Inspectorate of Housing, Spatial
Planning and the Environment
*Ministry of Infrastructure and the
Environment*

Post Fukushima Stress Test of the EPZ Nuclear Power Plant in the Netherlands

KFD review of the licensee's assessment

Colophon

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Date: December 5, 2011

Publication number: VI-2011-125

This publication can be downloaded via www.vrominspectie.nl

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Samenvatting

Het ongeval in Fukushima in maart 2011 heeft op Europees niveau geleid tot de beslissing om de bestaande kerncentrales in Europa te onderwerpen aan een stresstest. Een stresstest is een onderzoek waarin de veiligheidsmarges van de centrale opnieuw worden geëvalueerd; met name voor situaties als de centrale aan extreme (weers-) omstandigheden wordt blootgesteld.
Het onderzoek moet voldoen aan de vereisten en kwaliteitscriteria zoals die door ENSREG[1] zijn vastgesteld.(ref. Declaration of ENSREG 13 maart 2011).
Het uitvoeren van deze stresstest in Nederland is verplicht gesteld door de overheid, zie hiervoor de brief ETM/ED/11074538 van de minister van Economische Zaken, Landbouw en Innovatie gedateerd 01 juni 2011. In deze brief wordt naast de ENSREG stresstest ook gevraagd de invloed van andere externe factoren te onderzoeken die kunnen leiden tot het verlies van meerdere veiligheidsfuncties. Hierbij moet rekening worden gehouden met "man made", waaronder moedwillige, verstoringen
EPZ[2] heeft voor haar kerncentrale in Borssele een dergelijke stresstest uitgevoerd. De resultaten van de test zijn opgenomen in een document, getiteld "Complementary Safety margin Assessment", 31 oktober 2011.
De Kernfysische Dienst (KFD) als toezichthouder heeft het stresstestrapport van EPZ beoordeeld en komt tot de volgende bevindingen:

Het stresstestrapport

- De uitgevoerde beoordeling geeft geen indicaties dat de installatie en organisatie niet aan de eisen van de huidige vergunning voldoen.
- Het stresstestrapport is, met inachtneming van de verder in dit rapport vermelde opmerkingen en gelet op de strakke ENSREG tijdsplanning, in z'n algemeenheid van voldoende kwaliteit. Het rapport voldoet op hoofdlijnen aan de eisen van ENSREG en de door de minister van EL&I gestelde aanvullende eisen.
- Op het punt van severe accident maatregelen ontbreken een aantal belangrijke aspecten, waaronder lange termijn maatregelen en accident management maatregelen na het verlies van de integriteit van het containment.
- Het rapport geeft een vrij volledig en getrouw beeld van de huidige technische en organisatorische situatie in de centrale. Het rapport geeft een realistisch beeld van de omstandigheden waaraan de centrale in extreme situaties zou kunnen worden blootgesteld.
- Het rapport bevat een brede analyse van de wijze waarop de bedrijfsonderdelen van de centrale op die extreme omstandigheden reageren of daartegen bestand zijn.

Hierbij zijn de volgende algemene opmerkingen te maken, naast de specifieke opmerkingen per ENSREG vereiste die in hoofdstuk 2 zijn opgenomen:

- De effecten van een mogelijke brand die ontstaat als gevolg van andere extreme situaties zijn onvoldoende belicht.
- De beschrijving van 'cliff edges' (kleine verandering met grote, veelal onomkeerbare, effecten) is voor de meeste scenario's summier uitgevoerd.

[1] ENSREG: European Nuclear Safety Regulators
[2] EPZ: Elektriciteits Produktiemaatschappij Zuid-Nederland

- Door het hele rapport heen is geen duidelijk verband zichtbaar tussen de voorgestelde maatregelen en de geïdentificeerde cliff edges of geconstateerde marges.
- De KFD acht het nodig dat de analyse van de aanpak van zware ongevallen wordt 'verdiept' door ook de effectiviteit van de gekozen aanpak in de praktijk te toetsen.
- De door EPZ voorgestelde maatregelen lijken bij eerste lezing de veiligheid te vergroten. Nader onderzoek en analyse van deze maatregelen door EPZ is echter nodig om dit zeker te stellen. Hiernaast is vastgesteld dat verder onderzoek door EPZ op een aantal punten nodig is.

De robuustheid van de centrale in geval van extreme (weers-)omstandigheden

- In het rapport is aannemelijk beschreven dat de centrale van EPZ beschikt over veiligheidsmarges ten opzichte van de technische en organisatorische eisen waaraan de centrale op dit moment wettelijk moet voldoen. Toch acht de KFD, in het licht van Fukushima, kordate aanpak nodig bij het realiseren van enkele gebleken verbeterpunten door middel van het treffen van maatregelen en het uitvoeren van nadere studies. Hierbij wordt in het bijzonder gedoeld op
    - het vergroten van de mogelijkheid om in geïsoleerde moeilijke omstandigheden langer en beter de veiligheid van de centrale te kunnen waarborgen. Daarmee wordt gedoeld op maatregelen voor het verlengen van de autarkietijd (de tijd dat de centrale zelfvoorzienend is) van apparatuur en het uitbreiden van de (zelf-) redzaamheid van personeel,
    - het aardbevingsbestendig maken van de voorzieningen op het gebied van brandbestrijding en het ventileren van het containment (t.b.v. de afvoer van mogelijk vrijkomend waterstof),
    - het vergroten van de mogelijkheden om het splijtstofopslagbassin onder alle omstandigheden te (blijven) kunnen koelen en van water te kunnen voorzien,
    - het inrichten van onder alle omstandigheden beschikbaar magazijn met voorzieningen ten behoeve van de aanpak van calamiteiten.

De voorstellen voor verbetering van de robuustheid van de centrale

- Het rapport bevat aannemelijke voornemens voor verbetering van de robuustheid van de centrale. Op een aantal punten heeft EPZ nadere onderzoeken geformuleerd. Hieruit zouden aangepaste of nieuwe maatregelen noodzakelijk kunnen blijken.
- De verbeteracties zijn (nog) niet van een prioritering en tijdsplanning voorzien. KFD acht het nodig dat EPZ het verbeterplan met deze aspecten ter beoordeling aan de KFD voorlegt.

Concrete verbeteracties dienen bij voorkeur gescheiden van de komende 10-jaarlijkse veiligheidsevaluatie te worden ingepland en uitgevoerd, dit in tegenstelling tot het voorstel van EPZ.

De Nederlandse stesstest ten opzicht van centrales in omliggende landen
Het stresstestrapport van EPZ kan zich meten met de kwaliteit van vergelijkbare rapporten van centrales in de ons omringende landen.
Een helder en afrekenbaar tijdschema voor de realisatie van de aanpassings-voorstellen ontbreekt vooralsnog. In dat opzicht zou EPZ zich kunnen spiegelen aan sommige nucleaire bedrijven in de ons omringende landen, die concreet in de tijd geplande aanpassingsvoorstellen doen

De stresstest is nog niet ten einde. Een volgende stap zijn de peer-reviews in Europees verband. De KFD zal de komende tijd de beoordeling, inclusief het oordeel over noodzaak en planning van onderzoeken en maatregelen, voortzetten mede gebruik makend van de bevindingen uit andere landen, bijgestelde normenkaders en de resultaten van de internationale peer-review.

Summary [3]

The Fukushima accident in March 2011 has led to the decision at European level that the existing nuclear power plants in Europe are to be subjected to a stress test. A stress test is an assessment in which the safety margins of the plant will be re-evaluated, in particular for situations where the plant is exposed to extreme (weather) conditions.
The assessment must meet the requirements and quality criteria as established by ENSREG. (Ref. ENSREG Declaration of May 13, 2011).
Conducting the stress test in the Netherlands was made compulsory by the government; see letter ETM/ED/11074538 of the Ministry of Economic Affairs, Agriculture and Innovation dated June 1, 2011. In this letter it was requested that, in addition to the ENSREG stress test, also the influence of other external factors that may lead to the loss of several safety features were to be assessed. "Man made" disturbances, including those instigated wilfully, should be taken into account.

EPZ has performed such a stress test for their Borssele nuclear power plant. The results of the test are reported in a document entitled "Complementary Safety Margin Assessment", October 31, 2011. The Department of Nuclear and Radiological Safety, Security and Safeguards (KFD) as the supervision authority reviewed the stress test report of EPZ and makes the following findings:

The stress test report

- The assessment carried out shows no indications that the installation and organization do not meet the current license requirements.
- Given the comments mentioned in this report and the tight timetable of ENSREG, the stress test report is in general of sufficient quality. On the main points the report meets the ENSREG requirements and the additional requirements set by the Ministry of EL&I.
- Regarding severe accident measures some important issues are missing, including accident management measures after loss of containment integrity and long-term measures.
- The report provides a fairly complete and accurate picture of current technical and organizational conditions in the plant. The report provides a realistic picture of the conditions to which the plant could be exposed in extreme situations.
- The report contains a broad analysis of the response and resistance of the system components of the plant on extreme conditions.

