ENISS comments on
DS 507

COMMENTS BY REVIEWER Reviewer: ENISS Country/Organization: ENISS			Page 1 of 7 Date: 07/10/2019	RESOLUTION ENISS			
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1	4.16	In location where a fault zone comprises multiple fault segments, each fault segment should be taken into account both dependently and independently. The possibility of the multiple fault segments rupturing simultaneously during an earthquake, that might go up to total fault rupture length, should be evaluated to determine the conservative estimate and associated uncertainties of the potential maximum magnitude.	Consistency between maximum magnitudes estimates and tectonic context, mainly for intraplate domains where large inherited structures now face low deformation velocities			X	The next sentence in this para is the same intention.
2	4.16	Available information about the seismological and geological history of the rupture of a fault or structure (such as segmentation, fault length, and fault width) should be used to estimate the maximum rupture dimensions and/or displacements. This information together with magnitude-area scaling relationships should be used to evaluate the potential maximum magnitude of the seismogenic structure under consideration. Other data that may be used to	This section should be taken carefully: the consideration of scenarios including total fault rupture should not be a requirement, but a possibility when the deformation rate and tectonic settings of the region are such that this possibility could be realistic. This should be taken into account particularly in cases of stable continental regions.	X	Accepted with minor modification		

		construct a rheological profile should also be considered in this estimation, such as data on heat flow, crustal thickness, and strain rate.					
5	5.10	In active tectonic regions, relatively abundant empirical data exists and GMPEs should be developed primarily from that data or from data from similar seismotectonic settings. In areas with lower rates of earthquake activity, where data is much less abundant (such as stable continental regions), alternative empirical or semi-empirical methods have been developed for deriving GMPEs. Examples of these methods include the hybrid empirical method and hybrid reference empirical method, both of which rely on utilizing a GMPE developed for regions where abundant data exist (a host region). In the hybrid empirical method, simple parametric seismological models of the physical properties of the seismic source and diminution of seismic energy with distance are used to adjust the host GMPE to conditions consistent with the site or region of interest (the target conditions). For the hybrid reference empirical method, adjustments6 should be developed based on residuals between the empirical	The term "hybrid" is generally used (concerning ground motion) to identify motions obtained by mixing simulations techniques with observations. In this case we understand that this term is used to identify hot-to-target adjustment approaches. However, these procedures for adjusting the ground motion predicted by a GMPE to the target area ground motion characteristics require the availability of sufficient observations in the target area in order to avoid an artificial growth of the uncertainties. Such observations, however, are rare (at least for earthquakes in the magnitude-distance scenarios of concerns for the safety of nuclear installations) when stable regions are considered as target area.			clarification	In the EU, it is rare, but this guide needs to cover entire Member States. In high seismicity area, such as Japan, it is already practicable.

		data in the target region and the GMPE model from the host region. This approach requires an adequate number of empirical data in the target region to perform the necessary residual analysis for the development of the adjustments.					
4	5.12	The aleatory variability should be considered for the GMPEs and derived from the residuals between observed and predicted motions. The residuals may depend on magnitude, distance, or ground motion level itself. At the selected specific site, detailed site response analysis or the residual investigation using vibratory ground motions recorded at the site should be conducted in order to reduce the aleatory variability.	Similarly to the comment provided for § 5.10: the assessment of the aleatory variability based on residuals between observed and predicted motions requires to dispose of a sufficient amount of data in the target area, which is generally not the case for sites located in stable regions.				See above
5	5.14	Caution should be exercised in comparing the selected GMPEs with recorded ground motions from small, locally recorded earthquakes. The use of such recordings (e.g. in scaling the selected attenuation relationships) should be justified by showing that their inferred magnitudes and distance scaling properties are appropriate for earthquakes within the ranges of magnitude and distance that are of greatest concern regarding the seismic safety of the nuclear installation. Nevertheless, best efforts should be performed to	§5.14 states “magnitudes and distance scaling properties are appropriate for earthquakes within the ranges of magnitude and distance that are of greatest concern regarding the seismic safety of the nuclear installation”. Similarly to the previous item: This is most rare in stable regions				See above

