Note:
This is a translation of the RSK statement entitled
"Aspekte der Ermittlung des standortspezifischen Bemessungshochwassers"
In case of discrepancies between the English translation and the German original, the original shall prevail.

RSK statement
(481st meeting of the Reactor Safety Commission (RSK) on 10.02.2016)

Aspects of the determination of the site-specific design basis flood

1 Background

Against the background of recent international developments in rules and regulations, particularly in France following the flooding event in Blayais on the Gironde in December 1999 [1] and Issue T of the WENRA Reference Levels [2] newly developed in response to the events in Fukushima [2], the RSK Committee on PLANT AND SYSTEMS ENGINEERING (AST) discussed various aspects in connection with the determination of the design basis flood and examined the extent to which specifications should be recommended in relation to the relevant current requirements in the German rules and regulations.

2 Consultations

The VGB informed the AST Committee about the scope of protection of German nuclear power plants against floods at its 80th committee meeting [3] and on frequency curves for flood runoff volumes for nuclear power plant sites at the rivers Rhine and Neckar at its 81st meeting on 05.07.2016 [4]. At its 83rd meeting on 04.10.2012, GRS informed the Committee about recent scientific studies [5] and methods for the determination of flood levels in new French regulations and American approaches [6, 7]. The Committee resumed its consultations on the determination of the design basis flood at its 91st meeting on 10.07.2013 and heard a report on a study by the University of Karlsruhe on the determination of the design basis flood at the Neckarwestheim site (GKN) at its 94th meeting on 28.11.2013 [8]. Following further consultations of the Committee at its 95th meeting on 19.12.2013 and at its 104th meeting on 12.02.2015, the Institute for Water and River Basin Management of the Karlsruhe Institute of Technology (KIT) reported on the determination of design basis values for extreme flood events for safety analyses at the 105th meeting of the Committee on 05.03.2015 [9]. The Committee continued its consultations on this issue at its 106th meeting on 16.04.2015 and concluded the hearings with a report by the Institut de Radioprotection et de Sûreté Nucléaire (IRSN) on the determination of the design basis flood for French nuclear facilities [10] at its 107th meeting on 28.05.2015. At its 110th meeting on 03.09.2015, the Committee began consultations on a recommendation on the basis of documents [11] and [12]. At its 111th meeting on 15.10.2015, the Committee adopted the draft of an RSK statement, which was discussed and adopted by the RSK at its 481st meeting on 10.02.2016.

3 Consultation results

From the new Issue T of the WENRA Reference Levels [2] and the new relevant French regulations [1], the following aspects arise with regard to the determination of the design basis flood that exceed the degree of concretisation of the safety requirements for nuclear power plants (SiAnf) [13] and safety standard KTA 2207 [14]. This is relevant for the following requirements:

- a systematic assessment of uncertainties within the flood hazard analysis, and
- a comparison of the determined design basis flood with historical events.

In addition, the aspect "Taking into account the duration of flood events" is addressed below.

Determination and assessment of uncertainties

In [2] (Reference Level T3.3) the following requirements are made: *"The methods and assumptions used shall be justified. Uncertainties affecting the results of the hazard assessments shall be evaluated."* The requirement of the first sentence for inland sites can be considered as implicitly covered, provided that the flood hazard analysis is carried out according to the procedure described in Annex A 2 of safety standard KTA 2207 (extrapolation of the measurement data using the Pearson III distribution with maximised skewness). This is not necessarily the case if use is made of the opening clause "*In individual cases other site-independent procedures may be employed"* in Appendix A 1(2) of KTA 2207(Translator's note: In the German version of KTA 2207 it reads "*Standortabhängig sind im Einzelfall auch andere Verfahren anwendbar"* which means that depending on the site, other procedures may be employed in individual cases). In this case, the use of the selected procedure and the assumptions made are to be justified explicitly.