In addition to specific comments on the ENSREG requirements, given in Chapter 2, the following general comments have to be made:

- The effects of a potential fire as a result of other extreme situations have been addressed insufficiently.
- The description of 'cliff edges' (small change with large, often irreversible, effects) is worded briefly for most scenarios.
- Throughout the report no clear relation has been identified between measures that are envisaged and the cliff edges or margins observed.
- KFD sees it as imperative to deepen the analysis of handling of major accidents by practical tests.

[3] In cases where any differences occur between the English version and the original Dutch version, the Dutch version will prevail

- At first reading the measures proposed by EPZ seem to enhance safety. Further study and analysis of these measures is needed by EPZ to ensure this. Additionally, it is determined that further study on a number of aspects by EPZ is required.

The robustness of the plant in case of extreme (weather) conditions

- The report gives a plausible description that supports the conclusion that the EPZ power plant has safety margins with respect to the current technical and organizational requirements and the Dutch law. Nevertheless, in view of the Fukushima accident, KFD stresses that a resolute approach is taken in realizing improvements by means of implementing measures and carrying out further studies.
  This especially applies to
  - increasing and improving the potential of the plant to ensure the safety during isolated and more difficult conditions. This refers to measures to extend the autarky time (the time the plant is self-sufficient) of equipment and to expand the self-reliance of the staff,
  - proofing the facilities in the area of fire fighting and ventilation of the containment (for the disposal of potentially released hydrogen), against earthquakes,
  - increasing the number of options for the (continuous) cooling of the fuel storage pool and the supply of water to this pool,
  - setting up a warehouse with materials for dealing with emergencies and that will be available under all conditions.

The proposals for improving the robustness of the power plant

- The report contains plausible intentions for improving the robustness of the plant. On some points, further studies are specified by EPZ. It might turn out that these investigations result in the adjustment of already formulated measures or the determination of new measures.
- Up to now the improvements have not been prioritized and scheduled. KFD stresses the need for an improvement plan addressing these aspects and to be submitted to KFD by EPZ for review.

It is preferred that the planning and implementation of concrete improvement actions should be separated from the next 10-yearly safety evaluation, this in contrast to the proposal by EPZ.

The Dutch stesstest in comparison to plants in neighbouring countries

The stress test report of EPZ matches the quality of reports of similar plants in neighbouring countries.
A clear and accountable timetable for the implementation of the measures is lacking. In that respect, EPZ can take example from some nuclear operators in neighbouring countries that propose a specific schedule for the implementation of the measures.

The stress test is not over yet. The next step will be the peer reviews in the European context. Meanwhile KFD will continue the review, including the judgement on necessity and planning of studies and measures, using the findings from other countries, adjusted standards, frameworks and the results of the international peer-review.

1. Introduction

After the accident in March 2011 at the Fukushima Nuclear Power Plant in Japan, the European Council concluded that the safety of all EU nuclear plants should be reviewed in the light of Fukushima on the basis of a comprehensive and transparent risk assessment ('stress test'). The European Nuclear Safety Regulators Group (ENSREG) developed the scope and modalities of this test, which should be used as a framework for the test. The Dutch government endorsed the European stress test specifications and asked the licensee to pay attention as well to other (probably man-made) effects that can have an adverse effect on safety systems.

The test is defined as a targeted reassessment of the safety margins of the nuclear power plants.
The reassessment can be seen as an evaluation consisting of three elements:

- Provisions taken in the design basis and plant conformance to its design requirements.
- Evaluation of the available margins in the design basis.
- Assessment of the margins 'beyond design'; how far the beyond design envelope can be stretched until accident management provisions (design and operation) cannot prevent a radioactive release to the environment that requires mitigative actions to protect the general public.

The agreed methodology consists of one track on safety and another track on security. The first track focuses on extreme natural events like earthquake and flooding.
This track will also look into the consequences of loss of safety functions as a consequence of any other initiating event including man-made and other accidental impacts, for instance large disturbances from the electrical power grid and air plane crash. The second track, which deals with risks related to security threats, is not covered in this report.

EPZ, as the operator and licensee of the only nuclear power plant in the Netherlands, situated in Borssele (Zeeland), performed such an assessment. The results of the assessment are laid down in the report 'Complementary Safety margin Assessment' (October 31, 2011, final report). The report was sent to the Minister of Economic Affairs, Agriculture and Innovation (EL&I), who is responsible for all regulatory affairs under the Nuclear Energy Act.
The Department of Nuclear and Radiological Safety, Security and Safeguards (in Dutch Kernfysische Dienst, KFD), residing under the Inspectorate of the Ministry of Infrastructure and Environment as the independent nuclear supervision authority, reporting to the Minister of EL&I, reviewed the report of EPZ.

The KFD review has been performed by a group of KFD experts with specific knowledge in the areas of the stress test and people with broad experience in nuclear safety. The review has been carried out in a period of about three weeks with the assistance of several external national and international experts of governmental related organisations. National experts were consulted from specific institutes like KNMI (Royal National Meteorological Institute), Rijkswaterstaat (National Watermanagement Institute) and the Labor Inspectorate. KFD arranged for the input of additional international expertise by using experts from GRS (Gesellschaft für Anlagen – und Reaktorsicherheit) – a Technical Support Organisation on Nuclear Safety to the Ministry of Environment, Nature Conservation and Reactorsafety, Germany.

GRS prepared a first draft of its report in one week and sent this to KFD on 10th of November. The final report was provided on the 16th of November.
Furthermore, GRS did a plausibility and completeness check, and a comparison with the German stress test reports.
In its judgement KFD also took into account the available information about lessons learned from the Fukushima accident and partly also from public information that was provided by regulatory organisations or their technical safety organisations in other countries (e.g. FANC, IRSN). The scope of the stress test and the way to review the measures has be discussed with the other regulators

The timeframe set by the ENSREG stress test specification has implied that not all aspects could be analyzed thoroughly. KFD will continue with developing new insights from the Fukushima accident and using information from other nuclear power plants in other countries and the results of the peer reviews of all European stress test reports. These peer reviews will be performed in the first half of next year.

The measures as indicated by the licensee must therefore according to KFD be seen as a first initiative. Additional measures are necessary as this report shows. Although all measures given by the licensee seem to contribute in principle to the improvement of nuclear safety, more detailed analyses have to be performed in order to ensure that there are no adverse effects on nuclear safety.

One significant general measure showed by the licensee is the development of a set Extensive Damage Mitigation Guidelines (EDMG). This is a model developed by industry, specific in the US, largely put into effect after the September 11, 2001 events.
These EDMGs cannot be reviewed by KFD yet because they are under development by EPZ.

In the current report, Chapter 2 forms the main body of this report consisting of the overall summary of judgements on the main chapters of the EPZ assessment:

- General data of the site/plant
- Earthquake
- Flooding
- Extreme weather conditions
- Loss of electrical power and loss of ultimate heat sink
- Severe accident management
- Other extreme hazards

The detailed further actions that according to KFD should be taken by EPZ are collected in the ANNEX A. This annex is following the structure of the ENSREG requirements extended with the additional Dutch requirements.

2. Assessment of the ENSREG requirements

Introduction
This chapter should be read in conjunction with the EPZ report "Complementary Safety margin Assessment" (October 31, 2011, final report) and letter ETM/ED/11074538 of the Ministry of Economic Affairs, Agriculture and Innovation dated June 01, 2011. This information can be found on http://www.rijksoverheid.nl/onderwerpen/kernenergie/europese-stresstest-kerncentrales

2.1 Requirement 1: General data about the site/plant

ENSREG requires the licensee to provide general information about the plant and the site. This information should cover the general characteristics of the site and plant, the available systems to support the main safety functions and the scope and main results of the Probabilistic Safety Assessment (PSA). This chapter provides no results from analyses but forms the basis on which the following requirements have been build. Further details about the ENSREG requirements on general data about the site/plant can be found in appendix A.

In this review KFD has performed a check of the main issues of the supplied information related to requirement 1

KFD concludes that EPZ has provided an extensive overview related to this requirement that is beneficial for the assessment of the other requirements.
KFD has the following remarks:

- Before taking credit for the feeding of NS2 via fixed connection from the coal-fired plant (CCB), this supply-configuration should be demonstrated.
- EPZ mentions that in case of the deployment of MOX-fuel in the core the safety situation of the Borssele NPP is comparable to the current situation where only naturally enriched uranium is deployed. This does not automatically imply that the analyses presented in this report also cover the situation with a mixed core containing partly Mixed-Oxide fuel. Formally this is not an ENSREG requirement since up to now MOX fuel has not been deployed in the plant. However the use of MOX has to be taken in account in the future.

2.2 Requirement 2: Earthquake

ENSREG requires the licensee to provide information about the design basis of the plant in order to establish the magnitude of the earthquake against which the plant is designed. In addition to this the licensee has to evaluate the margins that exist on top of the design basis above which loss of fundamental safety functions or severe damage to the fuel (in vessel or in fuel storage) becomes unavoidable.
Further details about the ENSREG requirements on earthquake conditions can be found in appendix A.

