DESIGN OF REACTOR CONTAINMENT STRUCTURE AND SYSTEMS FOR NUCLEAR POWER PLANTS (NS-G-1.10 / DS 482)

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Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1	1.6/2	… management of energy, radioactive material ~~radionuclides~~ and combustible gases.	'Radionuclides' usually refers to fission product releases to primary system and containment atmosphere. Since DEC with core melting belongs to the scope of the present Safety Guide, quenching of corium deposited onto cavity basemat / pedestal –or retained in-vessel– should also be addressed within the safety system functions placed in containment. Therefore, radioactive material is a more generic term comprising also in-vessel and ex-vessel corium. Otherwise corium should be added to the list.			X	Approved with that terminology in 2004. We try to limit the number of changes
2	2.3/1st bullet	For operational states **and design basis accident conditions,** the cumulative annual effective dose received ….	As stated in SSR-2/1 the design release criteria are the same for operational states and design basis accident conditions. 5.25. The design shall be such that for design basis accident conditions, key plant parameters do not exceed the specified design limits.			X	Effective dose for operational states and for DBA is not the same.

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3	2.3/2nd bullet, 1st sub-bullet	For ~~**design basis accidents and**~~ design extension conditions without significant fuel degradation	See comment no. 2				
4	2.3/2nd bullet, 3rd sub-bullet	Sequences which might lead to early or large releases are "practically eliminated" by appropriate design provisions (see item 2.13/4).[1] **[1] The possibility of certain conditions arising may be considered to have been 'practically eliminated' if it would be physically impossible for the conditions to arise or if these conditions could be considered with a high level of confidence to be extremely unlikely to arise. The level of confidence should be below …….(to be specified)**	The requirements of SSR-2/1 are not specific. Specific recommendations should be given.			X	Recommendations for the practical elimination of situations leading to early or large radioactive releases are addressed in para. 3.9
5	2.7/3	… combustible gases and **barrier continuity**)	In case of DEC-B like severe accident, containment integrity will not preserved if only pressure, temperature and combustible gases are controlled. In case of corium ex-			X	The issue you raise is different and is addressed in par. 4.3.2

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			vessel relocation, Containment Filtered Venting, Containment Fan Coolers and PARs adequate performance will not prevent corium to keep eroding the basemat until melting it through. Therefore, it is important to highlight this fourth safety aspect / function that safety systems should independently take care of.				
6	2.8/1	… combination of loads **resulting from deterministic and probabilistic safety analysis for the entire spectrum of plant states** are such that…	Requirement 42 addresses compliance with design basis and defence in depth on the basis of safety analysis. Current text does not clearly show the link with that requirement.				That recommendation is linked with Req.42 ,item 5.73.
7	2.9/2	… a set of the most likely representative core melting conditions **that identify bounding cases** is postulated.	'Most likely representative' could be understood as if associated frequency would be the only selection criterion for choosing those conditions. However, as indicated in Req. 16 on PIEs, 'representative' should conduct or be related to bounding cases. Therefore, both statements together, i.e. risk-significant and bounding sequence, constitute a			X	The additional safety features implemented in the design are defined and designed on the basis of conditions resulting from the more likely scenarios for core melting accident.

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			clearer, more comprehensive criteria for sequence selection.				
8	POSTULATED INITIATING EVENTS	**IDENTIFICATION OF** POSTULATED INITIATING EVENTS **FOR AOO AND DBA AND IDENTIFICATION OF DESIGN EXTENSION CONDITIONS**	PIEs only affect operational states and DBAs whereas DECs, mostly DEC with core melting, i.e. severe accident, need to be defined not only by imposing the initial condition, i.e. PIE, but also the boundary conditions throughout accident evolution in terms of available mitigating systems. It is obvious that DECs play a fundamental role in containment design so they should also be included here.			X	SSR 2/1 rev.1 requirement for PIEs does not exclude DECs: …all foreseeable events with the potential for serious consequences… Moreover, keeping the wording used for SSR 2/1 overarching requirements help for clarity of the Safety Guide
9	3.6/6	… postulated initiating events **dealing with AOOs and DBAs** that should be	Containment integrity is threatened by DBA and DEC with core melting scenarios. Listed PIEs only deal with DBAs so more challenging DECs are missing.			X	Combining PIES and failures may result in DECs