According to the second sentence of Reference Level T3.3 cited above, the assessment of uncertainties of the site-specific hazard assessment is required. To meet this requirement, systematic recording of the aleatory[1] and epistemic[2] uncertainties is required in all relevant steps of the hazard analysis. In particular, the reliability of the data base has to be discussed (see, e.g., IAEA Specific Safety Guide SSG-18, Section 2.34 for the assessment of uncertainties in the determination of hydrological and meteorological hazards). A concretisation regarding the assessment of uncertainties is not explicitly contained in safety standard KTA 2207.

Moreover, DIN 19700-10:2004-07 and DIN 19700-11:2004-07 applicable to dams [15, 16] are of interest regarding the requirement for assessing uncertainties. As is the case for nuclear power plants, larger dams are to be designed against a 10,000-year flood event. In this respect, the following requirement in [15] goes beyond KTA 2207 [14]:

[1] due to randomness
[2] of or relating to theory of knowledge

Since the extreme flood inflows to be used as a basis for the design of dams against flood are subject to uncertainties with regard to the available methods, it is necessary to apply several different methods comparatively for the estimation of the parameters of extreme flood events (peak inflows, hydrographs, runoff volumes) (DIN 19700-10:2004-07, Section 5.3).

This means that DIN 19700-10:2004-07 requires that several different methods are applied and compared due to the uncertainties inherent in a flood hazard analysis. On the basis of such a comparison, the spread of the scientifically justifiable extrapolations and thus the reliability of the results of the flood hazard analysis can be better assessed.

Against this background, the RSK issues the following Recommendation 1 with regard to the determination and assessment of uncertainties:

The aleatory and epistemic uncertainties of the flood hazard analysis should be systematically recorded and assessed for the need to consider them for a conservative result. This can be done with regard to the aleatory uncertainties by means of the usual statistical methods. For the assessment of epistemic uncertainties, the RSK recommends that several different methods (using site-specific, scientifically justifiable extrapolation functions) should be applied for the determination of the design basis flood and that their results should be compared.

Comparison with historical events

With regard to the determination of the design basis event (here: the design basis flood), reference [2] (Reference Level T4.3) requires a comparison of the determined design basis event with historical events: "*The design basis events shall be compared to relevant historical data to verify that historical extreme events are enveloped by the design basis with a sufficient margin*". The safety requirements for nuclear power plants [13] require to postulate the external hazards having the most severe consequences site-specifically (SiAnf 4.2 (2)), but a requirement with regard to historical events is neither explicitly contained in the SiAnf nor in safety standard KTA 2207.

DIN 19700-10:2004-07, Section 5.3 [15] also recommends a comparison with historical events which occurred in the respective region or with a maximised flood event in terms of a probable maximum flood in order to verify the calculation results for the design basis flood: *In order to substantiate the calculation results for extremely rare flood inflows, specific flood inflows (e.g. the probable maximum flood (PMF)) and/or extreme historical flood events known for the respective region can be referred to on the basis of maximised input variables.* (DIN 19700-10:2004-07, Section 5.3).

Against this background, the RSK derives the following Recommendation 2:

The calculation result obtained in the determination of the design basis flood should be compared with historically documented flood events in the region in order to check whether these are covered. In this respect, the transferability of historical events to the present boundary conditions is to be taken into account.

Taking into account the duration of flood events

The German regulations [13] (Annex 3, No. 4.1.3, No. 4.2.1.2 (1)) generally require consideration of the duration of external hazards in the design of the plant (in the international context, see Reference Level T5.3) in [17]). The consideration of the duration in the determination of the design basis flood is also required in the subordinate KTA nuclear safety standards (KTA 2207 [14]).

4 Summary of recommendations

Recommendation 1:
The aleatory and epistemic uncertainties of the flood hazard analysis should be systematically recorded and assessed for the need to consider them for a conservative result. This can be done with regard to the aleatory uncertainties by means of the usual statistical methods. For the assessment of epistemic uncertainties, the RSK recommends that several different methods (using site-specific, scientifically justifiable extrapolation functions) should be applied for the determination of the design basis flood and that their results should be compared.

