Potential radiological Impacts of a Pressure Vessel rupture of Tihange 2

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Summary

In 2012, ultrasonic in-service inspections revealed an extensive number of flaw indications in the base metal of the Reactor Pressure Vessels (RPV) of Tihange 2 und Doel 3. As consequence, the Belgian regulatory authority FANC required the licensee re-demonstrate the safety of both reactors. This re-evaluation has been accepted in 2016 and FANC gave permission to resume operation for up to 40 years. There are differing views among experts, whether or not the RPV of Tihange 2 is safe for accident conditions.

The present work therefore postulates a RPV failure, which is a beyond design basis accident. The analysis, based on engineering judgment, showed that containment failure and severe core degradation as consequence of RPV failure are likely, or at least, cannot be excluded at the current state of knowledge. In a second step, potential radiological consequences for Aachen following a large release at the Tihange 2 NPP were evaluated using results of the FlexRISK project. Two types of results from this project – a single, unfavorable weather situation to present a bounding case and the weather-related probability of deposition – are discussed in this paper.

It can be shown that the expected lifetime dose from such an accident at the assumed unfavorable weather conditions for a citizen of Aachen is 20 times higher than the value specified in the German radiation protection ordinance. The calculated dose for a seven-day exposition following the accident, with release at the chosen date, would require an evacuation of the Aachen-area according to the German intervention limits. This impact on Aachen could be compared to that of towns within the 20km exclusion zone of Fukushima. Evaluating a set of representative weather conditions it could be shown that the weather-related probability of deposition is unfavorable for Aachen and the western part of Germany.

Introduction

The StädteRegion Aachen approached the Institute of Safety and Risk Sciences at the University of Natural Resources and Life Sciences, Vienna to provide a first, coarse estimate of possible radiological consequences of a RPV failure on the City of Aachen.

In 2012 the Belgian regulatory authority, the Federal Agency for Nuclear Control (FANC), informed the public that ultrasonic in-service inspections revealed flaw indications in the lower and upper core shells of the Reactor Pressure Vessels (RPV) of Tihange 2 und Doel 3 (FANC, 2015). Consequently, both reactors were shut down, and it was decided that they would remain shut down until Electrabel (the Licensee) manages to demonstrate that the discovered flaws would not influence the safety of the reactors. In 2014, as part of the safety demonstration material from a rejected Areva Steam Generator (SG), which was considered representative for the RPVs of Doel and Tihange since it contained hydrogen flakes, was subjected to radiation. The unexpected result was that irradiation had a bigger impact on the embrittlement of material than expected. At that point, FANC sought help at various international expert groups. After further investigation, FANC is now convinced, that structural integrity of the RPVs has been demonstrated for up to 40 years and gave permission in 2016 to resume operation.

However, among others, the German Reactor Safety Commission RSK cannot fully follow the conclusion of FANC. The protocol to the 483rd meeting of the RSK states that while … "it can be assumed that under operating loads, an integrity loss of the pressure-retaining boundary of the RPVs is not to be suspected" … the situation is not fully resolved under accident conditions: "with respect to the loads under accident conditions, the RSK cannot conclude (…) that the safety margins required for it and as stated in the safety cases actually exist."[1]

Like in most commercial NPPs, in Tihange 2 failure of the RPV is considered to be precluded by good quality of the RPV. This means that RPV rupture is a beyond design basis event. The core cooling system as well as the containment system is only designed to withstand a double-ended guillotine break of the cold leg at the RPV. While breaks of the RPV up to a certain break size might be manageable, a larger break of the RPV could lead to containment loads close to or above failure pressure of the containment.

The present analysis does not judge the likelihood of a RPV – failure at Tihange 2. Failure of the RPV over a large section is assumed as boundary condition. The first part of the analysis provides a coarse qualitative assessment of possible consequences of such an event. Since in such an event large releases at an early stage cannot be excluded, the second part of the analysis investigates radiological consequences with focus on the city of Aachen. The accident source term and outcome were taken from the Project FlexRISK[2], which was completed in 2013.

[1] Own translation of (RSK, 2016)

[2] http://flexrisk.boku.ac.at, Goal of the project was to evaluate risks and impacts of large nuclear accidents in Europe.

Tihange Unit 2 – Reactor description

Tihange Unit 2 is a nuclear power unit located in the Huy municipality on the right bank of the Meuse river in Belgium. The Tihange 2 unit has a three-loop pressurized water reactor (PWR) supplied by Framatome[3] (now AREVA). The unit is operated by Electrabel, a company of the GDF-SUEZ group and is authorized to operate until 2023. The reactor has an uprated design thermal power level of 3,064 megawatts, and a net electrical capacity of 1,008 megawatts. The reactor core includes mixed oxide fuel (MOX) since 1994.

The unit has a double containment. The inner, primary containment, which is designed to resist releases to the environment in case of an accident, is a prestressed concrete containment with a steel liner. The outer, secondary containment is a reinforced concrete containment. The purpose of the secondary containment is to protect the primary containment against external missiles such as aircraft impact. The secondary containment does not have a steel liner, and is not pressure-retaining. Rather, any leakage from the primary containment is collected in the annulus region between the primary and secondary containment, and then conveyed to a filtration before being released at the elevated plant stack.

Table 1: Tihange 2 key figures

Reactor type	PWR	Construction start	01.04.1976
Reactor model	Framatome 3-loop	First criticality	05.10.1982
Thermal capacity	3064 MW	First grid connection	01.06.1983
Net capacity	1008 MW	Commercial operation	13.10.1982
Gross capacity	1055 MW	Shutdown date	01.01.2023

The reactor pressure vessel (RPV) problem

The reactor pressure vessel (RPV) is the most important pressure boundary component of the nuclear steam supply system. Its function is to contain the nuclear core under elevated pressures and temperatures. Additional RPV functions are to provide structural support for the reactor vessel internals and the core (IAEA, 1999).