KFD concludes that

- The information provided by EPZ on the vulnerability of the plant for earthquakes is plausible.

- Thorough safety margins for earthquake have not yet been given by EPZ.
- Additional surveys and studies have to be carried out, mainly on the seismic aspects of both the NPP and area where the NPP is situated.
- Technical and / or organizational improvements are initiated by the licensee, mainly on the fire-fighting system in buildings 01, 02 and 35 and on the filtered venting system.

2.3 Requirement 3: Flooding

ENSREG requires the licensee to provide information about the design basis of the plant in order to establish the magnitude of external flooding against which the plant is designed. In addition to this the licensee has to assess the differences between maximum height of flood considered possible on site and the height of flood that would seriously challenge the safety systems, which are essential for heat transfer from the reactor and the spent fuel to ultimate heat sink.
Further details about the ENSREG requirements on flooding conditions can be found in appendix A.

KFD concludes that
- The information provided by EPZ on the vulnerability of the plant for flooding is sufficient and plausible given the model used by the licensee. However within the Netherlands other models with respect to flooding are known and in use. Some of these models give different values of water heights, water speeds and wave heights. The models have to be compared to each other and with existing data in order to draw a final conclusion.
- Safety margins on top of the design basis for flooding do exist.

2.4 Requirement 4: Extreme weather conditions

ENSREG asks for verification of the weather conditions that were used as design basis for various plants systems, structures and components: maximum temperature, minimum temperature, various type of storms, heavy rainfall, high winds, etc. by the licensee. Also the postulations of proper specifications for extreme weather conditions if not included in the original design basis are required.
Further details about the ENSREG requirements on extreme weather conditions can be found in appendix A.

The licensee evaluated the following weather conditions;
- maximum and minimum water temperatures of the River Westerschelde;
- extremely high and low air temperatures;
- extremely high wind (including storm and tornado);
- wind missiles and hail;
- formation of ice;
- heavy rainfall;
- heavy snowfall;
- lightning;
- credible combinations of the conditions mentioned above.

KFD concludes that
- The information provided by EPZ on the vulnerability of the plant for extreme weather conditions is sufficient and plausible.

- Safety margins for extreme weather conditions exist.
- However, additional surveys and studies have to be carried out on maximum roof-load of one building, the minimum depth of underground piping in order to be properly protected against freezing, and the possibilities to operate the diesel generators with extreme low temperatures.
- Technical and or organizational improvements have to be organised in order to cope with some of the extreme weather situations.

2.5 Requirement 5: Loss of electrical power and loss of ultimate heat sink

ENSREG asks for analyses of the situation of loss of electrical power and loss of ultimate heat sink. The two situations have to be analyzed using several different assumptions;

- Loss of off-site power
- Loss of off-site power and loss of the ordinary back-up AC power source (SBO-1)
- Loss of off-site power and loss of the ordinary back-up AC power sources, and loss of permanently installed diverse back-up AC power sources (SBO-2)
- Loss of the primary ultimate heat sink (e.g., loss of access to cooling water from the river, lake or sea, or loss of the main cooling tower)
- Loss of the primary ultimate heat sink and the alternate heat sink

In the case the connection with the primary ultimate heat sink for all safety and non safety functions is lost, the site is isolated from delivery of heavy material for 72 hours by road, rail or waterways. Portable light equipment can arrive to the site from other locations after the first 24 hours. Further details about the ENSREG requirements on loss of electrical power and loss of ultimate heat sink conditions can be found in appendix A.

KFD concludes that

Within the scope of ENSREG the following information is missing:

- In the case of SBO-2, credits for non-qualified systems, that need some necessary handling, are made within the first 24 hours.

Within the scope of ENSREG the following information is insufficient.

- The amount of diesel and lubricating oil should be considered as potential cliff-edge effects;
- Guides and procedures need to be developed such as deciding under which conditions the turbine oil pump must be switched off;
- Status of the core for the different solutions need to be considered too;
- In the case of SBO-2, the scenario without secondary feed and bleed should be analyzed.

Within the scope of ENSREG additional improvements shall be made by the Licensee EPZ:

- Qualification and classification of systems, structures and components important to handle severe accidents shall be defined.
- The quality of systems, structures and components important to handle severe accidents shall be enhanced.
- The systems, structures and components important to handle severe accidents shall be tested and the relevant procedures should be trained on a regular basis.

Finally, within the scope of ENSREG KFD concludes:
- No margins can be defined, but alternatives for loss of electrical (emergency) power and loss of ultimate heat sinks exist. However the alternative systems, structures and components are not qualified nor sufficiently proven;
- The potential modifications proposed by EPZ are necessary.

2.6 Requirement 6: Severe accident management

ENSREG requires the licensee to cover organization and arrangements for managing all type of accidents, starting from design basis accidents where the plants can be brought to safe shutdown without any significant nuclear fuel damage and up to severe accidents involving core meltdown or damage of the spent nuclear fuel in the storage pool.
Further details about the ENSREG requirements on severe accident management can be found in appendix A.

KFD concludes the following.

In general the ENSREG specification is well followed, but according to KFD the following issues or subjects are not (sufficiently) addressed with respect to severe accident management:
- Dose management
- Description of the radioactive release filters available in the installation
- Long term post-accident activities (beyond SAEG-1)
- Accident Management measures after the loss of containment (other than the use of existing equipment of the installation) such as:
  - Repair
  - Mitigating actions from outside
- Systematic analysis of access to rooms, equipment or reserve equipment in extreme situations for example:
  - access to the workshops and or warehouses for reserve equipment when the site is flooded
  - fires could start as indirect effect after aircraft crashes, explosions, earthquakes and lightning and could seriously impede access
- Potential hydrogen accumulations in other buildings than the containment

Although it is stated that the (Severe) Accident Management procedures are in place for all operational states it is unclear from the report what the typical differences are or which special actions are necessary for instance during shutdown. EPZ should provide additional information on this subject.
In a number of cases more information is needed to judge the issue.
The measures proposed are supported by KFD, but according to KFD more should be done. The list of measures that can be envisaged to enhance accident management capabilities should be extended by the additional measures from this review and the peer review process.

The most important additional issues according to KFD are:
The Severe Accident Management as it is currently organized makes use as far as possible from the existing resources and equipments that are available.
Equipment/instrumentation needed for the control of design basis accidents is in principle designed and classified for that purpose. For severe accidents it is assumed that equipment/instrumentation is used that is not designed or classified for that

purpose. The procedures are aimed at more or less checking what is available first and if so it will be used. KFD concludes that EPZ should start an action to improve the robustness of the plant by analyzing whether the equipment/instrumentation that is necessary or at least very useful to mitigate severe accidents can be improved (e.g. higher safety class, or from non-safety related to safety related, or introduce separate or additional equipment/instrumentation dedicated to the mitigation).

- Based on the lessons of Fukushima and R&D worldwide the SAMG's should be evaluated and improved when necessary.
- Before final measures are in place, temporary measures should be considered by EPZ.
- Analysis of the required additional staff and the organization for severe accidents has to be made.
- Evaluation of H-combustion vulnerability and H-management in several cases has to be improved.
- Severe accident mitigation strategies using other equipment than from the existing installation in cases like loss of containment and loss of water in the fuel pool have to be developed.
- The contract for external deliveries/support taking care of harsh circumstances has to be improved.
- The alternatives to provide electricity (AC and DC) like, batteries, battery loading, number of connections have to be improved.
- Procedures and solutions for the handling of large amounts of contaminated water have to be developed.
- The expected dose rates on the site and in the buildings have to be reevaluated.

2.7 Requirement 7: Other extreme hazards (additional requirement by the Dutch government)

The chapter of the licensee report covering this requirement handles other extreme hazards that may have a adverse effect on the nuclear power plant. This requirement is not included in the ENSREG requirements but is an additional requirement from the Dutch government. EPZ has evaluated the following potential threads;

- Internal explosion
- External explosion
- Internal fire
- External fire
- Airplane crash
- Toxic gases
- Large grid disturbances
- Failure of systems by introducing computer malware
- Internal flooding
- Blockage of the cooling water inlet

KFD concludes that

- The information provided by EPZ on the vulnerability of the plant for other extreme hazards is sufficient and plausible.
- Safety margins for external hazards are not clearly given.
- An evaluation of internal fire caused by electric powered equipment is missing.
- An evaluation of explosions on the NPP site outside of the buildings is missing

- Measures to account for the emergency control room not being protected against toxic gases are missing.
- As indicated by the licensee a more extensive study of the impact on the safety functions of different aircraft crashes has to be performed.

