Strål säkerhets myndigheten
Swedish Radiation Safety Authority

Important Research to Identify Robustness Against External Events

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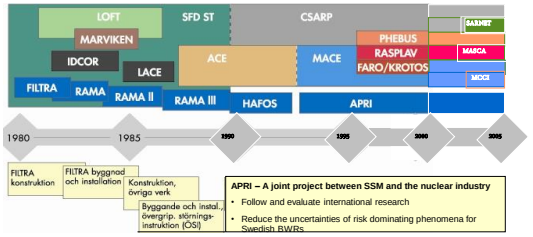
Requirements from the government after TMI

- … the requirements can be fulfilled if the release is less than **0.1% of the core inventory of the Cs-134 and Cs-137** contained in a reactor core of 1800 MW thermal power, assuming that other nuclides of significance in regard of land contamination are released to lesser or, at most, equal extent.
- The limit is well below 200 TBq.

Beyond-design accidents (sequences)

- Total loss of all AC power (Station Black-out)
- LOCA in combination with degraded PS-function (leakage in the diaphragm floor between drywell and wetwell)

Severe accident research during 3 decades



APRI – A joint project between SSM and the nuclear industry

- Follow and evaluate international research
- Reduce the uncertainties of risk dominating phenomena for Swedish BWRs

SA research and development

- One of the requirements after installation of SA mitigating measures was to:
  - … continuously follow and evaluate the international research and development

  and
  - draw conclusions of which additional measures that could be implemented to increase the safety as consequence of the increased knowledge level.

SA research and development

- To fulfill the requirement above, the research and development within SA area has been conducted mainly through a **joint project** between SSM and the nuclear industry.
- The focus of the project is on risk dominating phenomena in severe accidents.
- The name of the project is **APRI** which stands for **Accident Phenomena of Risk Importance**.

APRI – Accident Phenomea of Risk Importance

- The objective is
  - to create a common platform and knowledge base concerning phenomena and accident progression
  - to provide basis for modifications to improve the plants ability to resist severe accidents,
  - to provide basis to impove routines and instructions for accident management,
  - to reduce the uncertainties of risk dominant accident phenomena mainly for Swedish BWRs.

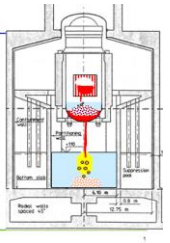
How to achieve the objectives?

- Participation and evaluation of the international research within SA
- Studies on risk dominant phenomena in Swedish BWRs, e.g. steam explosions, in-vessel and ex-vessel coolability (Royal Institute of Technology, KTH, Stockholm)
- Studies on severe accident chemistry (Chalmers University of Technology, Göteborg)

The on-going APRI-project (2012-2014)

The focus

- In-vessel corium coolability
- Ex-vessel corium coolability
- Steam explosion energetics
- Iodine chemistry during severe accidents



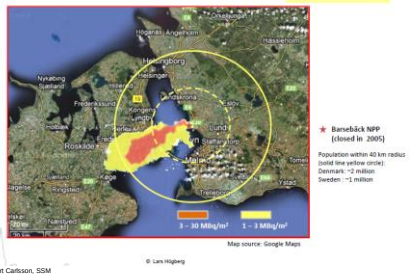
Swedish actions after Fukushima and EU stress tests

- Safety upgrades (and power upgrades) continue based on periodic safety reviews: redundancy, diversity, separation
- Reassessment of capability to cope with exreme natural events (seismic, flooding, weather)
- Reassessment of I&C response to extreme voltage transients
  - Continuation of work started after Forsmark and other incidents

Swedish actions after Fukushima and EU stress tests (cont.)

- Separate ”last resort” feedwater and emergency power train considered
  - Totally independent and possibly bunkered, also for security reasons
- Upgrading existing severe accident management capabilities:
  - Long-time endurance (>>24h). Simultaneous failures at several reactors.
- Reassessment of fuel pool cooling capabilities

Justification: Hypothetical impact of a 10 000 TBq Cs-137 release (~ Fukushima) from Barsebäck



Justification: Hypothetical impact of a 100 TBq Cs-137 release ("FILTRA-type") from Barsebäck

SOARCA 2012:
Peach Bottom SBO unmitigated:
~7 500 TBq Cs-137

★ Barsebäck NPP (closed in 2005)

Population within 40 km radius (solid line yellow circle):
Denmark: ~2 million
Sweden : ~1 million

Map source: Google Maps

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My conclusions: Robust protection against socio-economic impacts intolerable to both society and industry is justified

ACCIDENT	TYPE	RELEASE OF Cs-137 (TBq)	EVACUATED	ESTIMATED COSTS million US$
Three Mile Island 1979	Core melt	<< 1	Voluntary short-term evacuation of nearby communities	~6 500
Tjernobyl 1986	Runaway fission process destroying the reactor	85 000	>300 000 relocated	250 000 - 500 000
Fukushima 2011	Three cores severely damaged, probably melted	12 000	~150 000 evacuated, prospects to return still unclear after 20 months	100 000 - 500 000
Present Swedish release mitigation objective for station blackout sequence	Core melt	<150	Precautionary short term evacuation in the vicinity of the plant?	< 20 000 ?

A New Nuclear Safety Construct should include a call for severe accident management preparedness based on Best Available Technology (BAT) with the objective to
- *reach a stable state with preserved containment integrity without undue delay, and*
- *keep releases of radionuclides that cause long-term land contamination below the equivalent of about 100 TBq Cs-137 in case of a core melt.*

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