Inspections performed in September 2012 at the Tihange Unit 2 pressure vessel identified 1,931 flaw indications in the upper core shell[4] and 80 indications in the lower core shell. No indications were found in the transition ring or nozzle shell. Further inspections performed in 2014 identified 3064 flaws in the upper core shell (+59%) and 85 flaws in the lower core shell (FANC, 2015, p. 32).

[3] Note, that Tihange 2 is often falsely described as Westinghouse 3-loop reactor e.g. at the reactor database of the International Atomic Energy Agency (IAEA). https://www.iaea.org/pris/ last checked at 22.04.2016.

[4] The reactor pressure vessel consists of several parts welded together. Below the nozzle shell to which are attached the primary coolant piping is an upper core shell, a lower core shell, a transition ring, and a vessel bottom cap. Above the nozzle shell is the vessel flange, the vessel head flange, and the vessel head top cap. The interior of the vessel has a thin coating (cladding) of stainless steel, which is fixed by welding to the inside of the vessel. The vessel itself is fabricated from low-alloy steel, which is 20 cm (200 mm) thick on the cylindrical portion of the vessel.

The flaws were observed up to a depth of 100 mm from the inner surface. Most of the flaws are 20-70 mm from the inner surface. The indications are spread over the whole circumference of the shells and represent laminar flaws almost parallel to the wall of the pressure vessel. The flaws are rounded in shape. The most recent inspections (2014) show indications with maximum x/y dimensions of 155/71 mm, the average x/y dimensions are about 15/15 mm (FANC, 2015, p. 32).

According to the Belgian nuclear regulator FANC:

> *"The failure of the reactor pressure vessel is not envisaged: the margins incorporated in the design and construction of this component, according to stringent codes, ensure that cracking or failure of the reactor vessel is virtually impossible.*
> *Moreover, this scenario is not covered by safety studies, and the existing safety systems are not designed to handle such an occurrence.*
> *A major crack or fracture in the reactor pressure vessel would lead to a loss of water inventory and, in case of absence of cooling, to a possible core meltdown (referred to as a "severe accident")."*(FANC, 2013, p. 10)

FANC concluded (FANC, 2013, p. 29):

> *"Some uncertainty still exists regarding the capability to properly detect and characterize all present flaws in the reactor pressure vessel. In particular, tilted flaws, hidden flaws, flaws nearby the interface cladding/base metal, and smaller flaws may not be completely identified or fully described, implying a possible underestimation of the number and significance for safety of the flaw indications reported to date."*

FANC concluded that the most likely origin of the indications was hydrogen flaking during the manufacturing process, but cautioned that it is "*not possible to guarantee this assumption with absolute certainty without performing destructive testing on the reactor pressure vessels, which is not an option*" (FANC, 2013, p. 34).

Electrabel (the plant licensee) concluded that the only possible propagation mechanism is fatigue crack growth, the evolution of which was calculated to be less than 2.2% over 40 years. The licensee concluded that there "*is no risk of ligament cracking between the flakes*".

FANC stated that significant evolution of the hydrogen flakes was unlikely. FANC stated:

> *"… the only theoretical propagation mechanism is low cycle fatigue, which is considered to have a limited effect. However, there is little literature or experience about the influence of irradiation on flaw propagation in zones with hydrogen flakes. Hence, the potential evolution of the flaws under irradiation cannot be completely ruled out at this stage."*

However, in a recent statement (RSK, 2016) the German Reaktor-Sicherheitskommission seems less concerned with the material properties during normal operation

> *" …. kann davon ausgegangen werden, dass unter Betriebsbelastungen, ein Integritätsverlust der drucktragenden Wand der RDB nicht zu unterstellen ist."*

but rather during accident conditions:

> *„Bezüglich der Störfallbelastung ist aufgrund der oben genannten offenen Fragen für die RSK nicht nachvollziehbar, dass die hierfür geforderten und in den Nachweisen ausgewiesenen Sicherheitsabstände tatsächlich erreicht werden."*

Potential for Reactor Pressure Vessel rupture at Tihange Unit 2 and possible subsequent outcomes

It is assumed that reactor pressure vessel rupture occurs at Tihange Unit 2 below the nozzle shell where the vessel is connected to the primary coolant lines. As consequence the lower part of the reactor vessel - below the rupture - could be driven downward, impacting on the containment liner and basemat. The extend of damage to the basemat is uncertain without structural calculations.

It can be safely assumed that the primary containment would rapidly pressurize. It is likely that the resulting pressure rise would exceed the containment failure pressure, which is expected to be in the range of a factor two or three of the containment design pressure (this expectation is based on calculations for similar containment structures in probabilistic safety assessments).

The result of such a failure would likely be stretching and tearing of the prestressing tendons, followed by rupture of the containment wall in the vicinity of the midpoint of the containment cylinder. Such an outcome can be seen as confirmed at least in part by a large scale containment pressurization failure test of a prestressed concrete containment conducted at Sandia National Laboratories, although it must be remembered that this failure test was performed with water in the model and gas pressure above the water, and was largely a slowly building, almost static overpressure applied to the containment (Sandia National Laboratories, 2003). In this test, the 1:4 scale model containment failed at a pressure of 2.4 to 2.5 times design.