Appendix A: The ENSREG requirements for the national report including the detailed KFD review remarks

The ENSREG requirements are printed normal

The KFD remarks are printed italic

1. General data about site/plant
1.1 Brief description of the site characteristics • location (sea, river); • number of units; • license holder;
1.2 Main characteristics of the units • reactor type; • thermal power; • date of first criticality • existing spent fuel storage (or shared storage)
In this chapter in general minimum guaranteed quantities are reported. An exception seems to be the volume of UA demineralised water storage tanks of which the maximum volume is listed. KFD recommends that all quantities given in the report are checked to determine whether they are realistic, especially the UA, UJ storage tank and -pool.
1.3 Systems for providing or supporting main safety functions In this section, all relevant systems should be identified and described, whether they are classified and accordingly qualified as safety systems, or designed for normal operation and classified to non-nuclear safety category. The systems description should include also fixed hook-up points for transportable external power or water supply systems that are planned to be used as last resort during emergencies.
The information given in tables 1.8, 1.11 and 1.14 is not consistent. For example the RA main steam pressure relief valves in table 1.8: it is unlikely that the valves can not be operated with the power supply from emergency grid 1 while on the other hand they can be supplied by UPC1.
1.3.1 Reactivity control Systems that are planned to ensure sub-criticality of the reactor core in all shutdown conditions, and sub-criticality of spent fuel in all potential storage conditions. Report should give a thorough understanding of available means to ensure that there is adequate amount of boron or other respective neutron absorber in the coolant in all circumstances, also including the situations after a severe damage of the reactor or the spent fuel.
1.3.2. Heat transfer from reactor to the ultimate heat sink
1.3.2.1. All existing heat transfer means / chains from the reactor to the primary heat sink (e.g., sea water) and to the secondary heat sinks (e.g., atmosphere or district heating system) in different reactor shutdown conditions: hot shutdown, cooling from hot to cold shutdown, cold shutdown with closed primary circuit, and cold shutdown with open primary circuit.
1.3.2.2. Lay out information on the heat transfer chains: routing of redundant and diverse heat transfer piping and location of the main equipment. Physical protection of equipment from the internal and external threats.
1.3.2.3. Possible time constraints for availability of different heat transfer chains, and possibilities to extend the respective times by external measures (e.g., running out of a water storage and possibilities to refill this storage).

1.3.2.4. AC power sources and batteries that could provide the necessary power to each chain (e.g., for driving of pumps and valves, for controlling the systems operation).
1.3.2.5. Need and method of cooling equipment that belong to a certain heat transfer chain; special emphasis should be given to verifying true diversity of alternative heat transfer chains (e.g., air cooling, cooling with water from separate sources, potential constraints for providing respective coolant).
1.3.3. Heat transfer from spent fuel pools to the ultimate heat sink
1.3.3.1. All existing heat transfer means / chains from the spent fuel pools to the primary heat sink (e.g., sea water) and to the secondary heat sinks (e.g., atmosphere or district heating system).
Page 27, second bullet. Assumed is RS is the back-up of RL instead of RA.
1.3.3.2. Respective information on lay out, physical protection, time constraints of use, power sources, and cooling of equipment as explained under 1.3.2.
1.3.4. Heat transfer from the reactor containment to the ultimate heat sink
1.3.4.1. All existing heat transfer means / chains from the containment to the primary heat sink (e.g., sea water) and to the secondary heat sinks (e.g., atmosphere or district heating system).
1.3.4.2. Respective information on lay out, physical protection, time constraints of use, power sources, and cooling of equipment as explained under 1.3.2.
1.3.5. AC power supply
1.3.5.1. Off-site power supply
1.3.5.1.1. Information on reliability of off-site power supply: historical data at least from power cuts and their durations during the plant lifetime.
1.3.5.1.2. Connections of the plant with external power grids: transmission line and potential earth cable routings with their connection points, physical protection, and design against internal and external hazards.
1.3.5.2. Power distribution inside the plant
1.3.5.2.1. Main cable routings and power distribution switchboards.
1.3.5.2.2. Lay-out, location, and physical protection against internal and external hazards.
1.3.5.3. Main ordinary on-site source for back-up power supply
1.3.5.3.1. On-site sources that serve as first back-up if offsite power is lost.
1.3.5.3.2. Redundancy, separation of redundant sources by structures or distance, and their physical protection against internal and external hazards.
1.3.5.3.3. Time constraints for availability of these sources and external measures to extend the time of use (e.g., fuel tank capacity).
1.3.5.4. Diverse permanently installed on-site sources for back-up power supply
1.3.5.4.1. All diverse sources that can be used for the same tasks as the main back-up sources, or for more limited dedicated purposes (e.g., for decay heat removal from reactor when the primary system is intact, for operation of systems that protect containment integrity after core meltdown).
1.3.5.4.2. Respective information on location, physical protection and time constraints as explained under 1.3.5.3.
1.3.5.5. Other power sources that are planned and kept in preparedness for use as last resort means to prevent a serious accident damaging reactor or spent fuel
1.3.5.5.1. Potential dedicated connections to neighbouring units or to nearby other power plants.
1.3.5.5.2. Possibilities to hook-up transportable power sources to supply certain safety systems.
1.3.5.5.3. Information on each power source: power capacity, voltage level and other relevant constraints.
1.3.5.5.4. Preparedness to take the source in use: need for special personnel, procedures and training, connection time, contract arrangements if not in ownership of the Licensee, vulnerability of source and its connection to external

hazards and weather conditions, as well as arrangements for accessing these, including where they are stored (both in relation to the site and protection from potential hazards), and whether they are shared between units or sites.
1.3.6. Batteries for DC power supply
1.3.6.1. Description of separate battery banks that could be used to supply safety relevant consumers: capacity and time to exhaust batteries in different operational situations.
1.3.6.2. Consumers served by each battery bank: driving of valve motors, control systems, measuring devices, etc.
1.3.6.3. Physical location and separation of battery banks and their protection from internal and external hazards.
1.3.6.4. Alternative possibilities for recharging each battery bank.
In paragraph 1.3.6.4.1, it is stated that the emergency power system of the coal-fired plant (CCB) can feed emergency grid 2by means of a fixed connection. KFD recommends that this supply-configuration shall be demonstrated before credit is taken.
1.4 Significant differences between units This section is relevant only for sites with multiple NPP units of similar type. In case some site has units of completely different design (e.g., PWR's and BWR's or plants of different generation), design information of each unit is presented separately.
1.5 Scope and main results of Probabilistic Safety Assessments Scope of the PSA is explained both for level 1 addressing core meltdown frequency and for level 2 addressing frequency of large radioactive release as consequence of containment failure. At each level, and depending on the scope of the existing PSA, the results and respective risk contributions are presented for different initiating events such as random internal equipment failures, fires, internal and external floods, extreme weather conditions, seismic hazards. Information is presented also on PSA's conducted for different initiating conditions: full power, small power, or shutdown.
During the latest IPSART mission at the Borssele NPP it was concluded that the "living" PSA of the plant requires updating.
The source term data presented in tables 1.23to 1.25 should be re-evaluated using the findings of the analysis of the Fukushima accident and the subsequent R&D activities in this field.
1.6 Future use of Mixed Oxide fuel
Since the Borssele NPP did not operate on a partially MOX fuelled core on the reference date for the analysis, 30th of June 2011, the impact of MOX on the analyses is not mandatory according to ENSREG. EPZ argues that during the licensing procedure it has been shown that the safety of the Borssele NPP with the use of MOX fuel is comparable with the current situation in which Enriched Natural Uranium (ENU) is used as fuel. However, for long term situations (>48 hours) the decay-heat of MOX-fuel is significantly larger than for ENU-fuel. Furthermore, the analyses presented in this report cover a much larger range of accident scenario's than analysed for the license application. Therefore the deployment of MOX fuel is not covered by the analyses provided in the report.

2. Earthquakes

Both the reactor and the spent fuel pools, as well as spent fuel storages at site, are to be considered.

2.1 Design basis

2.1.1 Earthquake against which the plants are designed

2.1.1.1 Characteristics of the design basis earthquake (DBE)
Level of DBE expressed in terms of maximum horizontal peak ground acceleration (PGA). If no DBE was specified in the original design due to the very low seismicity of the site, PGA that was used to demonstrate the robustness of the as built design.

Possible effects by human induced earthquakes should be mentioned; e.g. earthquakes as a result of gas drilling in the Northern part of The Netherlands and shale gas drilling in Noord-Brabant.

2.1.1.2 Methodology used to evaluate the design basis earthquake
Expected frequency of DBE, statistical analysis of historical data, geological information on site, safety margin.

The median return period associated with the intensity of the DBE corresponds to around 30,000 years. This has been adopted in the seismic hazard curve of the PSA, based on the original determination of the DBE. Information and systematics used to define this DBE might be dated. A re-evaluation should be carried out in order to update the DBE and the return period. In this re-evaluation the most recent insights in earthquake systematics and data must be taken into account.

2.1.1.3 Conclusion on the adequacy of the design basis for the earthquake
Reassessment of the validity of earlier information taking into account the current state-of-the-art knowledge.