		reflect those observed data in the selection of the GMPEs					
6	7.5.a)	If it shows evidence of past movement (such as significant deformations and/or dislocations) within such a period that it is reasonable to conclude that further movements at or near the surface might occur over the life of the nuclear site or installation. In highly active areas, where both seismic and geological data consistently reveal short earthquake recurrence intervals, evidence of past movements in the period of Upper Pleistocene to Holocene (i.e. the present) may be appropriate for the assessment of capable faults. In less active areas, it is likely that much longer periods (e.g. Pliocene to Holocene, i.e. the present) are appropriate. In areas where the observed activity is between these two rates (i.e. not as highly active as plate boundaries and not as stable as cratonic zones), the length of the period to be considered should be chosen on conservative basis (i.e. quaternary with possible extension to Pliocene depending on areas tectonic activity level). One way to calibrate the time frame for fault capability may be to check if the site is in the deformed area of major regional faults. Longer time frames should be	Consistency between consideration of Pliocene – Holocene periods in cratonic regions and a reduce time frame for regions with highest tectonic activity (but not as high as in active regions for which Upper Pleistocene – Holocene period is retained)	X			

		used when the site is far away from the potentially deformed areas of these regional structures.					
7	7.5b	If the capability of a fault cannot be assessed as indicated above because it is not possible to obtain reliable geochronological data by any avail-able method, the fault should be considered capable if it could be structurally linked with a known ca-pable fault (i.e. if a structural rela-tionship with a known capable fault has been demonstrated such that the movement of one fault may cause movement of the other at or near the surface).	It is not clear what is intended for a fault to be "structurally linked with a known capable fault". Is there any distance to consider to link the studied fault and the "known capable fault"?			clarifica-tion	The distance may depend on the region and it is matter of each Member States. But for the con-servative con-sideration, the link should be carefully consid-ered.
8	7.5.c)	~~If the capability of a fault cannot be assessed as described in (a) and (b) because it is not possible to obtain the relevant reliable data by any available method, the fault should be considered capable if the potential maximum magnitude associated with the seismogenic structure, as determined in Section 4, is suffi-ciently large and at such a depth (i.e. sufficiently shallow) that it is rea-sonable to conclude that, in the cur-rent tectonic setting of the site area, movement at or near the surface could occur.~~	Such definition appears too vast for intraplate domains where capable faults are rare and re-cent markers of deformation (i.e. Pleistocene to present) of-ten absent.			X	This is the states of practice of the Member States. See Para 8.4 in SSG-9.

COMMENTS BY REVIEWER Reviewer: M-L Järvinen Page.... of.... Country/Organization: STUK Date: 2nd November 2019				RESOLUTION			
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1.	5.10, footnote 6	Footnote 6 on hybride methods for GMPE determinations mentions "MS regulation". A reference would be helpful.	The topic is of general interest, but it is not generally known what the MS regulation is and where it can be found.			X	In order to explain the method, this footnote has been added. As it can be recognized, this is the Japanese method and the reference is in Japanese. In future, when many records will be accumulated, this will be applicable to the other site. Strong motion observation at the site is encouraged for this fact as well. Add (available only in Japanese ref)
2.	5.11	The meaning of terms ergodic and non-ergodic in this context should be explained or a reference should be added.	The terms are not very generally known even among seismologists or geotechnical engineers not specializing in this field.			X	It is quite usually used in seismological societies. And definitions can be found on the www.

