IMPACT OF THE FUKUSHIMA DAIICHI ACCIDENT ON THE NUCLEAR INSTALLATIONS IN PETTEN, THE NETHERLANDS

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P.J.M. Thijsen / M. Kater
NRG Nuclear Operations
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THE PETTEN SITE
APPROXIMATELY 1,400 EMPLOYEES
NUCLEAR FACILITIES

- HIGH FLUX REACTOR
- HOT CELL LABORATORIES
- MOLYBDENUM PRODUCTION FACILITY
  Mallinckrodt Medical B.V.
- DECONTAMINATION & WASTE TREATMENT
- RADIOLOGICAL LAB:
  JAAP GOEDKOOP LABORATORY
HOT CELL LABORATORIES HISTORY

1961: Building permit issued for construction of Hot Cell Laboratories

1964: Commissioning of HCL with opening by HRH Prince Bernard

1965: Waste Storage Facility in use

1996: Start of production of MO-99 for nuclear medicine

2013: Preventive shutdown of all nuclear facilities due to multiple reliability issues. Safety review of all installations and processes.

2014: All nuclear facilities are put back into operation, safer and more reliable.

2017: NRG is a global market leader in the production of radio-isotopes. Worldwide every day 30,000 patients are treated with medical isotopes from Petten.
Facts & Figures
1) Projected operations end date 2035, possible extension to 2045 related to HFR extended life time.

2) Isotope production: Rhenium, Yttrium, Erbium, Samarium, Aurum, Lutetium, Iridium, Molybdenum

3) Total production activity is approximately 550,000 TBq / year

4) Focus and mandatory improvements resulted in an asset improvement budget of ~80Mio€.
   - Ventilation System Renovation of the Hotlab
   - Manipulators renewal both manual & power driven.
   - Lead-glass windows replacement
   - Containment improvements
   - Criticality Control Improvement

5) Over 3000 transport postings between facilities.

6) Over 500 external road transports
HOT CELL LAB LAYOUT

Concrete cells
- Dismantling, NDE and radioisotope processing
- Dedicated for historic nuclear waste processing

Lead cells
- Alpha cell line, e.g. LM, SEM, EPMA, EBSD
- Mechanical and physical material characterization
- Boxed cells for chemical studies (dissolution, leaching)

Actinide lab, e.g. (MA-) fuel fabrication and characterization, fuel loading

Transport zone

Mo-99 facility
THE COMPLEMENTARY SAFETY MARGIN ASSESSMENT (CSA, STRESS TEST)

- Background
- Scope of the assessment
- Approach
- Highlighted examples of the results
- Lessons learned
BACKGROUND

- **European Council of March 24th and 25th 2011:**
  - ‘the safety of all EU nuclear plants should be reviewed, on the basis of a comprehensive and transparent risk assessment (“stress tests”)’
  - Primarily aimed at Nuclear power plants but nationally also applied to research reactors and other nuclear facilities

- **ENSREG (European nuclear safety regulators group):**
  - Broad technical scope of stress test
  - Extended on national level

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**Annex 1**

**EU “Stress tests” specifications**

*Introduction*

Considering the accident at the Fukushima nuclear power plant in Japan, the European Council of March 24th and 25th declared that “the safety of all EU nuclear plants should be reviewed, on the basis of a comprehensive and transparent risk assessment (“stress tests”), the European Nuclear Safety Regulatory Group (ENSREG) and the Commission are invited to develop as soon as possible the scope and modalities of these tests in a coordinated framework in the light of the lessons learned from the accident in Japan and with the full involvement of Member States, making full use of available expertise (notably from the Western European Nuclear Regulators Association); the assessments will be conducted by independent national authorities and through peer review; their outcome and any necessary subsequent measures that will be taken should be shared with the Commission and within ENSREG and should be made public; the European Council will assess initial findings by the end of 2011, on the basis of a report from the Commission.”
SCOPE OF THE ASSESSMENT

Installations
- All the NRG nuclear installations were assessed
  - Interference and dependencies between the installations

Hazards
- External hazards including man-made events
  - Credible (logical) combination of hazards

Output
- An evaluation of the response of the nuclear facilities when facing a set of extreme situations
- Determine additional (beyond design) safety margins (when feasible)
- Look for cliff-edges
- Findings & recommendations
ALL NRG NUCLEAR INSTALLATIONS IN-SCOPE
HAZARDS IN-SCOPE OF CSA

• Flooding (1953)
• Earthquake
• Severe weather
  o Extremely high wind (incl. storm and tornado)
  o Formation of ice
  o Heavy rainfall / snowfall
  o Lightning strike
  o Credible combinations of these events
• Man-made events.
  o Airplane crash
  o Internal / External explosion or fire
  o Grid disturbance
  o Cyber attacks
  o Toxic Gas attacks
The assessment considers three elements:

- Look for the provisions incorporated in the design basis to withstand extreme situations and determine the facility’s conformance to this design requirements.

- Evaluation of the design basis: to what extend does the installation withstand ‘by design’.

- Assessment of the margins ‘beyond design’:
  How far can the design envelope be stretched until accident management provisions (design and operational) can no longer prevent fuel damage and/or a radioactive release to the environment.
SEQUENTIAL LOSS OF THE LINES OF DEFENSE

Sequential loss of the lines of defense is assumed, in a deterministic approach, irrespective of the probability of this loss.

- initiating events,
- sequential loss of safety functions,
- severe accident management.