Figure 1: The failure state of the 1:4 scale containment (Sandia National Laboratories, 2003)

The Sandia report cautions:

> *"While the tests successfully obtained data on the response to pressurization and, secondarily, to prestressing, the application and interpretation of these results should recall that the test load does not faithfully represent the complex loading environment that will exist during a severe accident. The effects of temperature, the temporal relationship between pressure and temperature, the composition of the internal atmosphere, and the rate of loading may all affect the response and failure modes and the sequence of these events and should be considered in any evaluation of containment capacity."*

The extremely rapid pressurization of the containment is expected to lead to a large breach in the primary containment. The questions then become:

- What happens to the secondary containment?
- What happens to the containment annulus, to the elevated stack connection (and to the filtration system)?
- What is the impact on the sudden pressure rise and the rupture of the primary containment on the containment spray piping and spray rings inside the primary containment?

Given the large amount of rebar, prestressing tendon, and concrete debris generated in the containment model test at Sandia, it seems conceivable that primary containment failure could result in secondary containment failure. In considering this possible outcome, it is important to remember that:

- The secondary containment has no steel liner.
- The secondary containment is designed to resist external missile penetration, and not internal missile penetration and a concurrent sudden pressure rise within the containment annulus.

If the secondary containment does not immediately follow primary containment failure, the next consideration of the impact of the very sudden and very large pressure rise in the containment annulus on the ductwork connecting the annulus to the filtration system and the elevated release stack. A very large pressure rise can be expected because the containment annulus volume is much smaller than the primary containment volume, and would therefore see a sudden and very large pressure rise.

There are almost no details available on the nature of the ductwork connecting the containment annulus to the filtration system and the elevated release stack. It must be borne in mind, however, that this ductwork and filtration system are designed for design basis accident conditions in the primary containment plus some leakage rate (perhaps even design basis leak rate of less than one volume-percent per day). It can be considered likely, even if the secondary containment somehow survives primary containment failure dynamics, the ductwork will almost immediately fail and result in destruction and/or bypass of the filters. In case of either secondary containment structural failure or ductwork failure would result in a low release height for radionuclides released subsequent to vessel failure. An elevated release at the top of the stack is thus quite out of the question.

The last remaining important question here is whether the containment spray piping and spray rings survive the sudden pressure rise accompanying reactor pressure vessel rupture as well as the dynamic failure of the primary containment. If, however, the picture above of the 1:4 scale model test is any indication, it may be irrelevant since the dynamic forces and large opening accompanying primary containment failure could well fail the containment spray ring headers. If that happens, even if the piping leading from the spray system to the ring headers survives, water coming out the containment spray ring headers would probably not be effective in reducing the source term resulting from core degradation after reactor pressure vessel failure.

Accident Progression after Reactor Pressure Vessel failure and the resulting source term to the environment

Once the reactor pressure vessel fails, even if water is injected to the reactor vessel (assuming intact primary coolant piping) it will immediately spill of the failed vessel and only briefly delay core melt. Depending on the location of the containment sump, impact of the lower portion of the reactor vessel on the basemat could result in failure of the sump due to cracking, filling with debris, or blockage due to the location of the failed lower portion of the vessel. Should this occur, recirculation of coolant from the sump would be impossible and injection would cease once the contents of the refueling water storage tank are injected.

With no injection, core damage can be expected soon after vessel failure. In the event of a large LOCA with the vessel intact and injection failure, current codes predict the onset of core melt within 20-30 minutes. With the bottom portion of the reactor pressure vessel missing, core melt without injection will proceed more quickly. Even if the primary coolant legs remain intact following reactor pressure vessel failure, the delay in core melt cannot be longer than the injection phase.

In any event, core melt will be relatively prompt for reactor vessel failure scenarios. With the primary containment and probably the secondary containment as well failed, air access from the environment cannot be impeded, and core degradation and melting will take place in the presence of oxygen. High fuel temperatures can be expected due to ready fuel oxidation during degradation and melting. Much of the release can be expected within the first few hours, but with an open containment and near 100% core melt, it can be expected that release would continue for days.

At this point, it can be safely stated that considering failure of the RPV (which, as already mentioned, is not considered a design basis accident) a large early release as consequence cannot be ruled out without further analysis. To give an impression on the possible source term following such an accident (core melt and containment failure) two containment bypass sequences, as can be found in PSA studies, are reported:

- Containment bypass (SGTR with stuck open valve) has a source term of 44.7% iodine release, 27.2% cesium release, 1.63% tellurium release, 0.36% strontium release, and 4.48% ruthenium release (Sholly et al., 2014, p. 18). The RPV rupture scenario would have an even worse release, because it involves immediate containment failure, and core degradation in the presence of oxygen.
- IRSN specified S1 source term (containment failure occurring no more than a few hours after the onset of the accident) for a 900 MWe PWR (60% iodine, 40% cesium, 8% tellurium, 5% strontium, 2% ruthenium, 0.3% lanthanides and actinides) (IRSN, 2015, p. 71).

Generic accident radiological consequence analysis - Tihange 2

Accident Source Term

The accident source term for the dispersion calculations is based on the core inventory at the time of the accident plus release fractions due to the accident sequence.

The core inventory used for the analysis is based on the published inventory of the German PWR Isar 2 was used (burnup 42,35 MWd/kg, 8 days shutdown followed by a 325 day operation (SSK, 2003)) and scaled according to the thermal power of Tihange 2. Like Tihange 2, Isar 2 utilizes MOX fuel.

