I think means the same thing. No change.
Germany	6.12 c)	The important natural frequencies of the SSC should be estimated, or the peak of the design response spectrum multiplied by an appropriate factor greater than 1 should be considered as input. Multi-mode effects should be considered too;	From the text it is not clear whether the "appropriate factor" could also be < 1. Probably a factor > 1 is intended. The allowable range of factors should be clearly stated.	X	O.K.		
Russia	6.12 (c)	This paragraph should be replaced with the following: "The design finite element model shall comply with the following requirement: the response parameters of concern for the finite element model shall not differ substantially with further condensation of the grid. Source data for the analysis such as damping shall contain con-				x	These elements are covered by 6.12 b)

		servative assessment of the potential element behaviour in case of an earthquake".					
Germany	6.12 f), Line 1	Energy dissipation ~~should~~ <u>may</u> be accounted for and can be modelled for SSCs in a number of ways. [...]	Accounting for energy dissipation reduces the conservatism of the assessment. Therefore, this should not be a recommendation.	X	Accepted with modification: Energy dissipation should be accounted for in a conservative manner (considering the associated uncertainties relate to dissipation mechanism) …		
Germany	6.12 f), Line 2	[...] If a modal analysis is being performed, modal damping values ~~can be and~~ are available for common types of components and materials from nuclear design codes.	Either the values are available or not. 'can be and' makes no sense here.	X	O.K.		
Russia	6.15	This paragraph should be replaced with the following: "Simplified analysis or design procedures may be used subject to the relevant substantiation".				X	The existing text says this already. No change.
Iran	Para 6.18/ Line 2	6.18. In addition to inertial effects, careful consideration should be given to the effects of differential seismic motions between supports of piping systems, since …	It is unclear that this para is applicable for which system, structure or component. Because it is applicable for piping system, it is better add the name of the system in the first statement.	X	O.K.		
Germany	Between paras. 6.26 and 6.27	~~**Conduct of tests**~~	Headline without following text. Is here something missing? If not, headline should be deleted.	X	Delete.		
Iran	Page 41		It seems the context of the "Conduct of tests" has been missed because there are not	X	Delete.		

			any recommendations in this part.				
Germany	7.1	Seismic robustness is expressed by seismic margin capacity which defines the capability of a nuclear installation to achieve certain performance for seismic loading exceeding the site-specific seismic hazard. ~~those corresponding to SL-2~~. Seismic margin should be provided by conservatism associated to definition of SL2, application of the nuclear safety requirements and applicable nuclear design codes.	The seismic margin is generally considered to be an indicator of the seismic robustness of the plant. But this is only the case if seismic margin is defined relative to the site-specific seismic hazard (as required to be taken into account according to the pertinent nuclear regulations) and not relative to the SL-2 level (which might be higher than the actual seismic hazard). A margin definition relative to the SL-2 level could be misleading with respect to the evaluation of the seismic robustness and should therefore be avoided.	X	O.K.		
Germany	7.3	Seismic margin ~~is~~can be measured by the High Confidence Low Probability of Failure[29] (HCLPF) which provides the link with the seismic fragility at the installation level.	HCLFP is one possibility, however, other options should not be excluded.	X	Accepted with modification "Seismic margin should be measured by the High Confidence Low Probability of Failure (HCLPF) which provides the link with the seismic fragility at the installation level."		
Germany	7.6 Lines 3 and 5	Line 3: < ~~1.0^{-5}~~ 10^{-5} Line 5: < ~~1.0^{-6}~~ 10^{-6}	Clarification	X	O.K.		
Germany	7.6, footnote 30	~~When Seismic Margin Assessment is used for sites with low/medium seismicity the adequate seismic margin (at facility level) is typically defined by HCLPF > 1.5x SL-2.~~	As explained in the Comment referring to Para. 7.1, relating margins to SL-2 is not recommendable. Besides this, this footnote is superfluous as footnote 10 already gives examples for factors considered acceptable by some Member			X	Footnote 30 (now is 32) was made consistent to footnote 10. Since footnotes are relative to the context where they are used I suggest keeping it as modified:

			States. Therefore, this footnote should be deleted.				"The adequate seismic margin (at facility level) is typically defined by a factor of 1.4, 1.5 or 1.67 based on PGA corresponding to SL-2"
Iran	Page 42/ foot-note 30		There is a similar recommendation about adequate seismic margin in footnote 10. It is recommended that this foot-note is omitted.			X	Footnote 30 (now is 32) was made consistent to footnote 10. Since footnotes are relative to the context where they are used I suggest keeping it as modified: "The adequate seismic margin (at facility level) is typically defined by a factor of 1.4, 1.5 or 1.67 based on PGA corresponding to SL-2"
Iran	Para 7.8/		Because one of the most important challenging issues in seismic design and evaluation of nuclear facilities between regulatory body and licensee is quantitative criteria for low/ moderate and high seismicity, for clarification it is recommended to add quantitative criteria for low/ moderate and high seismicity in this guide.			X	Disagree. This would make the guide prescriptive and also take it beyond its scope as a design safety guide. MSs make policy decisions on these issues. Also, it requires reference back to higher level IAEA safety documents covering guidance on setting LERF and CDF goals etc.
Germany	7.11	The facility level seismic margin (HCLPF) should be compared with the adequate seismic margin defined ~~in~~ according to paragraph 7.6 or established by the national regulatory body.	Para. 7.6 itself does not specify an 'adequate seismic margin' but describes how such a margin should be derived and that it should be consistent with pertinent performance goals. Only footnote 30 gives an indication of how large an 'adequate seismic margin'	X	Re-formulated: The facility level seismic margin (HCLPF) should be compared with the adequate seismic margin defined in paragraphs 7.4 and 7.6 or established by the national regulatory body. Para 7.4 says:		

			could be under certain circumstances albeit using an unsuitable definition of margin as explained in the Comment on Para. 7.1. Therefore, the text of this paragraph should be reformulated to better reflect the actual content of Para. 7.6.		"There is a correlation between hazard level used to define SL-2, seismic margin capacity (HCLPF) and seismic performance goal (e.g. Seismic Core Damage Frequency (S-CDF), Large Release Frequency (S-LRF) or Large Early Release Frequency (S-LERF) as applicable). In this context, the minimum required seismic margin capacity of the nuclear installation should be prescribed to ensure that seismic performance goal is achieved, and cliff edge effect will not occur".		
Iran	Para 8.1/ Line 1	Putting "Seismic instrumentation" definition in footnote.	The definition of "Seismic instrumentation" has been presented in this para. It is recommended that it is moved to footnote.	X			
Germany	8.7 / below c)	8.7.A In addition to the minimum seismic instrumentation described in paragraph 8.7 additional instrumentation should be considered for sites having an SL-2 free field acceleration equal to or greater than 0.2g.	This passage should be new para, para 8.7.A, because it contains a new aspect in comparison to 8.7 above.	X	As modified can remain in Para 8.7: "In addition to the minimum seismic instrumentation described above additional instrumentation should be considered for sites having an SL-2 free field acceleration equal to or greater than 0.2g"		
Iran	Para 8.7/ Line 2	8.7. A suggested minimum amount of seismic instrumentation should be installed at any nuclear power plant site as follows…	This recommendation is applicable for nuclear power plant, as it is mentioned in clauses b and c of this para, then it is recommended to change nuclear installation site to nuclear power plant site. It is also recommended to add a	X	8.7 was modified to apply for all nuclear installations. Also Section 9 includes a paragraph regarding seismic instrumentation.		