3.	3.20, 3.26, Definitions	Definitions include the term "site area border". Exactly this form was not found in the draft guide. Paras 3.20 and 3.26 include expressions "border of the site area" and "boundary of the prospective selected site area". The consistency of wording should be checked.		X	Unified to 'boundary'		
4.	3.32 (a)	**… Boreholes should, where practicable, be drilled down to seismic bedrock**. Boreholes should **also** be drilled deep enough to confirm that no cavities or karstic features are underlying the foundation of nuclear installations, such as in limestone areas.	Regarding the depth of boreholes, only detection of possible cavities and karstic features is mentioned as a criterion. Other criteria should also be mentioned. However, this may lead to extensive and possibly controversial additions which can be considered in the next update.	X	Accepted with minor modification.		
5.	ANNEX-TYPICAL OUTPUT OF PROBABILISTIC SEISMIC HAZARD ANALYSES TABLE A-1 Uniform	Mean and fractile uniform hazard response spectra should be reported in tabular as well as graphic format. Unless otherwise specified in the work plan, the uniform hazard response spectra should be reported for annual frequencies of exceedance of 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} ~~and~~**,** 10^{-6} **and** $\mathbf{10^{-7}}$ and for fractile levels of 0.05, 0.16, 0.50, 0.84 and 0.95.	Draft Safety Guide DS490, Seismic Design of Nuclear Installation, mentions annual frequency of exceedance of 10^{-7}. Perhaps it could be considered here also.			X	After fragility is considered, the number decreases to order 10^{-7}. But at the seismic hazards evaluation stage, there are normally very large uncertainties in going much below 10^{-6}. (this only works if the plant fragility curve goes to unity at around 10^{-6})

	hazard response spectra						
6.	ANNEX-TYPICAL OUTPUT OF PROBABILISTIC SEISMIC HAZARD ANALYSES TABLE A-1 Mean and modal magnitude and distance	The mean and modal magnitudes and distances should be reported for each ground motion parameter and level for which the M–D deaggregated hazard results are given. Unless otherwise specified in the work plan, these results should be reported for response spectral frequencies of e.g. 1, 2.5, 5, 10**, 25** Hz, and peak ground acceleration.	From an engineering point of view, area from 10 Hz to PGA should be reported also, e.g. 25 Hz. The frequencies of interest depend on the site conditions (hard rock / soft soil / etc.). PGA was added in accordance with comment in Step 8 but not a freaquency between 10 Hz and PGA. However, we think that some frequency between 10 Hz and PGA is should be reported.	X	Due to innovation of the ground motion observation, higher frequency signal can be available than SSG-9 stage.		

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Date: 30/09/2019
pages</td><td colspan="4">RESOLUTION</td></tr>
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1.	5.20	5.20 Alternative ground motion simulation methods utilize a more direct physical representation of the seismic source and wave propagation. These ‘physics-based’ methods use fault rupture modelling and path-specific wave propagation to estimate ground motions. These procedures may be especially effective in cases where nearby faults contribute significantly to the vibratory ground motion hazard at the site and/or where the existing empirical data is limited (on the hanging wall of a nearby fault for example). The physics-based methods for fault rupture description fall into two general categories, kinematic and dynamic. Some details on fault rupture modeling and example of methods are provided in IAEA Safety Reports Series No. 85, Ground Motion Simulation Based on Fault Rupture Modelling for Seismic Hazard Assessment in Site Evaluation for Nuclear Installations [*please add the reference to the reference list*]**.** ~~The kinematic simulation method should specify the following parameters:~~ ~~(a) Fault geometry parameters (location, length, width, depth, dip, strike);~~ ~~(b) Macro-parameters (hypocenter, seismic moment, average dislocation, rupture velocity, average stress drop);~~ ~~(c) Micro-parameters (rise time, dislocation, stress parameters for finite fault elements);~~ ~~(d) **Crustal** Subsurface structure parameters **from source to site**, such as shear and compressional (alternatively, Poisson's ratio) wave velocities, density and anelastic attenuation factor (i.e. seismic quality factor Q).~~	The list of parameters is only for kinematics, and too detailed, bringing some confusion to 5.20. The suppression of the list makes the 5.20 more general and less confusing The reader is advised to refer to SR-85 for technical information on fault rupture modelling.	X	Accepted with minor modification		