As described in the previous section, RPV failure is assumed to be precluded by design. The consequences of RPV failure have not been evaluated as part of the safety case. Since, consequently, the containment is not designed to withstand RPV failure, it cannot be excluded that core damage would occur and the containment would fail. Based on engineering judgement – with no further technical basis – a large release is expected from such a failure. Therefore, a significant source term from the FlexRISK project was selected for consequence analysis:

- 100% of the noble gases (Xenon, Krypton),
- 30% of the alkali metals (Cesium, Rubidium),
- 30% of the halogens (Iodine, Bromine),
- 12% of the tellurium group, 6% of strontium and 8% of the noble metals.

The release is assumed to last four hours, starting three hours after the accident.

Dispersion modeling

For the present study, the results from the FlexRISK research project were used[5]. The FlexRISK project was carried out 2010 - 2012 by the Institute of Meteorology and the Institute of Safety and Risk Sciences of University of Natural Resources and Life Sciences, Vienna and the Austrian Ecology Institute. FlexRISK calculates the geographical distribution of the risk stemming from a severe accident in a selected NPP in Europe. The dispersion calculations have been carried out with the Lagrangian particle dispersion model (LPDM) FLEXPART[6] (Stohl et al., 2005, 1998). LPDMs have distinct advantages for the simulation of dispersion from point sources, as they avoid the artificial smoothing and broadening of the plume or puff due to the grid resolution, as happens in Eulerian models (Arnold et al., 2013).

Two distinct results from FlexRisk’s Tihange-2 calculations are presented: first, a single case dispersion calculation, using the source term above, for specific weather conditions. Second, a meteorological probability map, where a representative number of weather conditions (about 3000) were used for dispersion and consequence calculations, to show, given that a severe accident at Tihange had happened,

[5] See http://flexrisk.boku.ac.at/ and (Seibert et al., 2013).

[6] The FLEXPART model is well established within the scientific community, see http://transport.nilu.no/flexpart/flexpubs. It is used for dispersion modeling at institutions such as the Swiss Federal Laboratories for Materials Science and Technology, the US National Oceanic & Atmospheric Administration and the Austrian Zentralanstalt für Meteorologie und Geodynamik.

which region around Tihange 2 will be subject to radiological consequences at what probability (due to the specific weather conditions at Tihange 2).

As described in the FlexRISK project documentation (Seibert et al., 2013), the basic methodological approach was to generate simulations for a large number of possible meteorological situations, so that statistical evaluations of the results will reflect the climatological dispersion properties of the atmosphere in the respective regions. Ensuing criteria were:

1. The number of simulations should be large enough so that results are not unduly influenced by sampling statistics.
2. Simulations should be evenly distributed over the calendar year.
3. Simulation starts (release times) should be evenly distributed over the hours of the day, without seasonal or geographical biases.

Subsequently the resulting radiation doses[7] could be calculated and the consequences of a severe accident were estimated. For detailed information on assumptions, modelling and uncertainties refer to the latest FlexRISK report (Seibert et al., 2013).

Radiological consequences for the city of Aachen

As described above, it has been postulated that the selected source term would be released for about 3000 weather situations, which are representative for the site. As radiological criteria, a contamination of 1480 kBq/m2 with Cs-137 has been selected (that number has been used as criteria for relocation after the Chernobyl accident). Then the probability to exceed this contamination (based on the meteorological situation at Tihange 2) has been evaluated. The results are presented in Figures 2 and 3. As can be seen, the specific meteorological situation of Tihange 2 makes a radiological contamination of Aachen more likely than equally distant places in direction south-west.

Second, a single, very unfavorable weather situation has been picked out to present a bounding case without considering its likelihood (Figures 4 and 5). The 7-day effective dose for the selected release (Figure 4) is depicted to allow for comparison with the German intervention limits (Table 2), while the lifetime dose (Figure 5) allows for comparison with the German radiation protection ordinance. Finally, the total Cs-137 deposition in comparison with Fukushima is shown (Figure 6).

[7] 20 nuclides were used for dose calculation (Seibert et al., 2013, p. 41).