In the original definition of the DBE the site-specific local conditions are not taken into account. Although it is mentioned that in the update of the DBE (part of the second 10 yearly evaluation) the site conditions have been taken into account, specific data on the local geology are missing. So far, no seismic measurements have been carried out at the site. These measurements should be carried out in order to obtain more insight in the local site conditions (e.g. local geological features can cause local vibrations) and possible measures that must be taken to improve the resistance against earthquakes.

2.1.2 Provisions to protect the plants against the design basis earthquake

2.1.2.1 Identification of systems, structures and components (SSC) that are required for achieving safe shutdown state and are most endangered during an earthquake. Evaluation of their robustness in connection with DBE and assessment of potential safety margin.

The evaluation of the seismic capacities of mechanical, electrical and instrumentation and control (I&C) systems is done by comparison with earthquake experiences at other NPP's. Although this might give some insight in the behaviour of systems, this doesn't provide a solid proof. Differences in design and local conditions influence the margins. These margins should be assessed.

In the analysis of the robustness of the systems required in order to achieve the safe shutdown state, insufficient attention is given to instrumentation and the availability of staff.

2.1.2.2 Main operating contingencies in case of damage that could be caused by an earthquake and could threaten achieving safe shutdown state.

2.1.2.3 Protection against indirect effects of the earthquake, for instance
2.1.2.3.1 Assessment of potential failures of heavy structures, pressure retaining devices, rotating equipment, or systems containing large amount of liquid that are not designed to withstand DBE and that might threaten heat transfer to ultimate heat sink by mechanical interaction or through internal flood.
In the report it is noted that the fire-fighting systems in buildings 01, 02 and 35 are not designed for operability after a DBE. This is listed as a weakness and therefore as a possible modification. In chapter 2.2.4 the weakness is again mentioned, however, a specific modification isn't mentioned. To enhance the protection against internal fire these systems should be qualified for the DBE.
2.1.2.3.2 Loss of external power supply that could impair the impact of seismically induced internal damage at the plants.
2.1.2.3.3 Situation outside the plants, including preventing or delaying access of personnel and equipment to the site.
2.1.2.3.4 Other indirect effects (e.g. fire or explosion).
The possibility of an explosion as an indirect effect of an earthquake has not been assessed. Only a possible fire is addressed
It is mentioned that liquefaction of certain ground layers cannot be ruled out. However, it is stated that there is sufficient margin against failure of the plant's foundations and loss of pile-bearing capacity. It is not made clear that liquefaction doesn't have negative influences on systems. This should be made clear.
2.1.3. Compliance of the plants with its current licensing basis
2.1.3.1 Licensee's processes to ensure that plants systems, structures, and components that are needed for achieving safe shutdown after earthquake or that might cause indirect effects discussed under the previous section remain in operable conditions.
2.1.3.2 Licensee's processes to ensure that mobile equipment and supplies that are planned to be available after an earthquake are in continuous preparedness to be used.
It must be made clear which internal and external mobile equipment is needed to control the DBE.
2.1.3.3 Potential deviations from licensing basis and actions to address those deviations.
Improvements on the availability and preparedness of auxiliary mobile equipment as made clear in the check performed as a result of the WANO Significant Operating Experience Report (SOER) are mentioned. These improvements should be further elaborated.
2.2. Evaluation of safety margins
2.2.1. Range of earthquake leading to severe fuel damage Weak points and cliff edge effects: estimation of PGA above which loss of fundamental safety functions or severe damage to the fuel (in vessel or in fuel storage) becomes unavoidable.
2.2.2. Range of earthquake leading to loss of containment integrity Estimation of PGA that would result in loss of integrity of the reactor containment.
2.2.3. Earthquake exceeding the design basis earthquake for the plants and consequent flooding exceeding design basis flood Possibility of external floods caused by an earthquake and potential impacts on the safety of the plants. Evaluation of the geographical factors and the physical possibility of an earthquake to cause an external flood on site, e.g. a dam failure upstream of the river that flows past the site.
Paragraph 2.2.3 mentions that the systems required for a safe shutdown in buildings 01, 02, 33 and 35 will remain available after a beyond design basis

earthquake of 0.3 g. In paragraph 2.2.1, however, it is mentioned that buildings 01 and 02 have a HCLPF capacity of 0.15 g. A more thorough seismic margin assessment is needed in order to determine the specific margins.
2.2.4. Measures which can be envisaged to increase robustness of the plants against earthquakes Consideration of measures, which could be envisaged to increase plants robustness against seismic phenomena and would enhance plants safety.
A cliff-edge is identified in the case that no personnel is available to replenish back-up feedwater system storage tanks within 10 hours.
The identified cliff-edge on the structural failure of the missile shield inside the containment for PGAs > 0,3 requires further clarification and analysis.
The measures proposed do not seem to be related to the identified cliff-edges. Although all measures proposed are worthwhile to consider, it should be made clear whether the identified cliff-edges give rise to further potential measures
The report gives an estimation of the seismic margins. PGA's that would result in a loss of fundamental safety functions or loss of integrity of the reactor containment are not estimated. The described measure of reducing the uncertainties in the seismic margins by carrying out a Seismic Margin Assessment or a seismic probabilistic Safety Assessment is supported by the KFD.

3. Flooding **Both the reactor and spent fuel pools, as well as spent fuel storages at site, are to be considered.**
3.1. Design basis
3.1.1. Flooding against which the plants are designed
3.1.1.1 Characteristics of the design basis flood (DBF) Maximum height of flood postulated in design of the plants and maximum postulated rate of water level rising. If no DBF was postulated, evaluation of flood height that would seriously challenge the function of electrical power systems or the heat transfer to the ultimate heat sink.
3.1.1.2 Methodology used to evaluate the design basis flood. Reassessment of the maximum height of flood considered possible on site, in view of the historical data and the best available knowledge on the physical phenomena that have a potential to increase the height of flood. Expected frequency of the DBF and the information used as basis for reassessment.
In the case of flooding with a mostly intact dyke the wave height on-site is determined based on the diminishing effect of the dyke on the wave height and the enhancement of the wave height due to reflections against buildings. The latter effect is estimated to lead to a doubling of the wave height. In the case of flooding with a completely failed dyke only wave height reduction due to the shallowness of the site is assumed. No doubling due to reflections against buildings is taken into account. In order to perform a consistent analysis however, either the doubling of wave height due to reflections against buildings must be taken into account or the complete destruction of all buildings must be assumed. This contradiction should be clarified by the licensee
3.1.1.3 Conclusion on the adequacy of protection against external flooding
The NPP Borssele will be informed about expected water heights by external sources. There are no water level criteria given for preventive shut down the NPP. A preventive shut down level should be investigated by the licensee
In the analysis a possible weak point is identified: the stability of the end pylon of the overhead line connecting the step-up transformer to the grid during flooding situations. It is argued that in case of flooding this connection is not required as the normal procedure is to switch to house-load operation. In this argumentation the possible impact of a short circuit in the overhead line as a result of the failing end pylon on a flooded site is not analyzed. The licensee should analyze the effects of shirt circuit in the overhead lines.
According to some experts, extreme floods, may be violent and may have the potential to flood most of the province of Zeeland and even major parts of the Netherlands. According to aforementioned experts, this type of flood might feature a fast increase of water level. It also may feature large flow rates and speeds. As a consequence its waves may have the potential to entirely destroy dikes (like dikes A and B) and non-bunker type buildings. Above a certain level of damage to the dikes, they may not be able to limit the height and strength of the waves. It is unclear what impact this type of flood will have on the safety of the NPP. The licensee should make a comparison of the model used by the licensee and external experts.
3.1.2. Estimation of safety margin against flooding

Estimation of difference between maximum height of flood considered possible on site and the height of flood that would seriously challenge the safety systems, which are essential for heat transfer from the reactor and the spent fuel to ultimate heat sink. Provisions to protect the plants against the design basis flood
3.1.2.1 Identification of systems, structures and components (SSC) that are required for achieving and maintaining safe shutdown state and are most endangered when flood is increasing.
The NPP Borssele final report states that building 4 can withstand floods until 5 m +NAP but will be unavailable at 7.3 m +NAP. What is the status of the instrumentation (including wiring and power supplies) necessary to monitor and control the power plant during flooding conditions? The licensee should clarify this.
3.1.2.2 Main design and construction provisions to prevent flood impact to the plants.
3.1.2.3 Main operating provisions to prevent flood impact to the plants.
3.1.2.4 Situation outside the plants, including preventing or delaying access of personnel and equipment to the site.
3.1.3. Plants compliance with its current licensing basis
3.1.3.1 Licensee's processes to ensure that plant systems, structures, and components that are needed for achieving and maintaining the safe shutdown state, as well as systems and structures designed for flood protection remain in faultless condition.
3.1.3.2 Licensee's processes to ensure that mobile equipment and supplies that are planned for use in connection with flooding are in continuous preparedness to be used.
3.1.3.3 Potential deviations from licensing basis and actions to address those deviations.
3.2. Evaluation of safety margins
3.2.1. Estimation of safety margin against flooding Estimation of difference between maximum height of flood considered possible on site and the height of flood that would seriously challenge the safety systems, which are essential for heat transfer from the reactor and the spent fuel to ultimate heat sink.
3.2.2. Measures which can be envisaged to increase robustness of the plants against flooding. Consideration of measures, which could be envisaged to increase plants robustness against flooding and would enhance plants safety.
In the analysis of the effects of a rupture of the VC pipe flooding is only considered as a result of the event. It is however not unlikely that flooding will be the initiating event of VC pipe damages due to for example the static pressure of the water on site. The potential complications from the failure of the VC pipe on a flooding scenario have not been taken into account. In case of a rupture of the VC pipe without causing a flooding of the site, the plant will be more vulnerable to high tides and storm surges until the damage has been repaired. The report misses a clear set of measures to protect the plant in case this situation occurs. The licensee should analyze the effects of flooding on the VC system.
In the analysis of the flooding of buildings 33 and 35 it is suggested to install a parapet in order to prevent the splashing of waves against the air intakes. This measure is not mentioned in 3.2.2 where the measures to increase the robustness of the plant against flooding is discussed. This should be clarified by the licensee.