Recommendation 2:
The calculation result obtained in the determination of the design basis flood should be compared with historically documented flood events in the region in order to check whether these are covered. In this respect, the transferability of the historical events to the current boundary conditions is to be taken into account.

References

[1] Protection des installations nucléaires de base contre les inondations externes.
Autorité de Sûreté Nucléaire (ASN) Guides de L'ASN No. 13
08.01.2013

[2] Western European Nuclear Regulator Association (WENRA):
WENRA Safety Reference Levels for Existing Reactors, Update in Relation to Lessons Learned from TEPCO Fukushima Dai-Ichi Accident,
Report, September 2014

[3] VGB Powertech
80. Sitzung des RSK-AST „Schutzumfang deutscher Kernkraftwerke gegen Hochwasser“
Bericht der Betreiber, Präsentation, 80. AST-Sitzung am 31.05.2012

[4] Kurven zur Ermittlung des Bemessungshochwassers an Rhein und Neckar
81. AST-Sitzung am 05.07.2012

[5] Dr. G. Thuma
Bemessungshochwasser
Anforderungen nach KTA 2207 und neuere wissenschaftliche Entwicklungen
Präsentation, 83. AST-Sitzung am 04.10.2012

[6] Dr. G. Thuma
Schutz von Kernkraftwerken gegen Hochwasser
KTA 2207- NUREG/CR 7046-ASN-Entwurf
Präsentation, 83. AST-Sitzung am 04.10.2012

[7] U.S. NRC
Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America
NUREG/CR-7046 November 2011

[8] Schwarz, 20.11.2013
Bemessungshochwasser Standort GKN
Präsentation, 94. AST-Sitzung am 28.11.2013

[9] Dr.-Ing. Jürgen Ihringer, KIT- Institut für Wasser- und Gewässerentwicklung
Ermittlung von extremen Bemessungswerten für Sicherheitsbetrachtungen
Präsentation, 105. AST-Sitzung am 05.03.2015

[10] Laurent Guimier, IRSN, May 28 2015.
Bestimmung des Bemessungshochwassers für französische kerntechnische Anlagen.
Präsentation, 107. AST-Sitzung am 28.05.2015

[11] „Für die Ermittlung des Bemessungshochwassers relevante Aspekte aus den WENRA Reference Levels und der DIN 19700“,
Beitrag der GRS zu den Beratungen des RSK-Ausschusses ANLAGEN- UND SYSTEMTECHNIK zum Thema „Bestimmung des Bemessungshochwassers für deutsche Kernkraftwerke“
Köln, 26.08.2015; 110. AST-Sitzung am 03.09.2015

[12] Pistner, Öko-Institut e. V.
Beitrag zu einer RSK-AST-Beratungsunterlage zum Thema „Bestimmung von Auslegungsereignissen für externe Überflutung“
110. AST-Sitzung am 03.09.2015

[13] Sicherheitsanforderungen an Kernkraftwerke, 03. März 2015, BAnz AT 30.03.2015 B2

[14] Kerntechnischer Ausschuss (KTA):
KTA 2207 Schutz von Kernkraftwerken gegen Hochwasser,
Sicherheitstechnische Regel des KTA, Fassung 11/04, November 2004

[15] Deutsches Institut für Normung e.V. (DIN):
DIN 19700-10, Stauanlagen Teil 10: Gemeinsame Festlegungen, Normenausschuss Wasserwesen (NAW) im DIN, Beuth Verlag, Juli 2004

[16] Deutsches Institut für Normung e.V. (DIN):
DIN 19700-11, Stauanlagen Teil 11: Talsperren, Normenausschuss Wasserwesen (NAW) im DIN, Beuth Verlag, Juli 2004

[17] WENRA RHWG:
Guidance Document. Issue T: Natural Hazards. Head Document. 21 April 2015

[18] Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations
Specific Safety Guide IAEA Safety Standards Series SSG-18
Published: 2011