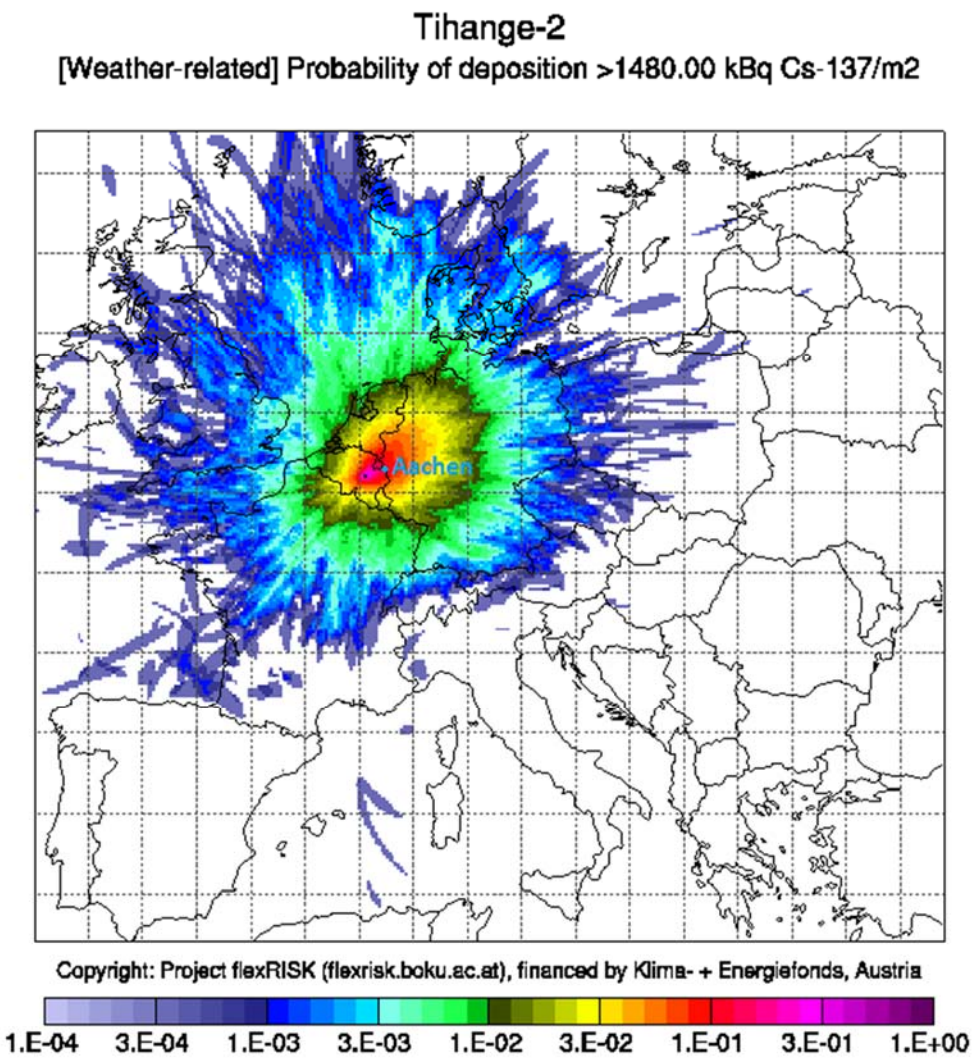


Figure 2: (Weather-related) probability of depositions over 1480 kBq Cs / m². This was the limit beyond which at Chernobyl accident, the population was resettled.

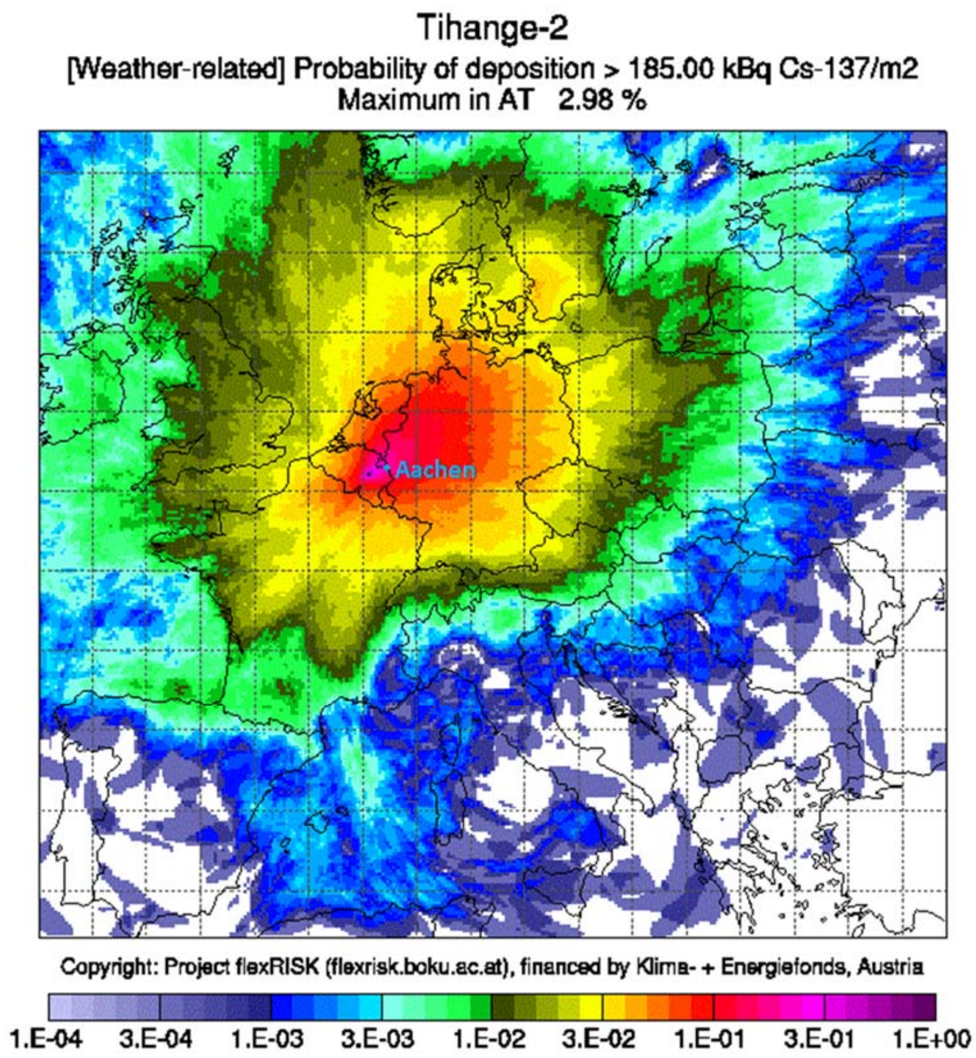


Figure 3: (Weather-related) probability of depositions over 185 kBq Cs / m². Relevant because of possible exceedance of a yearly dose of 1 mSv.