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10	3.6/(new)	Regarding DEC scenarios, a selection of specific sequences with core melting (severe accidents) should be made in order to establish the design basis for the safety features for mitigating core melt accidents, according to the plant safety objectives. These sequences should be selected in order to represent all main physical phenomena involved in core melt sequences. Although design extension conditions are, to a large extent, technology and design dependent, the accidents below are provided as a preliminary reference of design extension conditions with core melt (severe accidents) that should be relevant for the design of the containment and its associated systems: • Loss of core cooling capability, such as an extended loss of off-site power with partial or total loss of on-site AC power sources (exact sequence is design dependent), or/and the loss of the main	Please read above comment 6. This text has been almost entirely taken from paras 3.45 and 3.48 of ongoing SSG-2, Rev. 1, including examples. If not agreed with the form, something similar should be written down.				

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		ultimate heat sink, • Loss of RCS integrity, such as loss of coolant accidents without the availability of emergency core cooling systems (ECCS) or exceeding their capabilities.					
11	3.10 / Table	Aircraft crash[1] [1] long distance passenger aircraft with full fuel tanks	Without specified the aircraft type the requirement has no sense. Besides the dynamic load of the aircraft, the fuel fire has an impact on the structural integrity of the containment.				Table 3 will be deleted
12	3.16/10	… to prevent ~~hydrogen~~ flammable gas detonations;	Though highly plant-dependent (in particular basemat chemical composition dependent), long-term combustion process might be more governed by carbon monoxide rather than hydrogen generation.		X Hydrogen fast deflagration or detonation		For consistency of the terminology used in the document
13	3.19/3	… to the environment**, and to challenge equipment survivability placed in containment**.	Accident conditions should also be determined to identify containment environmental bounding conditions (as indicated in 3.20).				Included in : " jeopardize the capability to limit the … If equipment necessary to mitigate the consequences are

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							not qualified to operate under the accident conditions, you jeopardize the mitigation
14	3.22/5 (addition)	… in the design **[Para 5.5, 5.6 of SSG-2 Rev. 1]**	Special emphasis should be made on user effects. The included reference gives indications in this respect.			X	Codes used for design might different from codes used for assessing completeness and correctness of the design. Moreover the intention is not to confuse MS with recommendations for design and recommendations for design assessment.
15	3.32/1	… a set of the most likely representative conditions **that identify bounding cases** in case of an accident….	Please see rationale of above comment 7				Most likely representative conditions reflect well the intention probability/ main physical phenomena

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16	3.33/7	Pressure at ~~onset of core damage~~ RPV failure	Pressure at RPV failure features far-reaching consequences than at core damage: in the elapsed time between both events the operators might have depressurize the primary system so that HPME (hence DCH, large corium relocation, etc.) is avoided.				What about in vessel retention strategy?
17	3.33/(addition at the end as new para)	Core melting scenarios result from safety systems failing to succeed in performing their intended safety function. DBA scenarios, alongside DEC without significant fuel degradation, in combination with mitigating system failures and leading to extended core damage, constitute a long list of scenarios highly difficult to handle with. Moreover and contrary to DBAs, bounding sequences will be different depending on the severe accident acceptance criteria. DBA standard technical criteria, such as maximum PCT or clad oxidation, constitute a set of	No structured approach or generic rule is suggested to identify which severe accidents should be taken in deterministic safety analysis for design extension condition identification regarding containment design. The suggested paragraph should only serve as an instance in this respect.		X Proposed modification: Conditions with core melting retained as boundary conditions for the design of the containment structures and for the associated systems should be justified on the basis of PSA level 2 analyses supplemented by engineering experience to select the more likely and representatives .		

