**Draft Safety Guide DS488 “Design of the Reactor Core for Nuclear Power Plants”**

**(Version dated 18 August 2016)**

**Status: STEP 8 − Submission to the Member States for comments**

Note: Underlined are those to be added in the text. ~~Crossed out~~ are those to be deleted in the text.

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|  | COMMENTS BY REVIEWER  Reviewer: **Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)** (with comments of GRS, VdTUeV, Physikerbüro Bremen) Page 1 of 8  Country/Organization: **Germany** Date: 2016-12-29 | | | | RESOLUTION | | | |
| Rele-vance | Comment No. | Para/Line No. | Proposed new text | Reason | Accepted | Accepted, but modified as follows | Rejected | Reason for modification/rejection |
| 1 | We did not find requirements with regard to “anticipated transients without scram, ATWS” (conditions which should be categorized as design extension conditions without significant fuel degradation). The related core design requirements (inherent neutronic feedbacks) and acceptance criteria should be added. | | | |  |  |  |  |
| 2 | 1 | 1.4 (d) | … and guide tubes for reactivity control devices (for pressurized water reactors); | Guide tubes in the fuel assemblies only exist for the PWR and not for BWR |  |  |  |  |
| 2 | 2 | 2.4, last sentence | (…) For design basis accidents and design extension conditions without significant fuel degradation, the reactor core is required to be coolable (Requirement 44 of Ref. [1]) and to remain a configuration that can be shutdown. | It may be implicitly the case, that a coolable core can also be shut-down safely, but this should explicitly be required.  Or, it should be stated elsewhere, that coolable includes “able to be shut-down”. See also para. 3.25 and 3.44 |  |  |  |  |
| 1 | 3 | 2.11 | Consequences of ~~earthquake~~ external hazards, especially earthquakes, should be taken into account… | Shouldn’t “External Hazards” also include airplane crash and Tsunami?? |  |  |  |  |
| 2 | 4 | 2.14, last sentence | (…) Structural integrity of fuel assemblies is required to maintain geometry compatible with design basis, in particular, to ensure a coolable geometry during DBA and DEC without core melt~~accidents~~, a geometry that can also be shutdown safely. | Clarification to exclude severe accidents.  It may be implicitly the case, that a coolable core can also be shut-down safely, but this should explicitly be required.  Or, it should be stated elsewhere, that coolable includes “able to be shut-down”. See also para. 3.25 and 3.44 |  |  |  |  |
| 2 | 5 | 2.24 (b) | (b) ~~Temperature coefficient of reactivity for the fuel~~ Reactivity feedback of fuel temperature changes (Doppler effect resp. coefficient); | The term “reactivity coefficient” is related to point-kinetics. The text should be methodological neutral. |  |  |  |  |
| 2 | 6 | 2.24 (c) | (c) ~~Temperature coefficients of reactivity for the coolant and the moderator~~ Reactivity feedback of coolant and moderator temperature changes, including related density changes; | See line above. |  |  |  |  |
| 2 | 7 | 2.24 (d) | (d) ~~Void coefficients of reactivity for the coolant and the moderator~~ Reactivity feedback due to changes in the void content in the coolant/moderator (void effect resp. coefficient); | See line above. |  |  |  |  |
| 1 | 8 | 2.24 | (k) Kinetic parameters  (l) Reactivity coefficient of boron concentration  (m) Occurrence of nuclear-thermal-hydraulic instabilities (for boiling water reactors) | Missing safety-related parameters |  |  |  |  |
| 1 | 9 |  | In the safety analysis calculation methods shall be used which are validated for the respective scope of application, and any uncertainties associated with the calculation shall be quantified or covered by suitable methods. | Missing requirements for validation and verification procedure of the nuclear analysis systems. |  |  |  |  |
| 2 | 10 | 3.5 | (h) adequate creep properties | Cladding creep is also one important property of the cladding |  |  |  |  |
| 2 | 11 | 3.9 | The choice of moderator and the spacing of the fuel elements within it should meet engineering and safety requirements on the moderator temperature ~~coefficient~~ feedback of reactivity, while aiming at optimizing the neutron economy and hence fuel consumption. The prevalent thermal reactor types use either light water or heavy water as the moderating medium. | The term “reactivity coefficient” is related to point-kinetics. The text should be methodological neutral. |  |  |  |  |
| 2 | 12 | 3.15, last sentence | Appropriate provisions should be included in the reactivity coefficients or other reactivity feedback modeling approaches used in the safety analysis for all applicable plant states. | The term “reactivity coefficient” is related to point-kinetics. The text should be methodological neutral. |  |  |  |  |
| 2 | 13 | 3.16, first sentence | The maximum reactivity worth of the reactivity control devices (e.g., control rods and/or soluble boron feeding systems) | Clarification |  |  |  |  |
| 1 | 14 | 3.22 / last para | In some reactor designs critical heat flux conditions during transients can be tolerated if it can be shown using suitable analytical methods that the cladding temperatures do not exceed the failure ~~dryout~~ limits. | This is a post-dryout criterion |  |  |  |  |
| 1 | 15 | 3.24.b | …does not ~~excced~~exceed a limit, e.g., at ~~least~~most one element per thousand in the reactor core; | This is an *upper* limit. Thus, one rod at *most* may go into dryout. |  |  |  |  |
| 2 | 16 | 3.30 | The design should assure that the dimensional stability of light water reactor fuel assembly structures ~~are limited~~is guaranteed, so that contacts or interactions between the fuel rods and the fuel assembly components (top and bottom fuel assembly nozzles) are avoided, and that fuel rod bow and assembly bow, as well as control rods swelling and any potential interaction with the assembly guide tubes do not affect the thermal hydraulic design limits, the structural integrity of fuel assemblies or the performance of control rod safety functions. | Original text does not make sense  Rod bow may affect DNBRs (due to neutronic feedback by enhanced water channels), see also para. 3.43 (b). |  |  |  |  |