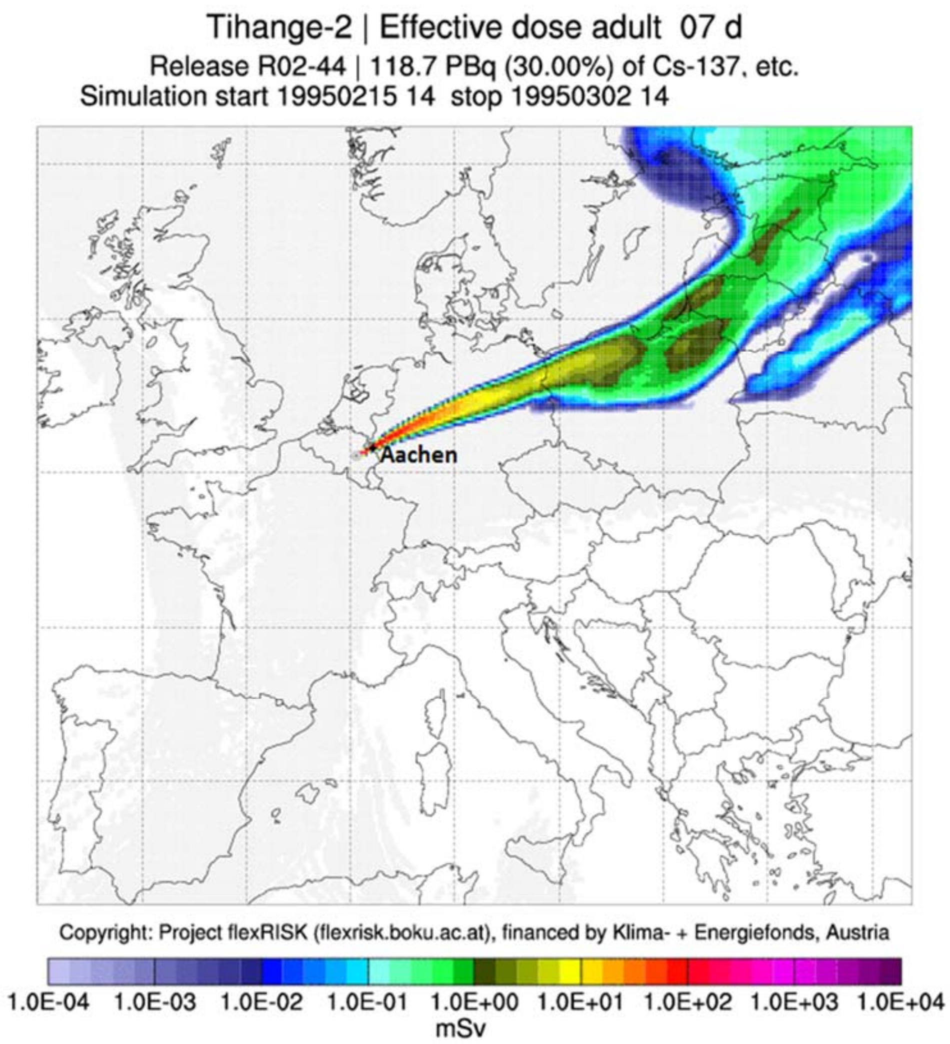


Figure 4: Sample case selected for further discussion - 7d effective dose. For comparison with the German intervention limits (Eingreifrichtwerte) (SSK, 2014)