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		intimately related variables so that conditions leading to one variable maximization will likely lead to the other. However, this is not the case for severe accidents where related acceptance criteria can be constituted by highly independent variables to an extent that maximization conditions for one surrogate variable could mean minimization conditions for another. One typical example could be containment hydrogen concentration whose maximization will hardly be bounded by containment pressure bounding sequences. Therefore, a structured approach should be employed here for severe accidents identification. One very useful tool may come from Level 2 PRA so-called Plant Damage States, which constitute a comprehensive set embracing the entire spectrum of severe-accident phenomena					

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		embedded in risk-significant (looking backwards) groups of sequences leading to core damage and (looking forwards) featuring similar evolutions in containment.					
18	3.34/3	… to stabilize the molten core, ~~and~~ to remove the heat from containment **and to avoid flammable gas detonations**.	Detonation phenomenon cannot be avoided by the same means that containment overpressurization; it requires dedicated mitigating system device. Corium stabilization and containment heat removal will occur late in time enough for hydrogen and carbon monoxide to build up until reaching DDT conditions.		X and to avoid fast deflagration and detonation of combustible gases.		
19	3.35/All	*Please see rationale*	The reviewer is quite surprised to read this para since FCV as mitigating system device is responsible for pressure relief in the containment. Maybe the intention was to distinguish between hard and filtered? Please clarify.				Modified as follow to answer ther comments from MS; “Different means to control the pressure build up in accident conditions inside the containment should be implemented, and venting (if any)

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							should be used as the last resort mean”
20	3.36/1	*To be removed / relocated*	3.36 belongs to current section 3.52 on DECs so not fitting here.	X			Relocated in para. 3.5.1
21	3.39/5	Direct leakage **through specific location such as hatches, airlocks or penetrations**	For clarification's sake.				The issue is a limit for unfiltered leakages (e.g for single wall containment)
22	3.53/1	*Please see rationale*	Such 'independence' should be explicitly defined: fully independent support systems? Sharing buildings hosting those components means dependency? Reservoirs or other passive components such piping are included within that independency? A footnote clarifying this concept or a due reference, applicable to all locations throughout the text where independence is referred to, should be added to the text.			X	To fulfill SSR 2/1 Rev.1 Req. 7, item 4.13 A. Guidance for implementing adequate independence is given in para. 3.8 Independence of levels of defense is a cross cutting safety issue and thus

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							cannot be described in one specific safety guide.
23	3.54/2	… in ~~paragraphs~~ sections 3.3, 3.4 and ~~3.10~~ 3.11 respectively.	Typos			X	Para. Is sused
24	3.57/All	Conditions leading to early and large releases highly depend on plant-specific features, e.g. mitigating systems performance, containment characterization, etc., and regulatory as-defined categories of what is meant by 'early' and 'large' release. Notwithstanding the above, several generic scenarios present significant contributions to both categories whose elimination will hence help achieve the 'practically eliminated' objective: 1) Early releases: a. Uncontrolled reactivity transients; b. High-pressure RPV failure (potentially leading to Direct	1. For clarification's sake. 2. Containment isolation failure, not included in containment bypass scenarios, is lacking. 3. Uncontrolled reactivity accident is lacking. 4. Reference to stress the highly plant-specific nature of such release categories is lacking. 5. Since conditions leading to early and large releases should be eliminated by design, implementing measures addressing that elimination should be indicated. Therefore, rather than only speaking on severe-accident phenomena like HPME or steam explosion, the text should direct				Examples given in the text are those that are relevant for DS 482. Regarding your proposed text, once situations not relevant for DS 482 removed, everything is true, but a Safety guide is not a TECDOC and should more focused on “should recommendations” and less on description

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		Containment Heating hence jeopardizing containment mechanical integrity); c. Containment isolation failure; d. Containment bypass: Interfacing System LOCA (ISLOCA), both as initiating event and at recirculation switch; SGTR; e. Steam Explosions: In-Vessel explosions (so-called ALPHA mode) whose latest state of the art has estimated this phenomenon to be 'practically eliminated'; and Ex-Vessel at RPV failure in case of wet pedestal / reactor cavity configuration. However, steam explosions hardly fit with operator control, i.e. no mitigating human action or equipment can be implemented to avoid such severe-accident phenomena. 2) Large releases: a. Aside from the scenarios mentioned above, all kinds of containment failure may lead to	recommendations to corresponding operative, useful actions. This way, instead of talking about DCH, it should be better to refer to RPV failure at high pressure as a necessary condition for DCH to occur.				