2.	5.21	5.21 In the kinematic simulation approach, the slip velocity function and rupture time distribution on the finite fault should be defined. ~~Most of the~~ The model parameters ~~mentioned above~~ cannot be known in advance for future ruptures on a specific fault. Hence the simulations should represent these parameters values ~~properties~~ as random variables with appropriate correlation among them ~~amongst some of the variables~~. The specific characteristics of the seismotectonic setting where the site is located should also be given due consideration. A sufficient number of simulations should be conducted to provide a stable estimate of the median ground motions at the site of interest as well as the variability about that median. Kinematic models typically utilize a stochastic approach to model the high frequency portion of the spectrum as Green's function. However, the aleatory variability should be at least comparable to that associated with empirical GMPEs, since a potential weakness of simulations is the inability to capture the full variability of ground motions.	Proposed modification to be consistent with new proposed 5.20 and keep a similar description in 5.21 and 5.22 The last sentence formulation leaves with the impression that simulations variability is useless. This is a bit confusing and definitive. I guess that the intended warning was to pay attention to the fact that a lower variability one could get from simulations may lead to reduced hazard.	X	Accepted with minor modification		

3.	6.9	6.9 A probabilistic approach should be used when the safety of the nuclear installation against earthquake loading needs to be demonstrated with explicit consideration of the likelihood of occurrence of the relevant seismic hazards (e.g. vibratory ground motion level). Probabilistic approaches consider the rates of recurrence of events in each of the seismic sources for all magnitudes from a bounded minimum magnitude, up to the estimated potential maximum magnitude ~~along with their estimated maximum size~~. In these cases, the annual frequency of exceedance of different levels of the relevant hazard parameters (e.g. the peak ground acceleration) should be estimated to define an appropriate design basis and/or to perform a seismic probabilistic safety assessment. In subsequent analyses these results may be used to demonstrate the nature of cliff edge effects and to ensure that performance targets are met.	The proposed modification clarifies the range of magnitude distribution.	X	Accepted with minor modification		

4.	6.17	~~6.17 To be meaningful, deterministic seismic hazard assessments are appropriate only for regions where enough appropriate data exists for key parameters. If this is not the case, the level of statistical uncertainty implied for each parameter can lead to the use of excessively conservative bounding values that is likely in turn to lead to grossly excessive predictions of seismic hazard levels. The main difference between deterministic and probabilistic assessments is that the former does not model parameter uncertainty explicitly; this is an especially important and sometimes dominant consideration in seismic hazard assessments for regions of low seismicity.~~	This paragraph incorporates misleading statements about differences between PSHA and DSHA: - To be meaningful, both PSHA and DSHA need data. - Main difference between DSHA and PSHA is the annual rate of occurrence of the events. For DSHA, scenarios considered have the probability of 1, for PSHA it depends on the magnitude => associating a frequency to the ground motion. - DSHA is able to model explicitly uncertainties on key parameters (regarding catalogs, magnitudes, distances, GMPES, site, and so on – same as for PSHA), leading to a distribution of hazard, but no frequency. - In low seismicity regions, the PSHA is also challenging, due to the lack of appropriate data for key parameters for PSHA (with the additional need for evaluating seismicity rates…). This paragraph does not bring fair information. The data is needed for both approaches. Uncertainty can be model explicitly in both approaches.			clarification	The comment makes the case that PSHA and DSHA are different in some respects but equivalent in many others. It obscures the point that deterministic analyses handle uncertainty in a fundamentally different way to probabilistic analyses. Deterministic analyses uses qualitative approach because they effectively use informed guesswork to judge the range of uncertainty for a parameter. The range normally has to be truncated to remove “outliers” because the entire range is treated in effect as equally probable (a uniform Probability density function). However make some changes to the para. As below: “~~To be meaningful,~~ **D**~~d~~eterministic seismic hazard analyses are appropriate ~~only~~ for regions where sufficient appropriate data exist for key parameters. If this is not the case, the level of statistical uncertainty implied for each parameter can lead to the use of excessively conservative bounding values, which is likely in turn to lead to grossly excessive predictions of seismic hazard levels. The main difference between deterministic analysis and probabilistic analysis is that the former does not **employ quantitative statistical methods to** explicitly model uncertainties in the parameters; this is an especially important and sometimes dominant consideration in seismic hazard assessments for regions of low seismicity.