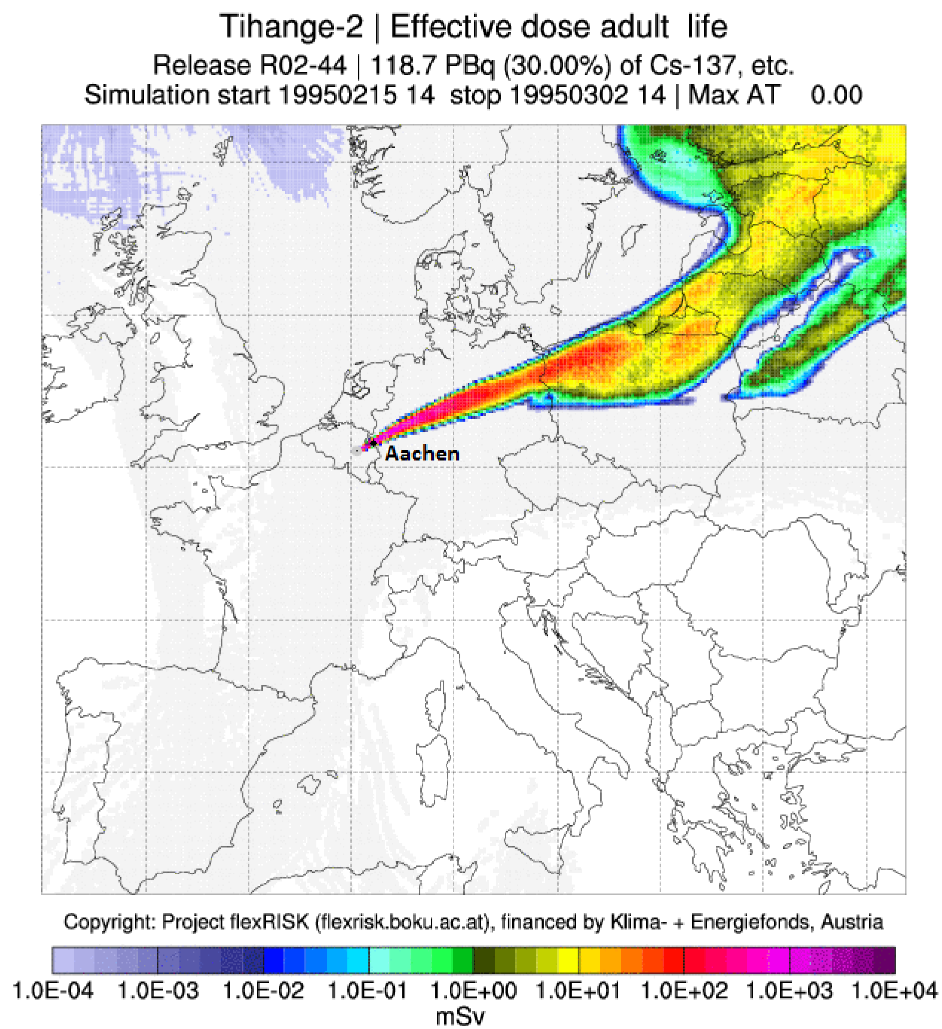
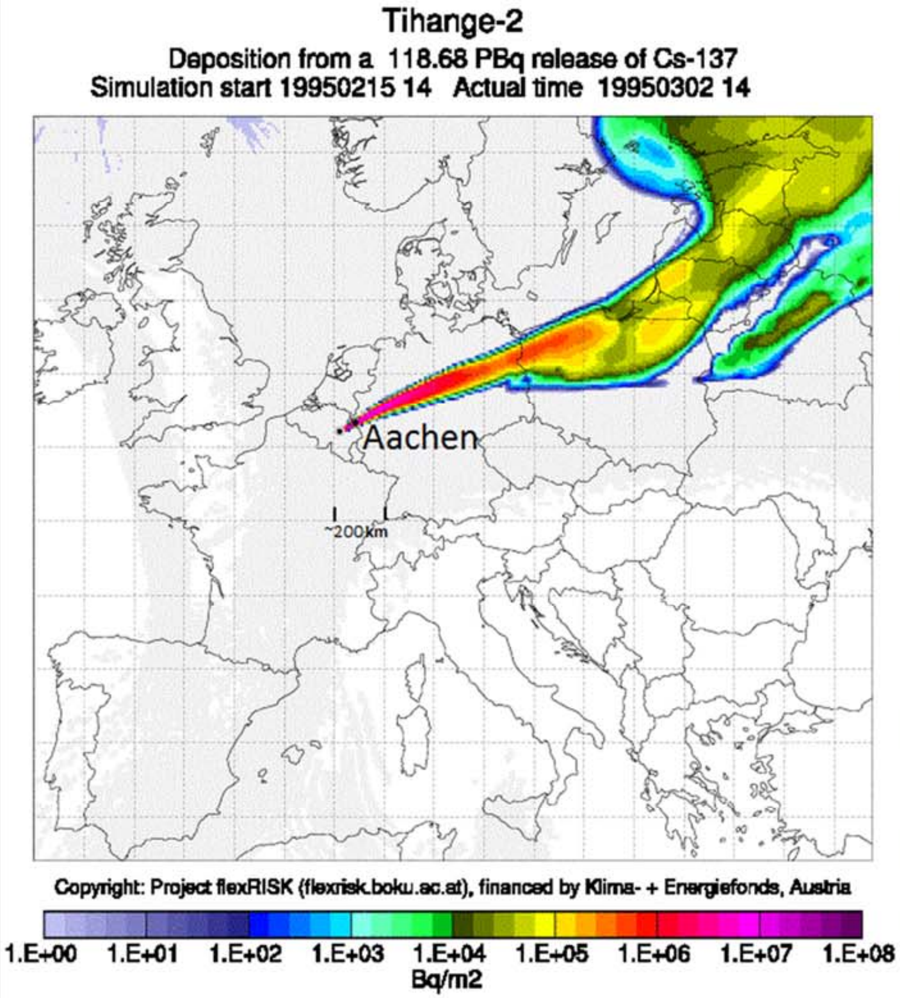


Figure 5: Sample case selected for further discussion – 50 year effective dose. For comparison with the German “Störfallplanungsdosis“(Bund, 2001)