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		severe source term releases in the long term as a consequence of losing the last defence-in-depth barrier.					
25	3.64/3	… (e.g. containment spray system **if provided with heat exchanger**)	For precision's sake. Many NPP designs feature containment spray system without associated heat exchanger so that long-term containment cooling is provided by a different system.			X	Spraying itself is effective to stop and limit the pressure build up inside the containment
26	3.66	Add: Structures, systems and components of the containment needed for mitigation and monitoring during design extension condition accidents shall undergo a specific qualification. The qualification shall ensure the operating of the systems and equipment in the ambient environmental conditions that are anticipated for design extension conditions.	SSR-2/1 para. 5.48 requires for the ambient environmental conditions that are anticipated in the design basis for the plant.			X	"Shall" is not appropriate in a safety Guide. No real difference with 3.65
27	3.67/1	… testing, **survivability** analysis and the use of…	For clarification's sake. Such survivability analysis, when applied to severe accidents, is meant to be performed through system code simulations.				For new builds survivability does not exist. Qualification is requested. When qualification is not

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							achievable, local protection might be in some cases an alternative and if not justification should be provided
28	3.68/2	… pressure, humidity, **flammable gas concentration**, radiation levels, …	Ongoing IAEA-TECDOC-1135 on "ASSESSMENT OF NUCLEAR POWER PLANT EQUIPMENT RELIABILITY PERFORMANCE FOR SEVERE ACCIDENT CONDITIONS" led by A. Duchac from IAEA focuses exactly on this topic and ways to tackle with it. Flammable gas concentration is one of the selected figures of merit of containment characterization for equipment qualification. The authors are invited to look it up.				That Safety guide does not aim at providing recommendations as detailed.as those given in TECDOC or Safety guide dedicated to a specific topic. That is why it is stated that more detailed recommendations can be found in the referenced documents.
29	4.3/General	*Please see rationale*	Just a general comment on a relevant aspect which is currently missing on minimum requirements to be accomplished by the containment space located right below the RPV, i.e. reactor cavity basemat or pedestal, in				

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			terms of thickness, openings, etc. Equivalent to inherent primary physical parameter determining containment peak pressure as indicated in 4.53, inherent safety parameter on MCCI and IVMR failure consequences to drive off gases released from cavity, basemat erosion, peak pressure impacting on RPV, etc. is cavity thickness, geometry and openings and chemical composition.				
30	4.6	Add: The design shall consider the needs for in-service inspections as well as inspections needed for the ageing management of the containment.	The design shall consider the necessary accessibility for the execution of surveillance and in service inspections.			X	See recommendations 4.1.2, 5.2.3, 5.2.4.
31	4.9/General	*Please see rationale*	Is this comment too generic? Shouldn't it be focused on local actions performed in containment or affected by containment boundaries, e.g. penetrations building?			X	Also relevant for the actuation of systems necessary to mitigate accident conditions

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32	4.23	Loads should be….	Capital letter in Loads	X			
33	Table 2/Loads due to accidents	*Replace* peak *by* peak and time dependent profile	When talking about DEC with core melting conditions which determine the most severe conditions challenging safety barriers and equipment, results should not only be limited to identify the peak but also the time profile of the figure-of-merit variable throughout the entire accident from the initiating event up to achieving a steady state condition. Histogram representations fit well with equipment reliability performance since this is more related to a maximum value along a certain period of time.	X			
34	4.41	…pipe breaks, water flowing….	It should be ","	X			

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35	4.45/(new)	Should in-vessel strategy by ex-vessel flooding fail to save the vessel, adequate provisions to withstand new, derived consequences should be necessary, in particular regarding large pressure peaks derived from significant corium flowrates being deposited into a large pool of water. Analysis of potential ex-vessel steam explosion and large pressure peaks both on containment and RPV, e.g. RPV displacement, should be carefully carried out.	According to the latest studies, IVMR probability of failing to save the RPV is significant. Negative consequences derived from corium relocation and deposition into a large mass of water within a confined compartment may constitute a new challenge introduced by IVMR strategy so that it should duly be taken into account.				I do agree with the new text but not sure that we can reach consensus on this point. One possibility is to request for a demonstration proving that such conditions are practically eliminated. Will be presented at the NUSSC meeting.
36	4.62/2	… associated with ~~various likely combinations of normal operating events and anticipated operational occurrences~~ **all kind of plant states** should be determined.	Accident conditions should be taken into account within the analysis of the hydraulic response of the pressure suppression pool and entire containment.		X Hydraulic response of and loads imposed to the pressure suppression pool in the different plant states should be determined and considered for design.		