5.	7.3	7.3 Fault displacement is the relative movement of the two sides of a fault at or near the surface, measured in any chosen direction, generated by an earthquake. Primary or principal ~~Principal~~ displacement ~~faulting~~ occurs along a main fault rupture plane (or planes) that is the location of release of the energy. Secondary or distributed fault displacement ~~faulting~~ is the rupture that occurs off ~~near~~ the principal displacement ~~faulting~~, possibly on splays of the main fault or antithetic faults. In other words, fault displacements could be associated with the causative (i.e. seismogenic) fault or could occur co-seismically on ~~secondary~~ neighboring faults. It should be noted that tectonic relative displacements on discrete fractures associated with folds (synclines and anticlines) are also included in the term 'fault displacement'. Fault creep, when demonstrated as such, is considered as a slowly progressing geological hazard that may affect the safety of nuclear installations but is not seismically induced and therefore not considered in this Safety Guide.	Proposed modification of terminology to reflect the definitions adopted in the scientific community, as well as in international guidelines (e.g. ANSI/ANS-2.30-2015) : - "Principal" should be "Primary or Principal" for consistency. - This paragraph is about displacement. Faulting introduces confusion with a hierarchical classification of faults. Thus "faulting" is replaced by "fault displacement" throughout the 7.3. - "Near" term suggests a quantitative estimation that should be mentioned (how much is 'near'?). We suggest to use "off", in order to stay "binary" (on/off or principal/secondary) - "secondary faults" is too restrictive in the case secondary displacement occurs along a major structure. Neighboring fault (or other faults, neighboring structures) is more general, including cases where the causative fault is a minor fault and the secondary displacement is seen on a major fault. - Add 'discrete fractures' to the fold-related displacements; otherwise it is confusing to read fold-related relative displacement and fault displacement	X	Accepted with minor modification		

6.	7.11 7.12	7.11 During the selection and evaluation stages of a proposed new site for a nuclear installation, if reliable evidence is collected demonstrating the existence of a capable fault ~~with potential for seismogenic (i.e. primary) fault displacement~~ within the site vicinity, or within the site area, and its effects cannot be compensated by proven design/engineering protective measures, this issue should be treated as an exclusionary attribute (see para. 3.8 of IAEA Safety Standards Series No. SSG-35, Site Survey and Site Selection for Nuclear Installations [9]) and an alternative site should be considered. ~~7.12 If during the selection and evaluation stages of a proposed new site for a nuclear installation, reliable evidence is collected demonstrating the existence within the site vicinity area of secondary fault belonging to a seismogenic capable fault located outside the site vicinity, this issue may be treated as a discretionary attribute (see para. 3.8 of SSG-35 [9]). However, if reliable evidence shows that this secondary fault is traced or extended to the site area, and its effects cannot be compensated by proven design/engineering protective measures, this issue should be treated also as an exclusionary attribute and an alternative site should be considered.~~	Large faults with significant paleo-earthquake history are often the host for 'principal' surface rupture with large offsets. However, there are examples in the world with significant rupture appearing on previously unknown or on structures known to be secondary-order faults, even hosting the 'principal' surface rupture (eG. M7+ El Mayor Cucapah in 2010 or M6 Napa earthquake in 2014). Based on this knowledge, it seems hazardous to guarantee that a 'secondary' tectonic feature will remain in this category. The formulation of 7.11 and 7.12 leaves the impression that there is confusion between primary (major)/secondary (minor) fault and primary/secondary surface rupture. Fault displacement hazard is actually assessed based on different equations/predictions for primary and secondary surface ruptures during earthquakes, which can occur on any kind of fault. The distinct characteristics of primary and secondary ruptures and their dependencies are implemented in PFDHA for existing sites. If it is kept, 7.12 would better refer to **a capable fault with potential for distributed (i.e. secondary) surface displacement** instead of "secondary fault". Since the concept of secondary fault is qualitative, it mostly depends on the existence of a larger fault nearby. Therefore, the application of section 7.12 could lead frequently to some difficult decision situations, where a capable fault crossing the **site vicinity** would be left to a discretionary decision because a larger fault would be known in the neighborhood. The application of 7.12 has also the following consequence: if the new **site area** is crossed by a capable fault with potential for distributed displacement (or a secondary fault in the original formulation), moving the site only a **few hundreds of meters** (depending on the site area dimensions) so that this same structure lies out of the site area but within the site **vicinity** will be enough to avoid the exclusionary attribute and consider the issue can treated as a discretionary attribute. For a new site, it seems reasonable to **avoid any capable fault within the site vicinity** (moving the site a few kilometers). As a consequence, it is proposed to remove the 7.12. The proposed formulation for 7.11 en-			clarification	As discussed in NUSSC46, exclusionary attribute is distinct between these two paras. Please see slide 23 of https://www-ns.iaea.org/committees/files/NUSSC/1886/Item2.8-46NUSSC-DS507-Y.Fukushima.pdf If there are not enough evidences or data to differentiate between primary and secondary faults, a conservative approach should be applied and the fault should be identified and characterized as the capable fault. Respecting also the Japanese MS comment, Para 7.11 was amended to avoid the risk.