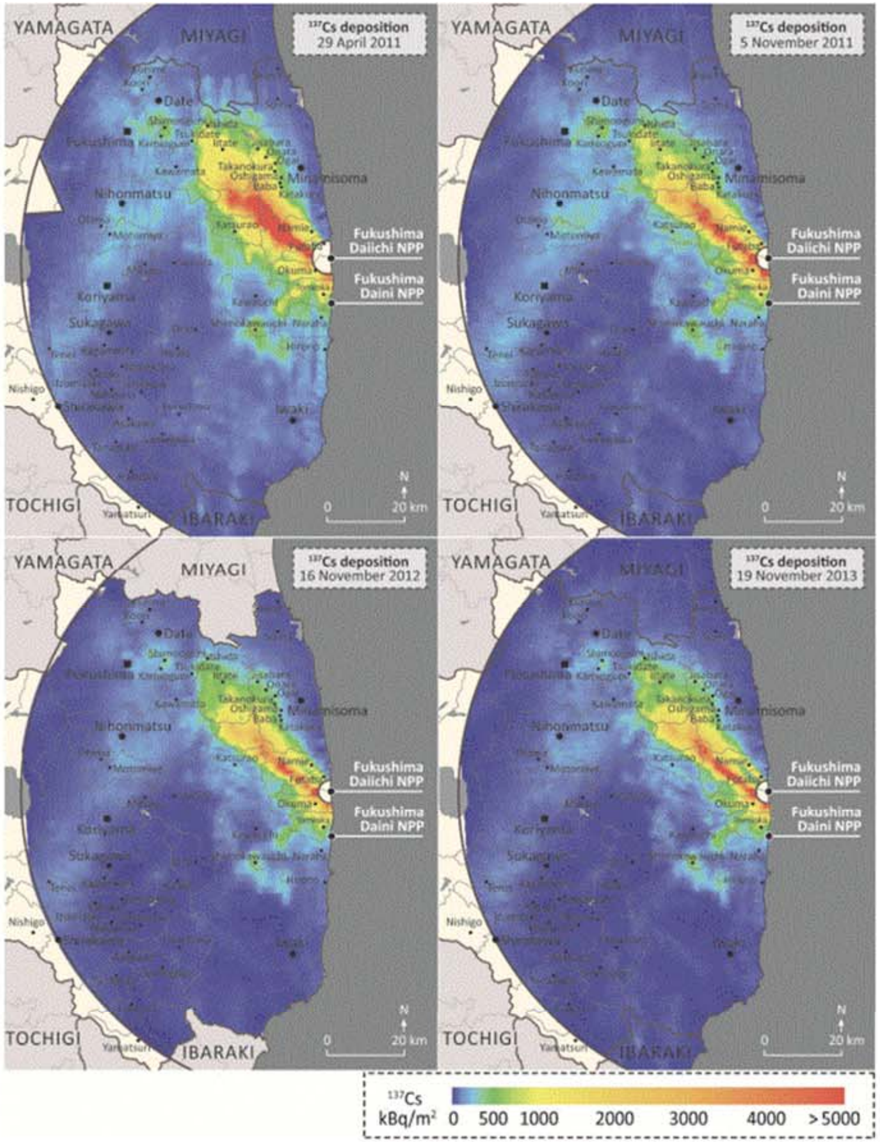


FIG. 4.1–14. Deposition density of ^{137}Cs as measured by aerial surveys.

Figure 6: Comparison of the selected case with Fukushima contamination.

Notes:

- Logarithmic scale is used left, linear scale on the right. Yellow to red on the right figure corresponds to the reddish area starting with 1.E+06 on the left figure (1000k Bq/m^2 equals 1.E+06 Bq/m^2).
- Scale: The distance between 2 vertical lines on the left figure is roughly 200km. A 20km scale is provided on the figures on the right.

Source: (IAEA, 2015)

Conclusions

Today there are significantly differing views among experts, whether or not the RPV of Tihange 2 is safe for accident conditions. The present report presented a qualitative, heuristic analysis postulating a RPV failure, which is a beyond design basis accident. The analysis, based on engineering judgment, showed that containment failure and severe core degradation as consequence of RPV failure are likely (at least are not ruled out). Therefore, the radiological consequences of a severe accident for the city of Aachen have been evaluated, postulating a significant release from Tihange NPP unit 2.

It has been shown that the specific weather conditions of Tihange are unfavorable for Aachen. Radiological contamination is more likely to affect the regions north – east of Tihange, than they are likely to affect the regions south – west of Tihange. Figure 2 shows the probabilities that a deposition of more than 1480 kBq Cs / m² occurs (criteria for resettlement following the Chernobyl accident). The weather related probability for Aachen to exceed said deposition, given that the postulated release takes place at Tihange 2, is around 10 percent. Figure 3 is similar to Figure 2 but it shows the probability for a lower level of contamination 185 kBq Cs / m². At this contamination level it is expected, that an additional yearly dose of 1 mSv is exeeded. This is the maximum additional dose allowed per year for a single individual in EU-member states. The weather related probability for Aachen to be affected in such manner is around 30 %.

A comparison with German radiation protection limits was made via figures 4 and 5.

In Figure 4, which is relevant for comparison with the intervention limits, Aachen is in the red area. The calculated dose as result of an exposition for seven days within the area is roughly 100 mSv. According to the German intervention limits (Table 2), this would require an evacuation of the area.

Table 2: Intervention limits for „sheltering", "iodine prophylaxis" and "evacuation", own translation based on (SSK, 2014).

Measure	Intervention limits	
	Thyroid dose	Effective dose
Sheltering		10 mSv
Iodine prophylaxis	50 mSv: Infants and children under 18 years, and pregnant women 250 mSv: People from the age of 18 to 45	
Evacuation		100 mSv

The German radiation protection ordinance §49 states (Bund, 2001):

> *„Sicherheitstechnische Auslegung für den Betrieb von Kernkraftwerken, für die standortnahe Aufbewahrung bestrahlter Brennelemente und für Anlagen des Bundes zur Sicherstellung und zur Endlagerung radioaktiver Abfälle*
>
> *(1) Bei der Planung baulicher oder sonstiger technischer Schutzmaßnahmen gegen Störfälle in oder an einem Kernkraftwerk, das der Erzeugung von Elektrizität dient, darf bis zur Stilllegung nach § 7 Abs. 3 des Atomgesetzes unbeschadet der Forderungen des § 6 in der Umgebung der Anlage im ungünstigsten Störfall durch Freisetzung radioaktiver Stoffe in die Umgebung höchstens*
>
> *1. eine effektive Dosis von 50 Millisievert, ….“*

Aachen is well within the area corresponding to about 1000 mSv (see Figure 5). Thus, the expected lifetime dose from the postulated release is 20 times higher than the value specified in the radiation protection ordinance.

Figure 6 provides a comparison between the Cs-137 ground contamination of the postulated accident at Tihange and the Fukushima accident. The following findings can be pointed out:

- For the selected release, the region close to Tihange is more severely affected than surroundings of Fukushima.
- In the case of the hypothetical accident, the impact on Aachen could be compared to that of towns within the 20km exclusion zone of Fukushima.

Concluding, it can be stated, that failure of the RPV is a beyond design basis accident that could lead to severe core degradation and containment failure. International experts like the RSK consider the evidence presented by FANC as not sufficient to prove that the safety of Tihange RPV during accident conditions is ensured. Aachen and the western part of Germany are in a weather-related unfavorable position concerning possible accidents at Tihange 2.

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