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37	4.102/(addition)	Possible paths for recirculation interfacing system LOCAs should be analyzed and eliminated as far as possible. Interfacing system LOCAs during recirculation switch occur due to valve performance failures enabling containment sumps inventory and atmosphere to be in contact with outside environment, for instance, through cooling source deposits used during the injection mode. Since such deposits are usually not designed for withstanding high pressures going beyond atmospheric values, radioactive effluents coming from the containment would directly end into outside environment.	Interfacing system LOCAs as initiating events have been addressed in para 4.102. Nonetheless, according to Level 2 PRA typical results, similar frequencies are featured by interfacing system LOCAs during recirculation switch, both of them likely classified within LERF category.			X	Better to focus the recommendation on the obligation to identify all the possibilities for interfacing LOCAs. We know that they are design dependent.
38	4.124/2	… when evaluating the threats, both to the outside environment and attached buildings to containment, e.g. penetration buildings or auxiliary buildings hosting safety equipment.	For clarification's sake.	X			

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39	4.7.3/title	Measures for the prevention of ~~hydrogen~~ **combustible gases** detonation	Independent on the combustible gas, equal challenging scenarios and mitigating measures apply.		X See New Title: "Measures for the prevention of hydrogen combustions challenging the containment integrity"		
40	4.127/(new)	Deterministic safety analysis by simulating the most risk-significant and bounding scenarios threatening containment and / or attached buildings for determining removal device design features, e.g. number and location, type, etc., should be carried out.	For precision's sake.			X	4.118 is ok
41	4.133	Outside.	Remove one dot from ".."	X			
42	4.164	..design of types of concrete [7].	Add reference [7]	X			

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43	4.9.4	…requirement 6.30….	Blank space before 6.30	X			
44	4.177, 4.183/(new)	Monitoring of combustible gas concentration; Monitoring of oxygen concentration; Containment flooding level; RPV failure detectors;	1. Combustible gas challenges containment integrity; 2. Oxygen depletion might drastically modify combustible gas concentration in case PARs act as dedicated mitigating system; 3. Important for obvious reasons; 4. IVMR or core reflooding success might be difficult to check in some scenarios, e.g. lack of appropriate instrumentation, low RCS pressure at RPV failure, etc.			X	Already included in 4.202
45	Section 5/Title, general	The section should be changed to MAINTENANCE, SURVEILLANCE AND IN-SERVICE INSPECTION With reference to SG No. NS-G-2.6	Besides specific IN-SERVICE INSPECTION also specific Maintenance and Surveillance recommendations should be given.			X	Section 5 primarily deals with tests and inspection of the containment structure whose specificity made sense to be developed in NS-G 1.10 and DS 482. For systems

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							recommendations are not detailed and we refer to NS-G 2-6. For maintenance, provisions which need to be considered for design are addressed in para. 4.1.2., but all generic aspects and maintenance programme cannot be in this safety guide
46	Section 5/ general	Add paragraph: **SURVEILLANCE PROGRAMME** **A surveillance programme as specified in NS-G-2.6 shall be set up. Specific attention should be given to the availability of systems for pressure reduction and hydrogen measurement and ignition system.**	See comment 45				Idem

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47	Section 5/ general	Add paragraph: **MAINTENANCE PROGRAMME** **A maintenance programme as specified in NS-G-2.6 shall be set up. Specific attention should be given to the availability of systems for pressure reduction and hydrogen measurement and ignition system.**	See comment 45				Idem
48	Section 5/ general	Add paragraph: **IN-SERVICE INSPECTION PROGRAMME An in-service inspection programme as specified in NS-G-2.6 shall be set up.**	See comment 45				Idem
49	Section 5.2.2/ general comment	Please add: The testing method of the containment integrated leak test should be qualified.	A integrated leak test is a complex testing. Qualified procedures and testing methods are necessary, as for other NDT methods.	X			
51	References	[7] IAEA Nuclear Energy Series No. NP-T-3.5 "Ageing Management of Concrete Structures in Nuclear Power Plants", Vienna, January 2016.	New IAEA document more adequate to be referenced than the previous one.			X	NSNI is revising IAEA Safety Standard (draft DS 385) for ageing . As Safety Standards are

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							reviewed by Committees and CSS before publication , the contents reflect MS opinion and consequently I prefer it is more appropriate to refer to Safety Standards