
Note:

This is a translation of the RSK assessment “Vorläufige Kurzbewertung der Sicherheitsnachweise für die Reaktordruckbehälter der belgischen Kernkraftwerke Doel-3 / Tihange-2”.

In case of discrepancies between the English translation and the German original, the original shall prevail.

483rd meeting of the Reactor Safety Commission (RSK) on 13.04.2016

Preliminary brief assessment of the safety cases for the reactor pressure vessels of the Belgian nuclear power plants Doel-3 / Tihange-2

Background and proceeding

With preliminary IRS report no. 8244, the Belgian authority FANC reported on flaw indications at the reactor pressure vessel (RPV) of the Belgian nuclear power plant Doel, Unit 3, detected during ultrasonic testing. By letter dated 23.08.2012, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) then requested the RSK to prepare a statement on the event. After preparatory work of the RSK Committee on PRESSURE-RETAINING COMPONENTS AND MATERIALS (DKW) at the 122nd meeting on 12.09.2012, the RSK discussed the facts and circumstances and presented its statement on the flaw indications at the reactor pressure vessel of the Belgian nuclear power plant Doel, Unit 3 (Doel-3) at the 454th meeting on 17.01.2013 [1].

At the request of the BMU, the RSK Committee DKW resumed discussions at the 129th meeting on 28./29.05.2013. At the 150th DKW meeting on 16./17.12.2015, it was reported that the Belgian supervisory authority FANC published a press release on 17.11.2015 according to which the restart of the Belgian nuclear power plants Doel-3 and Tihange-2 had been authorised. At the same time, FANC also published reports on the safety cases and their review and assessment. The open issues identified by the RSK Committee DKW at its 150th meeting [2] were submitted to the BMUB in the form of a catalogue of questions.

In the RPVs of the plants, ultrasonic tests revealed indications that were attributed to hydrogen flakes, i.e. crack-like flaws within the material. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) presented the catalogue of questions to FANC during a workshop on this topic hosted by the Belgian supervisory authority FANC on 11./12. January 2016. The 15 questions of this list have partially been addressed at the workshop. Written answers were submitted to the BMUB by FANC on 19.02.2016 [3]. These answers comprise a total of 31 pages, also including quotes from reports already submitted.

The BMUB requested the RSK Committee DKW to assess the soundness of the safety cases at its 152nd meeting on 17.03.2016 with respect to the integrity of the reactor pressure vessels of the Doel-3 and Tihange-2 nuclear power plants. Based on this assessment, in-depth discussions were held on technical details of the safety cases at a bilateral meeting between the BMUB and the Belgian authority with the participation of members of the RSK Committee DKW and GRS on 05./06.04.2016. The additional detailed information thus obtained has been considered in the assessment.

The RSK discussed and adopted the preliminary brief assessment at its 483rd meeting on 13.04.2016.

Preliminary brief assessment

Cause and indications

The described cause of segregations created during manufacture and the occurrence of crack-like flaws in the material due to “hydrogen flakes” is comprehensible and plausible. The results from the non-destructive examinations can therefore be used for further assessments. The state of flaws in the forged rings of the two RPVs is largely determined by the means of NDE. Possible flaws or ligaments between hydrogen flakes that are fully shadowed cannot be identified. These, however, would be included geometrically through the definition of the cuboid area to characterise the crack field (“box”).

Material condition considering the effects of irradiation

The proceeding applied for the determination of material properties is largely comprehensible. The transfer chain for determining the reference temperature for the brittle-ductile transition after irradiation represents a pragmatic approach. The currently known uncertainties regarding the material condition due to the extent of segregation zones in the two RPVs are accounted for by additional margins with regard to the reference temperature for the brittle-ductile transition.

Integrity assessment

The indications require an integrity assessment using fracture-mechanical calculation models. Regarding the calculations models, there are still unresolved questions with respect to the load assumptions and boundary conditions for emergency core cooling transients, the determination of local crack-driving forces and the consideration of the anisotropy of the material as well as the residual stresses in the base material beneath the cladding as a result of the cladding process.

The also required assessment of the load-bearing capacity was performed using ASME BPVC, Section III. Here, a calculation model was used which includes the crack indications. However, the material model used does not consider the fracture-mechanical behaviour of a component with cracks, so that the load-bearing capacity of the RPV is possibly overestimated.

Conclusion

Due to the extensive investigations and assessments performed on the Doel-3 and Tihange-2 RPVs and due to the findings from research studies within the framework of reactor safety research in Germany, it can be assumed that under operating loads, an integrity loss of the pressure-retaining boundary of the RPVs is not to be suspected.

With respect to the loads under accident conditions, the RSK cannot conclude, due to the unresolved questions mentioned above, that the safety margins required for it and as stated in the safety cases actually exist.

To confirm that the required safety margins are complied with, further proof is needed, both by experiments and by analyses. Here, it is particularly important to verify the conservatism of the application of the equivalent flaw for crack fields in anisotropic material areas during accidents with multi-axial loading conditions.

From today's perspective, there is no concrete evidence that the safety margins are depleted. However, it cannot be confirmed that these are safely maintained.

References

- [1] Ultraschallanzeigen am Reaktordruckbehälter des belgischen Kernkraftwerks Doel, Block 3 (Doel-3)
RSK statement of 17.01.2013

- [2] Fragen zum Sicherheitsnachweis für die Reaktordruckbehälter der belgischen Kernkraftwerke Doel-3 / Tihange-2
Annex to the minutes of the 150th meeting of the RSK Committee on PRESSURE-RETAINING COMPONENTS AND MATERIALS (DKW)
on 17.12.2015

- [3] FANC – federaal agentschap voor nucleaire controle
Letter dated 18.02.2016 to the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Appendix 1
(http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Nukleare_Sicherheit/belgische_kernkraftwerke_antworten_en_bf.pdf)