			compasses all the capable faults (either responsible for primary or secondary displacement) within the vicinity of the site and the site area to be regarded as a reason to find an alternative site.					

7.	7.17	7.16 In the probabilistic fault displacement hazard analysis, the following two types of possible fault displacements should be considered with careful and appropriate treatment of the involved uncertainties (both epistemic and aleatory): (a) ~~Primary displacement, typically in the form of direct seismogenic fault rupture;~~ Primary or Principal displacement which occurs along a main plane (or planes) that is (or are) the locus of release of seismic energy. (b) ~~Secondary displacement (also called indirect or subsidiary displacement), typically associated with induced movement along pre-existing slip planes (e.g. a triggered slip on an existing fault or a bedding fault plane from an earthquake that occurred on another fault).~~ Secondary or distributed displacement which occurs in the vicinity of the principal displacement, possibly on splays of the main fault or antithetic faults. In some cases, triggered slip has been considered to be a form of secondary or distributed displacement (a triggered slip is a remote triggering of slip along a fault from a distant earthquake). The fault displacement is generally characterized as a three-dimensional displacement vector that should be resolved into components of slip along the fault trace and along the fault dip, with the resulting amplitude equal to the total evaluated slip (for a given annual frequency	Proposed modification of terminology to reflect the definitions adopted in the scientific community, as well as in international guidelines (e.g. ANSI/ANS-2.30-2015)	X	Accepted with minor modification		

		of exceedance and for a given fractile of hazard).					
8.	7.19	The range of annual frequencies of exceedance, for which the amount of displacements is to be calculated, should be compatible with the safety principles of the nuclear installation. From the hazard curve thus obtained, the annual frequency of exceedance corresponding to the level required for safety evaluation purposes should be adopted to establish the corresponding surface rupture evaluation basis to conduct the safety evaluation of the installation. ~~The level of annual frequency of exceedance should be defined considering the plant event sequences that could result in high radiation doses or in a large radioactive release have to be practically eliminated (see SSR-2/1(Rev. 1) [9], para. 2.11)~~.	The link between hazard and practical elimination concept is not so straightforward and SSR-2/1 (or SSR-3 and 4) do not provide any requirement that allow to establish directly such a recommendation in DS 507.	X	Accepted with following modification: (right end column)		“The range of annual frequencies of exceedance~~,~~ for which **fault displacements are** ~~the amount of displacements is to be~~ calculated should be compatible with the safety significance of the nuclear installation. **This will enable a fault displacement hazard curve to be constructed over the frequency range of relevance to nuclear safety for the installation. The response of the installation to these displacements might be evaluated to determine its fragility to probabilistic fault displacement hazard, i.e. the probability of failure as a function of fault displacement. From both the hazard curve and the probability of failure function, the frequency of failure due to fault displacement hazard can in principle be calculated, and this could be compared to relevant regulatory safety goals, such as large early release frequency (LERF), that apply to the installation. On the basis of this information, a judgement could be made as to whether the installation meets the intent of Requirement 20 and para. 5.27 of SSR-2/1 [9] in terms of ‘practical elimination’. See also** ~~From the hazard curve obtained in this way, the annual frequency of exceedance for safety evaluation purposes should be adopted to establish the corresponding surface rupture evaluation basis to conduct the safety evaluation of the installation. This level of the annual frequency of exceedance should be defined considering that event sequences at the installation that could result in high radiation doses or in a large radioactive release have to be ‘practically eliminated’ (see SSR-2/1 (Rev. 1) [9],~~ para. 2.11; SSR-3 [10], para. 6.8; and SSR-4 [11], para. 6.7).