Logistic problems caused by national chaos included.
APPRAOCH & METHODOLOGY [3/3]
POSTULATED ACCIDENT SCENARIOS

- Use of Postulated Accident Scenario’s
- Availability of systems during the event
- Which paths lead to fuel damage and/or a radioactive material release
RESULTS

The assessment is reported in the Final Report “Complementary Safety Margin Assessment onderzoekslocatie Petten”.

Overall conclusion is that the nuclear installations of NRG:
- comply to all nuclear safety related license conditions (conformation)
- can withstand a variety of extreme weather conditions
- the safety performance needed improvement in a number of severe conditions

NRG identified 55 improvements grouped in categories (Total / Laboratories):
- Measures/hardware (18/2)
- Studies (22/2)
- Procedures (15/1)
**EARTHQUAKE**

Results:
- Area with low seismic activity
- Current DBE is **very conservative** (4 m/s²)
- Sufficient safety margins for the nuclear facilities (reactor & laboratories)

Improvements:
- Seismic instrumentation in the HFR
- Site specific Design Base Earthquake
- Characterization of the soil behavior
- Extension of seismic characterization of installations and systems [like ventilation and fire extinguisher system]

Red = natural earthquake
Bleu = man induced earthquake
Yellow = urban areas
# ASSUMPTIONS DESIGN BASED EARTHQUAKE (DBE) OLP-SITE

<table>
<thead>
<tr>
<th><strong>year</strong></th>
<th><strong>observation</strong></th>
<th><strong>DBE HFR-site</strong></th>
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</thead>
<tbody>
<tr>
<td>1986</td>
<td>Seismometer network introduced in the north of The Netherlands.</td>
<td></td>
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<tr>
<td>1994</td>
<td>Gas induced earthquakes observed in the Bergermeer area.</td>
<td>First seismic response analyses HFR and MPF. DBE based on NRC100; PGA 1.0 m/s².</td>
</tr>
<tr>
<td>1998</td>
<td>KNMI concludes maximum possible horizontal PGA of gas induced earthquake is likely 4.0 m/s². Until 2008 the following earthquakes are observed in the Bergermeer area:</td>
<td>DBE for HFR-site and OLP-site based on:</td>
</tr>
</tbody>
</table>

- Epicenter gas induced earthquakes on top of gas field.
- Distance Bergermeer – OLP-site 20 km. PGA OLP-site approx. 10% of PGA at epicenter.

<table>
<thead>
<tr>
<th>Date</th>
<th>Richter</th>
<th>Mercalli</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/8/1994</td>
<td>3.0</td>
<td>4.5</td>
</tr>
<tr>
<td>21/9/1994</td>
<td>3.2</td>
<td>5</td>
</tr>
<tr>
<td>9/9/01</td>
<td>3.5</td>
<td>6</td>
</tr>
<tr>
<td>10/9/01</td>
<td>3.2</td>
<td>5</td>
</tr>
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![Diagram](image)

- KTA 2002 for natural earthquake.
- KNMI estimate for non-natural (gas-induced) earthquake.
- Vertical PGA = 2/3 Horizontal PGA.

**Peak Ground Acceleration [m/s²]**

**Horizontal PGA**

**Frequency [Hz]**
FLOODING

Results
- No design base for flooding
- Highest tidal wave 4.65 m NAP (dunes are 8-16 m high)
- Laboratory at 4.7 m NAP ("island in hinterland")
- Emergency Power Supply building at 4.1 m NAP
- Leads to LOOP and possibly SBO

Improvements
- Study of leak tightness of some buildings
- Leak detection systems
- Anchoring of components (storage tanks)
- Installation of external power connections
LOSS OF SAFETY FUNCTIONS

Results
LOOP:
3 EP generators 37 up to 89 hours with alternative load scheduling

Improvements:
Increase availability (Emergency) Power Supply:
- Load scheduling and increase of available diesel in storage (now > 100 hours at peak power demand)
- Auxiliary (mobile) generators including connections to the installations
- Increase capacity of backup batteries for monitoring systems (RMS in place)
SEVERE ACCIDENT MANAGEMENT

Results
- Emergency Response Organization is been completely new designed & implemented

Improvements
- Autonomy (72h) of equipment and personnel
- Additional emergency decontamination facilities
- Update of the Function Recovery Procedures
EXTREME WEATHER CONDITIONS

Results:
- Analysis based on regulations of 1950/1960
- Most installations have no design basis
- Building drawing incomplete
- Margin load due to snow
- No margin [possible] for rain and wind

Improvements:
- Preventive shutdown procedures for extreme weather conditions

Additional studies on:
- Building construction data
- Weather conditions
- Snow and rainfall
LESSONS LEARNED

- Installations have a robust design
  - Comply with license
  - Are able to withstand severe conditions, beyond license requirements
  - Regard to earthquake additional hardware measures have been implemented

- Emergency preparedness had to be improved, is now state-of-the-art

- Weaknesses regarding flooding have been analyzed
  - Floating of waste tanks in basement, no actions needed;
  - Emergency power supply capacity has been increased, installed at a appropriate height above sea level

- Robustness regarding man-made events is increased (improved security)
CONCLUSION

The Fukushima Daiichi(1F) accident has had a worldwide impact. In the Netherlands Complementary Safety Margin Assessments were carried out for all nuclear facilities in order to find opportunities to increase in the robustness of the facilities to extreme situations, beyond their existing safety margins.

NRG has carried out a comprehensive improvement program involving amongst others cliff-edge evaluations of the impact of seismic activity, flooding and extreme weather conditions. These evaluations resulted in proposed measures that have been implemented.
THANK YOU FOR YOUR ATTENTION