4. Extreme weather conditions
All relevant weather conditions have been assessed
4.1. Design basis
4.1.1. Reassessment of weather conditions used as design basis
4.1.1.1 Verification of weather conditions that were used as design basis for various plants systems, structures and components: maximum temperature, minimum temperature, various type of storms, heavy rainfall, high winds, etc.
Most minima and maxima are not designed based but result from engineering and/or national codes.
The plant will be informed by the local authorities in case of extreme water-level forecast.
4.1.1.2 Postulation of proper specifications for extreme weather conditions if not included in the original design basis.
A cliff-edge is found for the minimum air temperature (-18°C).
Concerning frozen fire lines: it is not clear what method has been used to determine the minimum depth of the lines in the soil that safeguards them from freezing. There is only a limited difference between the actual pipe depth (0,8m) and the mentioned frost zone (0,7m) in the soil.
It is not clear whether sufficient engineering features are in place to keep the VE-piping in the upper part of the wells free of frost.
The soil temperature at the level of the hydrant piping is not monitored. KFD suggest EPZ to consider the possibility to monitor the soil temperature around the hydrant piping.
A check should be made whether the emergency diesel generators and their auxiliary systems can operate for a longer period with extreme low temperatures caused by the combustion air.
The potential effect of build-up of snow dunes (accumulation of wind-transported snow) on the roofs of the buildings has no be taken into account.
Attention should be paid for the roof-load in combination with heavy rain or snow, especially building 33 which has such a high roof edge that the maximum roof-load will be exceeded in combinations with blocked drains and heavy (extreme) rain or other source of much water like fire fighting actions.
The effects of lightning are difficult to asses. In June 2008 several annunciators were spuriously activated and one of the two main feedwaterpumps tripped. Analysis of the incident showed that disturbance of the electronics was caused by lightning and damaged lightning-shielding on building 15 due to construction work.
LOOP caused by failures of pylons or salt on isolators forces the plant to fall back on emergency grid 1. House-load operation will not be possible as the lines will be short circuited and the plant has no generator switch.
4.1.1.3 Assessment of the expected frequency of the originally postulated or the redefined design basis conditions.
The figures used for the frequency will be assessed by the national Metrological institute.
4.1.1.4 Consideration of potential combination of weather conditions.
4.1.1.5 Conclusion on the adequacy of protection against extreme weather conditions
4.2. Evaluation of safety margins

4.2.1. Estimation of safety margin against extreme weather conditions Analysis of potential impact of different extreme weather conditions to the reliable operation of the safety systems, which are essential for heat transfer from the reactor and the spent fuel to ultimate heat sink. Estimation of difference between the design basis conditions and the cliff edge type limits, i.e. limits that would seriously challenge the reliability of heat transfer.
4.2.2. Measures which can be envisaged to increase robustness of the plants against extreme weather conditions Consideration of measures, which could be envisaged to increase plants robustness against extreme weather conditions and would enhance plants safety.
The licensee has the intention to develop a check-list for plant walk-downs en required actions after exposure to various levels of the foreseeable hazards. Where applicable hardware provisions should be taken to increase the robustness of the backup emergency cooling water systems VE and UJ to extreme low temperatures

5. Loss of electrical power and loss of ultimate heat sink

For writing chapter 5, it is suggested that the emphasis is in consecutive measures that could be attempted to provide necessary power supply and decay heat removal from the reactor and from the spent fuel.
Chapter 5 should focus on prevention of severe damage of the reactor and of the spent fuel, including all last resort means and evaluation of time available to prevent severe damage in various circumstances. As opposite, the Chapter 6 should focus on mitigation, i.e. the actions to be taken after severe reactor or spent fuel damage as needed to prevent large radioactive releases. Main focus in Chapter 6 should thus be in protection of containment integrity.

In general the worst case is LPUHS-SBO2. For qualified systems 3 hours of secondary cooling is available using 185 m3 water of the feed water tank (RL). In this case the water is pumped into the steam generator using the steam driven pump (RL023) or forced using the steam coming from the outlet of the steam generator (RA), the so called secondary feed and bleed. All other options as suggested in the report are non qualified systems like using fire-hoses (UJ). This system is important in most scenarios.

KFD recommends that the UJ system shall be modified to a nuclear safety class 3 or higher safety class as proposed by EPZ. In addition, KFD recommends that the UJ system should be resistant to external events to a higher level than the design based external events. This includes both pumps. It should be investigated if the UJ system can be brought to a operational system for 24 hours without any physical human interaction.

In addition, the diesel generators of the coil fire plant are in this report for the first time mentioned as the back-up system in case of SBO-2. However, all back-up actions involving CCB are not qualified. KFD recommends testing this possibility and improving the connection according to the SAHARA principle.

The degradation of the core (in time) is not presented in the analyses. KFD recommends to have this information available to determine the highest priority during a severe accident.

Measure M9 should be accompanied by a measure to improve the cooling capacity of the well pump system in order to reduce the at least 13h before the pump system can be put in operation.

5.1 Nuclear power reactors

5.1.1 Loss of electrical power

All offsite electric power supply to the site is lost. The offsite power should be assumed to be lost for several days. The site is isolated from delivery of heavy material for 72 hours by road, rail or waterways. Portable light equipment can arrive to the site from other locations after the first 24 hours.

5.1.1.1 Loss of off-site power

Dependence on the functions of other reactors on the same site. Robustness of the provisions in connection with seism and flooding.
Autonomy of the on-site power sources and provisions taken to prolong the service time of on-site AC power supply

5.1.1.1.1 Design provisions taking into account this situation: back-up power sources provided, capacity and preparedness to take them in operation.

5.1.1.1.2 Autonomy of the on-site power sources and provisions taken to prolong the time of on-site AC power supply

In addition to the mentioned diesel fuel storage, the lubricating oil

consumption and the amount of lubricated oil in stock should be considered as well.
5.1.1.2. Loss of off-site power and loss of the ordinary back-up AC power source
5.1.1.2.1 Design provisions taking into account this situation: diverse permanently installed AC power sources and/or means to timely provide other diverse AC power sources, capacity and preparedness to take them in operation
5.1.1.2.2 Battery capacity, duration and possibilities to recharge batteries
5.1.1.3 Loss of off-site power and loss of the ordinary back-up AC power sources, and loss of permanently installed diverse back-up AC power sources
5.1.1.3.1 Battery capacity, duration and possibilities to recharge batteries in this situation
Normally, the battery discharge time is two hours. However by switching of the turbine oil pump this time can be increased to 5.7 hours, but it will destroy the turbine. Because of the economical consequences it is unlikely that the turbine oil pumps will be switched off immediately and therefore the maximum battery time will be less than 5.7 hours. KFD recommends EPZ to establish a clear set of criteria to determine when to switch off the turbine oil pump in order to reduce the loss of battery time.
5.1.1.3.2 Actions foreseen to arrange exceptional AC power supply from transportable or dedicated off-site source
5.1.1.3.3 Competence of shift staff to make necessary electrical connections and time needed for those actions. Time needed by experts to make the necessary connections.
5.1.1.3.4 Time available to provide AC power and to restore core and spent fuel pool cooling before fuel damage: consideration of various examples of time delay from reactor shutdown and loss of normal reactor core cooling condition (e.g., start of water loss from the primary circuit).
5.1.1.4. Conclusion on the adequacy of protection against loss of electrical power.
The first alternative power for emergency grid 2 is using the emergency diesel generators of the coal-fired plant. This is not a proven practice or a qualified system. The second alternative power for emergency grid 2 is using the mobile diesel generator EY080 (1.0 MW) located at the site. However, this diesel generator is only mobile when (heavy) external equipment can be brought to the site. It cannot be classified as portable light equipment that can arrive to the site from other locations after the first 24 hours. A third alternative power for emergency grid 2 is using an external diesel generator (1.0 MW) from Rotterdam. However, this diesel is not available. No procurement arrangements with suppliers are arranged. In addition, it can't be classified as portable light equipment that can arrive to the site from other locations after the first 24 hours. Furthermore, there are no statements regarding protection against external events for the above three mentioned alternatives and it is not mentioned consistently whether procedures for these alternatives exist. KFD recommends an alternative power system in the case of SBO-2 for the first 24 hours without any physical human interaction. This system should be resistant to external events to a higher level than the design based external events level.
5.1.1.5. Measures which can be envisaged to increase robustness of the plants in case of loss of electrical power
In the case of SBO2 and exhausted batteries the primary pressure vessel relief valve (YP) cannot be operated neither by hand. Primary feed and bleed is not