Draft Safety Guide

DS507 "Seismic Hazards in Site Evaluation for Nuclear Installations", Step 11
Version from 30 August 2019

	COMMENTS BY REVIEWER Reviewer: **Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)** (with comments of GRS) Pages: 3 Country/Organization: **Germany** Date: 02.10.2019				RESOLUTION			
Rele-vanz	Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
3	1.	3.32 (a), line 9	[.....] Boreholes should be drilled deep enough to confirm that no cavities or karstic features are underlying the foundation of nuclear installations,~~s~~ such as in limestone areas.	editorial	X			
2	2.	3.52	The seismic monitoring network system should be installed for new sites from the very beginning of the site evaluation stage. For existing sites, for which such systems were not originally deployed, the seismic monitoring network system should be installed from the beginning of the seismic safety re-evaluation programme. These systems should be operated during the whole lifetime of the nuclear installation <u>to acquire more detailed information on path effects, empirical Green's functions, ground motion prediction equations, and site response. In addition, micro-</u>	Acquiring "more detailed information on path effects, empirical Green's functions, ground motion prediction equations, site responses" and "micro-tremor/ambient-noise measurement" are purposes of the high sensitivity seismometers of the seismic monitoring network system. As Paragraph 3.54 is dedicated to strong motion accel-			X	Two types of sensor are introduced and high sensitivity sensor is usually aim to detect micro event locations. Whereas the strong motion sensor is used to record the vibratory ground motions that is the target to evaluate in the hazard assessment. The recorded motion consists of the all

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Rele-vanz	Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
			tremor/ambient-noise measurement should be deployed if necessary to evaluate site response.	erometers, the text dealing with these issues should be transfered to Paragraph 3.52.				source, path and site effect of the target. Complementary, the ambient noise measurement will be used to evaluate site effect.
2	3.	3.54	If the selected instrumentation for the seismic monitoring network system cannot adequately record strong motions, several strong motion accelerometers should be collocated with the high sensitivity seismometers ~~to acquire more detailed information on path effects, empirical Green's functions, ground motion prediction equations, and site responses. In addition, micro-tremor/ambient-noise measurement should be deployed if necessary to evaluate site response~~.	As Paragraph 3.54 is dedicated to strong motion accelerometers, the text dealing with issues of the seismic monitoring network system(see Comment to Para. 3.52) should be transfered to Paragraph 3.52.			X	See above. Records, which observed by the high sensitivity seismometers, are mainly used to identify the hypocentres of seismic sources. As well as getting representative time histories of strong ground motion to underpin design time histories, or enabling better interpretation of macroseismic intensity data.

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Rele-vanz	Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1	4.	6.2, line 3	[…..] The vibratory ground motion hazard may should be evaluated by using probabilistic and/or, depending on national regulatory requirements, also deterministic methods of seismic hazard analysis. The choice of the approach depends on the national regulatory requirements and the end user specifications, which should be documented in the project work plan (see Section 10).	Understanding that differences in the regulatory approach exist the twofold approach should be still advocated. It was also one of the insights gained from the Fukushima nuclear accidents that information on the exceedance probability of external hazards provides important input for risk assessments. As the value of doing both, probabilistic and deterministic hazard assessments, has been recognized by IAEA, the twofold approach should be advocated in this guide. In Europe, it is already state of the art to use both methods as documented in the *WENRA Safety Reference Levels for Existing Reactors*, Paragraph T3.2.			X	This is the international documentation but not the EU regional documentation. Any approaches should have potential. But both applicants and regulatory authorities should take their responsibility.