			statement in this section or in section 9 for seismic instrumentation of nuclear installations other than NPPs.				
Iran	Para 8.9/ Line 1		In this para, it is recommended to compare damage indicators with the values derived from the free field design basis earthquake. It should be clarified that which damage indicators are intended.	X	Damage parameter is defined in modify Para 8.8 (used in 8.9 also): "The seismic instrumentation installed at the nuclear installation should be able to provide estimate of the damage parameters based on the integration of the acceleration record (such as CAV = cumulative absolute velocity Ref [13]), thus providing a more representative parameter of earthquake induced damage in the safety related equipment and as important tool and data for assessing the installation response in case of an earthquake occurrence."		
Finland	8.15	Please add a reference or a formula for definition of CAV.		X	Ref [13] was added.		
Germany	8.15 Line 9	… with spectral velocities in the 1–2 Hz range greater than 15~~15.2~~ cm/s.	15.2 cm/s indicates an unrealistic accuracy. 15 cm/s is enough.	X	Modified: CAV> 0.16 g sec Ref [13] or other damage indicators agreed by the national regulators.		
Israel	Par. 8.16	The definition of the significant earthquake is the responsibility of the licensee and ~~may require~~ **requires** agreement or approval by the regulatory body. *(We believe that this is a major safety parameter related to the*	Quality and clarity	X	O.K.		

		design of a nuclear installation with direct impact on the safety analysis report and operation of the installation and if so, it has to be agreed upon with and approved by the regulatory body.					
Germany	8.17 Line 4	… to the operating organization ~~at the plant site and at headquarters~~, ….	We think this detail is unnecessary. The operating organization as a whole is responsible for the appropriate actions after an earthquake.	X	O.K.		
Iran	Section 9		Consideration of nuclear installations other than NPPs in this document is very good job but it seems there are not enough recommendation in this section. It is suggested to add some other recommendation as following: - Presenting some examples for SDCs - Presenting quantitative criteria for SDCs determination(based on consequences) - Presenting Limit States with more details and examples. - Adding some definition in relation to Target Performance Goal, Seismic Hazard Level, and etc. - Identification and recommendation some nuclear design codes (if it is possible)			X	I don't recommend changing the text in this guide. This level of details is appropriate for a Safety Report or TECDOC. For Research Reactors example see Safety Report #94 (published this year).
Finland	9.6	The risk metric associated with the seismic performance goal should be defined.	For facilities other than NPPs the metric could be release frequency but there are also other possibilities.	X	A footnote was added in 9.6 for performance Goals:		

					"In this section Performance Goal is used instead of typical reactor-based Risk Metrics (e.g. CDF, LERF, LRF) since nuclear installations include a large variety of nuclear facilities (reactor and non-reactor facilities). Therefore, performance goal is associated with definition of severe accident conditions for these facilities (mainly losing barriers and controls of the confined nuclear materials).		
Canada	Section 10. Application of Management System. Paras 10.1 thru 10.7.	Delete paras 10.1 through 10.7, and replace with: 10.1. As part of the management system, Ref. [8], design controls, in the form of process(es), should take into account the recommendations and guidance provided in Ref. [9 paras 5.84—5.140]. Specifically, where Paras [5.95 (e), 5.99 (a), 5.128 and Annex A-1, Fig. A-1], provides seismic details into the design process(es).	As written this section reads as if it is disconnected from the rest of the document. I suspect it is a holdover from the version being superseded. It's a construction of illogically cherry-picking bits-and-pieces from IAEA Safety Guide GS-G-3.5 paras 5.84—5.140, offering little rather than adding value for seismic design. While the above may seem brief compared to the existing material it directs the reader to a single source—GS-G-3.5—for applicable recommendations and guidance.	x	It is the IAEA policy to have Quality Management Chapter in all Safety Guides. Section 10 was reduced to minimum possible with appropriate references to GS-R-Part 2 and GS-G-3.5.		
Israel	Par. 10.1 to 10.8	Section 10 deals with very important aspects of management systems, project management and peer reviews. It duly refers to the relevant detailed descriptions in Ref. [9]. Still, we are suggesting to consider in this section (or at least in a footnote), using the term of **System Engineering** which is	Completeness			x	I agree that system engineers have a key role in design of a nuclear installation. Going in such details we should specify more categories of disciplines and engineers – but this is not appropriate level of details for this SG.

		the encompassing approach used worldwide for projects design and management. If so, it could be considered to add to the list of references one of the many textbooks on System Engineering (if needed, I would be happy to suggest some suitable textbooks as a reference).					