possible. KFD recommends that this should be clear before developing Extensive Damaging Management Guides.
5.1.2 Loss of the decay heat removal capability/ultimate heat sink The connection with the primary ultimate heat sink for all safety and non safety functions is lost. The site is isolated from delivery of heavy material for 72 hours by road, rail or waterways. Portable light equipment can arrive to the site from other locations after the first 24 hours.
5.1.2.1. Design provisions to prevent the loss of the primary ultimate heat sink, such as alternative inlets for sea water or systems to protect main water inlet from blocking. Robustness of the provisions in connection with seism and flooding.
5.1.2.2. Loss of the primary ultimate heat sink (e.g., loss of access to cooling water from the river, lake or sea, or loss of the main cooling tower)
5.1.2.2.1 Availability of an alternate heat sink, dependence on the functions of other reactors on the same site.
5.1.2.2.2 Possible time constraints for availability of alternate heat sink and possibilities to increase the available time.
The quality of the water of the fire fighting pond of the CCB 1.600 m3 is poor. It is doubtful whether it can be used as cooling water. The risk of blocking the equipment of the fire-fighting is unknown. KFD recommends further investigation of the actual usefulness of this cooling water.
5.1.2.3. Loss of the primary ultimate heat sink and the alternate heat sink
5.1.2.3.1 External actions foreseen to prevent fuel degradation.
5.1.2.3.2 Time available to recover one of the lost heat sinks or to initiate external actions and to restore core and spent fuel pool cooling before fuel damage: consideration of various examples of time delay from reactor shutdown to loss of normal reactor core and spent fuel pool cooling condition (e.g., start of water loss from the primary circuit).
Strategy in priority measurements are dealt with in chapter 6.2.2. KFD recommends that in paragraph 5.1.2.3.2 information should be presented about the possibilities and required time to implement alternatives or recover lost heat-sinks. No (time) information is given about the degradation process of the core in the several scenarios.
5.1.2.4. Conclusion on the adequacy of protection against loss of ultimate heat sink
5.1.2.5. Measures which can be envisaged to increase robustness of the plants in case of loss of ultimate heat sink
Running out of diesel is an extra potential cliff-edge effect in the case of using the fire brigade pumps (UJ).
Pag 5-59, a procedure for direct injection of VE by UJ is addressed as a potential action to increase the robustness of the installation. In addition, alternative supplies for UJ are addressed. In the latter, KFD suggests that VE/UJ/RL should be a part of this assessment.
5.1.3. Loss of the primary ultimate heat sink, combined with station black out (see stress tests specifications).
5.1.3.1. Time of autonomy of the site before loss of normal cooling condition of the reactor core and spent fuel pool (e.g., start of water loss from the primary circuit).
5.1.3.2. External actions foreseen to prevent fuel degradation.
5.1.3.3. Measures, which can be envisaged to increase robustness of the plants in case of loss of primary ultimate heat sink, combined with station black out
Running out of diesel is an extra potential cliff-edge effect in the case of using the fire brigade pumps (UJ).
5.2. Spent fuel storage pools

Where relevant, equivalent information is provided for the spent fuel storage pools as explained in Section 5.1 for nuclear power reactors.
5.2.1. Loss of electrical power
5.2.1.1 Measures which can be envisaged to increase robustness of the plant in case of loss of electrical power
5.2.2. Loss of the ultimate heat sink
5.2.2.1 Measures which can be envisaged to increase robustness of the plant in case of loss of ultimate heat sink
5.2.3. Loss of the primary ultimate heat sink, combined with station black out (i.e., loss of off-site power and ordinary on-site back-up power source).
5.2.3.1. Measures, which can be envisaged to increase robustness of the plant in case of loss of primary ultimate heat sink, combined with station black out
See remark 5.1.2.3.2
No cliff-edge effects are specified.

6. Severe accident management
6.1. Organization and arrangements of the licensee to manage accidents Section 6.1 should cover organization and arrangements for managing all type of accidents, starting from design basis accidents where the plants can be brought to safe shutdown without any significant nuclear fuel damage and up to severe accidents involving core meltdown or damage of the spent nuclear fuel in the storage pool.
6.1.1. Organisation of the licensee to manage the accident
6.1.1.1 Staffing and shift management in normal operation
6.1.1.2 Plans for strengthening the site organisation for accident management
Calling of 2 additional shifts on site when the site is still intact: *• EPZ should develop criteria, based on the (predicted) evolution of the external hazard, when the additional shifts should be called.* *• Also the number of additional people needed for different hazards should be determined.* *• It is unclear how it can be guaranteed that two additional shifts are available during all the year; therefore EPZ should make arrangements to realize this* *• In case the site is flooded or after a (beyond) "design" earthquake, the current ACC could be available; therefore until the new shelter will be realized, a temporary solution should be developed/implemented.* *• It is unclear what measures are foreseen if the emergency organization is not complete for some reason (e.g. lines on communication and decision authorities). EPZ should provide additional information.*
6.1.1.3 Measures taken to enable optimum intervention by personnel
Tasks of ERO: *• EPZ should develop a strategy for the organization for a long duration of a complex emergency situation containing at least the following elements:* *o Provisions for communication with the public and the media.* *o Provisions for dealing with the long term, while the ERO is dealing with the actual situation.* *o Provisions for independent review of the ERO during its operation.* *• The incident of Fukushima has made clear that it is important to have communications with the public and liaison with the different authorities right from the beginning; EPZ should re-evaluate its current policy on this issue.*
6.1.1.4 Use of off-site technical support for accident management
EPZ should describe in more in detail the ROT en NPK organization and the corresponding responsibilities.
6.1.1.5 Procedures, training and exercises.
Procedures, training and exercises: *• In the light of Fukushima, EPZ should evaluate the contents and frequency of the SAMG'es training program, taking into account the EDMG's and harsh circumstances, including amongst others:* *o Reduced accessibility of the site.* *o Reduced number of ERO staff.* *o Reduced availability of instrumentation.* *o Long duration of the accident.* *• Periodic exercises of SAMG'es are necessary to ensure maintenance of the*

capability and guidance usability.
6.1.2. Possibility to use existing equipment
6.1.2.1 Provisions to use mobile devices (availability of such devices, time to bring them on site and put them in operation)
Improvement of off-site and on-site mobile diesel: • *The on-site mobile diesel generator shall be independent from external support.* • *The connection equipment should be simple and easy to handle.* • *The number of connection points should be analyzed/improved (not under all circumstances available). It should be analyzed what measures are necessary to use them in case of flooding.*
Reload of batteries: • *EPZ shall evaluate alternative means to reload batteries.*
6.1.2.2 Provisions for and management of supplies (fuel for diesel generators, water, etc.)
Contracts for chemicals or fuel supply : • *EPZ should evaluate/periodically control the contracts for fuel, chemical and boron supply to cope with extreme emergency situations (e.g. flooding).*
Repair of equipment: • *EPZ should evaluate the access to the workshops and or warehouses of reserve equipment in case the site is flooded or otherwise limited (e.g. by earthquake or fire) and if necessary improve the protection of those locations/buildings and the equipment.*
6.1.2.3 Management of radioactive releases, provisions to limit them
Contaminated water: • *EPZ should analyze/evaluate the capacity of the storage tanks and the processing of contaminated water for long term severe emergency situations, taking into account that the water could be heavily contaminated, and develop a written strategy/procedure to deal with it.* • *EPZ should analyze for severe accident situations the locations where contaminated water could appear (in- or outside the controlled area) and determine the way to deal with it.*
Radioactive release filtering: • *EPZ should evaluate the strategies for severe emergency situations to limit the potential radioactive release through other buildings.*
6.1.2.4 Communication and information systems (internal and external).
Voice and data communication: • *EPZ should determine the minimum time that the equipment, listed on page 6-12, should function in case of total loss of power and improve, if it is necessary.* • *For the independent voice and data communication EPZ should determine the criteria when to take it into operation.*
6.1.3. Evaluation of factors that may impede accident management and respective contingencies
6.1.3.1 Extensive destruction of infrastructure or flooding around the installation that hinders access to the site
New Emergency Response Centre: • *EPZ should consider for the emergency response centre design to include*