Japan NUSSC Comments on DS507, “Seismic Hazards in Site Evaluation for Nuclear Installations”

COMMENTS BY REVIEWER Reviewer: Japan NUSSC member Page..1. of..1. Country/Organization: Japan / Nuclear Regulation Authority (NRA) Date: 4 October, 2019				RESOLUTION			
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1.	7.11./4 7.12./5	We would like to highlight our particular support for the Netherlands’ comments #4 and #5, which are intended, as we commented in November 2018, to resolve apparent discrepancy between SSR-1 and DS507. The proposed amendments on para.7.11 and 7.12 could be considered helpful to ensure consistency between SSR-1 and DS507.					

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DS507 "Seismic Hazards in Site Evaluation for Nuclear Installations"

	COMMENTS BY REVIEWER Reviewer: **National Nuclear Regulator** Pages: Country/Organization: **South Africa** Date: 04.10.2019				RESOLUTION			
	Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1	1.	6.7	Consideration should be given to the possibility that ground motion hazard may be influenced by the fault rupture driven by anthropogenic activity, e.g. reservoir loading, fluid injection, fluid withdrawal, or other such phenomena. Specialist guidance should be consulted to deal with such situations.	The guidance provided in this document is based on the basic founding principle or accepted norms for conducting a seismic hazard analysis, namely that the occurrence of seismic events is random in space and time. To be consistent with this principle, it is a practice in seismic hazard analysis to screen out or exclude human-induced seismicity (i.e. seismicity driven by anthropogenic activity) deliberately. Thus, including human-induced seismicity goes beyond the scope of this guidance document.			X	The seismic events triggered by human activities are out of scope for this guide. This sentence is straight forward from SSG-9. Anyway, occurrence of seismic events is not restricted in random. For example, the time predictable model is also in the scope. (Same for the Comment 2)

	COMMENTS BY REVIEWER Reviewer: **National Nuclear Regulator** Pages: Country/Organization: **South Africa** Date: 04.10.2019				RESOLUTION			
	Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
2	2.	7.9	Consideration should be given to the possibility that faults that have not shown recent near surface movement might be reactivated by anthropogenic activity, e.g. reservoir loading, fluid injection, fluid withdrawal, or other such phenomena. Specialist guidance should be consulted to deal with such situations.	The guidance provided in this document is based on the basic founding principle or accepted norms for conducting a seismic hazard analysis, namely that the occurrence of seismic events is random in space and time. To be consistent with this principle, it is a practice in seismic hazard analysis to screen out or exclude human-induced seismicity (i.e. seismicity driven by anthropogenic activity) deliberately. Thus, including human-induced seismicity goes beyond the scope of this guidance document.				

Comments on IAEA Draft Safety Guide
***Seismic Hazards in Site Evaluation for Nuclear Installations Step 7* (DS507)**

COMMENTS BY REVIEWER Reviewer: USA/Nuclear Regulatory Commission Country/Organization: USA/Nuclear Regulatory Commission Date: Oct 22 2019				RESOLUTION			
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1.	3.32 (a):	…… (e.g. Poisson's ratio, Young's modulus, shear modulus reduction or non-linear properties, dynamic damping properties, density, relative density, shear strength and consolidation characteristics, grain size distribution, P-wave and S-wave velocities).	Dynamic damping properties (hysteretic damping, and damping ratio as function of shear strain) are important parameters in ground motion and site response determination.	X			
2.	6.22	Add a requirement either after (3) or after (7): (#) If the site strata are not horizontally uniform (e.g. valley, layers with inclination angle greater than 20 degrees), 2-D or 3-D effects in site response should be examined.	Irregular site strata will greatly affect site seismic response analysis results, therefore 1-D model may not be able to provide realistic site response estimate.	X	More generic term: 'heterogeneous' than 2-D or 3-D is used		
3.							
4.							
5.							