| 2 | 17 | 3.35 | …. Anomalies should be avoided or limited. | Missing pellet surface for example cannot be avoided but can be limited. |  |  |  |  |
| 1 | 18 | 3.47 | Delete this entire paragraph. | It seems that this rule calls for power ramp tests (up to and including rod failure) in a “live” reactor. This is (a) technically not feasible and (b) is an antagonism to all other safety criterions. |  |  |  |  |
| 2 | 19 | 3.55 (c) | Fuel core coolability should not be endangered due to, for example,  (…)  Flow blockage or other consequences due to fuel dispersal and fuel coolant interaction as a result of fuel cladding failure (e.g., in a reactivity initiated accident event). | Core coolability may be endangered not only by blockage effects under these conditions. |  |  |  |  |
| 2 | 20 | 3.56 (a) | Peak cladding temperature during the accident conditions should not exceed a level where cladding oxidation causes excessive cladding embrittlement or accelerates uncontrollably. In addition, for light water reactors, effects of fuel fragmentation and relocation inside the fuel rod on peak cladding temperature should be assessed as appropriate. Possible effects of fuel particles dispersal on dose consequences and core coolability should also be addressed; | For clarification. |  |  |  |  |
| 2 | 21 | 3.56 (b) | … oxidation (outer**-**side oxidation and possibly when the fuel rod is burst inner-side oxidation), as well ….. | Only when the fuel rod is burst inner-oxidation is possible |  |  |  |  |
| 2 | 22 | 3.58 | Dispersal of molten fuel particles in case of fuel element failure during a reactivity initiated accident transient should be prevented. This can be achieved by assuring that the radial average enthalpy at any axial location of any fuel element should not exceed a certain value derived from, for example, the analysis of a prototypical experimental database. | Add “element” for clarification (or cladding or element).  According to 3.56, integrity of the fuel element should be “ensured, reference should be made to this para. |  |  |  |  |
| 2 | 23 | 3.71 (d) | Rate of flow of coolant or changes in coolant or moderator temperature or density; | Clarification |  |  |  |  |
| 2 | 24 | 3.74 | ~~The maximum degree of positive reactivity and its rate of increase by insertion in all applicable plant states are required…~~  The maximum amount of positive reactivity inserted into the reactor core should be limited… | Clarification |  |  |  |  |
| 2 | 25 | 3.76 | The concentrations of the soluble absorber in all storage tanks should be monitored. Whenever boron is used the ~~enriched~~ B-10 concentration should be monitored. | Clarification |  |  |  |  |
| 1 | 26 | 3.90 | As indicated in para. 6.11 of Ref. [1], the means of shutdown is required to be adequate to ~~prevent~~ compensate any foreseeable increase in reactivity leading to | Some increases in reactivity cannot be prevented, e.g. decay of Xenon, but they can be compensated by having a large enough shutdown margin. |  |  |  |  |
| 2 | 27 | 3.91 (c) | Necessary and required margin of subcriticality; | “necessary” is interoreted as what is needed for the planned operational processed, but there is also an additional “required” margin (as acceptance criteria for sufficient subcriticality, usually 1 %). |  |  |  |  |
| 3 | 28 | 3.104 | The core monitoring parameters ~~such as the following examples to be measured~~ should be adequately selected, which will depend on the reactor type. The following are examples of parameters to be measured for the purposes of core monitoring: | Delete. Repeated in second sentence. |  |  |  |  |
| 2 | 29 | 3.117, last sentence | In reactor core analyses, multi-dimensional and multi-scale physics codes and system thermalhydraulic codes are preferentially used for realistic analysis of the reactor core for all applicable plant states. Uncertainties should be adequately incorporated in the analyses. | And a reference to the IAEA Guide that addresses adequate consideration of uncertainties (e.g. DS491 in its final format) should be given. |  |  |  |  |
| 2 | 30 | ~~2~~3.123 | The light water reactor core should be designed such that the consequences of the worst misloaded fuel assembly, if any, remain within nuclear and fuel design limits. If a misloaded fuel assembly can be prevented by special measures and equipment it shall be demonstrated that the requirements for the effectiveness and reliability of these precautionary measures are fulfilled. Computational analysis are required only if it cannot be demonstrated that the specified precautionary measures have been met. | Clarification |  |  |  |  |
| 1 | 31 | New para | The licensee shall have available a systematic, complete, qualified and up-to-date documentation of the state of the nuclear core components and the nuclear safety analysis system. | Requirements regarding documentation are missing. |  |  |  |  |
| 2 | 32 | 3.127 | Relevant nuclear parameters such as reactivity, reactivity coefficients, control rod worth and power distributions should be evaluated for the different fuel assembly designs. The compatibility evaluation may be developed based on single fuel assembly calculations in an infinite medium. The combined effects on the related core-wide parameters have to be determined. | Knowledge on fuel assembly related parameters is not sufficient, the effects on the core-wide parameters have to be determined. |  |  |  |  |
| 2 | 33 | 4.5 | …. such as fretting wear, oxidation, hydriding, crud buildup, fuel assembly bow etc. | Clarification |  |  |  |  |
| 2 | 34 | 4.9 (m) | ~~Guide tube wear characteristics~~  Control rod integrity (pressurized water reactor) | Clarification |  |  |  |  |