amongst others: *o The storage of mobile equipment.* *o The storage important spare parts.* *o A workshop.* *o The storage of sufficient protective equipment for personnel, taking into account a long term radiological emergency situation.* *o The emergency control room function (backup).* *o The monitoring of important parameters.*
6.1.3.2 Loss of communication facilities / systems
6.1.3.3 Impairment of work performance due to high local dose rates, radioactive contamination and destruction of some facilities on site
Dose management: *• EPZ should provide a dose management strategy for a long term emergency situation*
6.1.3.4 Impact on the accessibility and habitability of the main and secondary control rooms, measures to be taken to avoid or manage this situation
Accessibility of local control and sampling points: *• EPZ should re-evaluate accessibility of local control and sampling points in case of prolonged flooding (new emergency response centre will not solve this problem).*
Calculated dose rates (table 6.2): *• Based on the lessons of Fukushima and R&D, EPZ should (re)evaluate the dose rate calculations for several representative scenario's, including the experience of Fukushima-Daiichi taking in to account amongst others:* *o Different time evolution of releases.* *o Severity of the incident (e.g. lost containment).*
6.1.3.5 Impact on the different premises used by the crisis teams or for which access would be necessary for management of the accident
6.1.3.6 Feasibility and effectiveness of accident management measures under the conditions of external hazards (earthquakes, floods)
Protection of equipment against severe external hazards: *• EPZ should identify all safety-critical structures, systems and components essential to providing defence in depth in a severe accident situation, and to propose measures to strengthen such SSC's to withstand events beyond the basis of the plant's design. Amongst others one could think of:* *o Upgrading of the safety classification of those SSC's.* *o Increased automation.* *o Increased protection and defence against the external hazard.*
6.1.3.7 Unavailability of power supply
6.1.3.8 Potential failure of instrumentation
Batteries and instrumentation *• EPZ should consider to create alternative/independent ways to reload the batteries* *• EPZ should (re)evaluate which (additional) instrumentation is necessary to monitor the situation in a severe accident case and if necessary improve the availability for the harsh circumstances* *• EPZ should show/analyze the procedure in case of complete loss of hydrogen measurement*
6.1.3.9 Potential effects from the other neighbouring installations at site, including

considerations of restricted availability of trained staff to deal with multi-unit, extended accidents.
Possible impact of Coal Fired Plant (CCB) • *EPZ should provide a comprehensive list of shared installations or services with CCB and the potential negative effects on the KCB-installation/organization during a severe accident*
6.1.4. Conclusion on the adequacy of organisational issues for accident management
6.1.5. Measures which can be envisaged to enhance accident management capabilities
The list of measures that can be envisaged to enhance accident management capabilities should be extended by the additional measures from this review and the ENSREG peer review process. *List of EDMG's:* • *EPZ should improve/provide a complete list.*
6.2. Accident management measures in place at the various stages of a scenario of loss of the core cooling function
6.2.1. Before occurrence of fuel damage in the reactor pressure vessel/a number of pressure tubes (including last resorts to prevent fuel damage)
6.2.2. After occurrence of fuel damage in the reactor pressure vessel/a number of pressure tubes
6.2.3. After failure of the reactor pressure vessel/a number of pressure tubes
6.3. Maintaining the containment integrity after occurrence of significant fuel damage (up to core meltdown) in the reactor core
6.3.1. Elimination of fuel damage / meltdown in high pressure
6.3.1.1 Design provisions
6.3.1.2 Operational provisions
6.3.2. Management of hydrogen risks inside the containment
6.3.2.1 Design provisions, including consideration of adequacy in view of hydrogen production rate and amount
H2-production from spent fuel pool: • *EPZ should provide additional information to prove that the H2-production of the fuel pool was considered in the design and allocation of the PAR's.*
Spray and Hydrogen production: • *EPZ should provide additional information on the use of the spray system in a severe accident if H2 is already present in the containment*
6.3.2.2 Operational provisions
Inertization of the containment: • *EPZ should provide additional information about the usefulness and effectiveness of Nitrogen injection from the accumulators.*
6.3.3. Prevention of overpressure of the containment
Venting system: • *EPZ should evaluate the necessity and possibility (including accessibility: e.g. radiation level too high) to replace the filtering material in case the system is used a long term during a severe accident.* • *EPZ should evaluate the vulnerability to combustion in the venting system and provide more information about the design (e.g. capacity of the filters, off-gas piping, yes or no separate pipe to the stack exit).*
6.3.3.1 Design provisions, including means to restrict radioactive releases if prevention of overpressure requires steam / gas relief from containment
6.3.3.2 Operational and organisational provisions
6.3.4. Prevention of re-criticality

Prevention of re-criticality: *• EPZ should present results of evaluation of the prevention of re-criticality during severe accident mitigation.*
6.3.4.1 Design provisions
6.3.4.2 Operational provisions
6.3.5. Prevention of base mat melting through
6.3.5.1 Potential design arrangements for retention of the corium in the pressure vessel
6.3.5.2 Potential arrangements to cool the corium inside the containment after reactor pressure vessel rupture
6.3.5.3 Cliff edge effects related to time delay between reactor shutdown and core meltdown
According to KFD the EPZ statement: "EOP's and SAMG's provide strategies to mitigate the accident for all possible scenario's" is questionable.
6.3.6. Need for and supply of electrical AC and DC power and compressed air to equipment used for protecting containment integrity
6.3.6.1 Design provisions
6.3.6.2 Operational provisions
6.3.7. Measuring and control instrumentation needed for protecting containment integrity
Batteries and instrumentation *• EPZ should consider to create alternative/independent ways to reload the batteries* *• EPZ should (re)evaluate which (additional) instrumentation is necessary to monitor the situation in a severe accident case and if necessary improve the availability for the harsh circumstances* *• EPZ should show/analyze the procedure in case of complete loss of hydrogen measurement*
6.3.8. Capability for severe accident management in case of simultaneous core melt/fuel damage accidents at different units on the same site
6.3.9. Conclusion on the adequacy of severe accident management systems for protection of containment integrity
6.3.10. Measures which can be envisaged to enhance capability to maintain containment integrity after occurrence of severe fuel damage
6.4. Accident management measures to restrict the radioactive releases
6.4.1. Radioactive releases after loss of containment integrity
Actions if the containment is lost: *• EPZ should develop severe accident management strategy/actions for the situation if the containment is lost (this paragraph deals mainly with the prevention). Additional equipment than the existing systems could be required in this case.*
6.4.1.1 Design provisions
6.4.1.2 Operational provisions
6.4.2. Accident management after uncovering of the top of fuel in the fuel pool
6.4.2.1 Hydrogen management
H2-production from spent fuel pool: *• EPZ should provide additional information to prove that the H2-production of the fuel pool was considered in the design and allocation of the PAR's.*
Spray and Hydrogen production: *• EPZ should provide additional information on the use of the spray system in*

a severe accident if H2 is already present in the containment
6.4.2.2 Providing adequate shielding against radiation
• *EPZ should develop severe accident management action for the situation of the complete loss of cooling water from the fuel pool (this paragraph deals with the prevention).*
6.4.2.3 Restricting releases after severe damage of spent fuel in the fuel storage pools
6.4.2.4 Instrumentation needed to monitor the spent fuel state and to manage the accident
6.4.2.5 Availability and habitability of the control room
6.4.3. Conclusion on the adequacy of measures to restrict the radioactive releases
See 6.4.1
Ad Annex 6.1 page 6-38: EPZ should evaluate the relocation or protection of the TL003 system.

7. Other extreme hazards
7.1. Introduction
7.2. Internal explosion
No specific attention is given to explosions on the NPP site but outside of the buildings
7.2.1 General description of the event
7.2.2 Potential consequences for the plant safety systems
7.3. External explosion
On page 7-8 is assumed that the buildings 33 and 35 could be destroyed by an external explosion. Nothing is said about the buildings 01 and 02. However in chapter 4 can be found that the resistances against blasts for the four buildings 01/02/33 and 35 are about equal
7.3.1 General description of the event
7.3.2 Potential consequences for the plant safety systems
7.4 Internal fire
No specific attention is given to internal fire cause by electric powered equipment. In general these kind of fire will lead to specific threads because of the nature of these fire. Effects as fire in cable ducts, short-circuits and availability of instrumentation should be taken into account
7.4.1 General description of the event
7.4.2 Potential consequences for the plant safety systems
7.5 External fire
7.5.1 General description of the event
7.5.2Potential consequences for the plant safety systems
7.6 Airplane crash
7.6.1 General description of the event
7.6.2 Potential consequences for the plant safety systems
7.7 Toxic gases
No measures seems to be considered give the fact that the emergency control room is not protected against toxic gases
7.7.1 General description of the event
7.7.2 Potential consequences for the plant safety systems
7.8 Large grid disturbances
7.8.1 General description of the event
7.8.2 Potential consequences for the plant safety systems
7.9 Failure of systems by introducing computer malware
7.9.1 General description of the event
7.9.2 Potential consequences for the plant safety systems
7.10 Internal flooding
7.10.1General description of the event
7.10.2Potential consequences for the plant safety systems
7.11 Blockage of cooling water inlet
7.11.1 General description of the event
7.11.2 Potential consequences for the plant safety systems