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Vulnerability of the EPR to Fukushima-like accident

The French nuclear giant Areva has been making the most out of the Fukushima accident, with the CEO Anne Lauvergeon suggesting less than a week after the tsunami that the unfolding nuclear disaster was an argument for Areva reactors. Since then, the company's top executives have been touring the world, turning the accident into a sales pitch of the company's flagship nuclear design, the EPR:

> ***"Had the reactor in Fukushima been an EPR, it would have survived"***
>
> *Areva Chief Technical Officer Alex Marincic (Reuters Apr 19, 2011)*

> ***"There would have been no radiation leaks into the environment at (…) Fukushima had the reactors been designed using Areva's EPR technology."***
>
> *Areva CEO Anne Lauvergeon (Dow Jones Mar 16, 2011)*

To gauge the plausibility of these claims, Greenpeace commissioned a report from Austrian nuclear expert, Dr. Helmut Hirsch. The actual precautions designed into the Areva EPR reactor are much less impressive than the company would have us believe.

Greenpeace summary of the report by Dr. Hirsch[1]

What caused the Fukushima accident?

The immediate cause of the accident was obviously the East Japan earthquake and the massive tsunami it triggered. However, the reactors did not fail because of mechanical damage from the natural disaster, but because the earthquake cut the reactors off the electricity grid and the tsunami disabled the emergency diesel generators.

All nuclear reactors rely on electricity to power their emergency systems. Once the reactors had no power to run emergency cooling systems, the heat generated by the nuclear fuel started to build up and things spiralled out of control. The key lesson from Fukushima, therefore, is the vulnerability of reactors to loss of power supply to essential emergency systems.

What happens to the EPR if offsite power & primary emergency diesels are lost?

From the review by Dr. Hirsch, it is clear that the architects of the EPR failed to systematically design against a sustained loss of power to cooling systems. In addition to main emergency diesels, the EPR has two additional back-up generators, but they are insufficient to power many of the systems needed to bring the reactor to safe cold shutdown. The entire design is built on the assumption that either grid power or primary diesel generators can be restored within 24 hours, while in Fukushima the blackout lasted for 11 days. If faced with a situation similar to Fukushima, the operators of an EPR would have:

1 Dr. Helmut Hirsch in collaboration with A.Y. Indradiningrat and T. Wenisch: *Selected Aspects of the EPR Design in the Light of the Fukushima Accident.* Report for Greenpeace International.

- no ability to cool water in reactor below 100oC and achieve stable shutdown.
- no power to pump water into reactor coolant system. This would be critical if the reactor cooling system starts leaking or water level drops because of lack of cooling, and cooling via the steam generators fails.
- no operable boron injection system (boron is needed to keep the nuclear chain reaction from restarting)
- no power to cool spent fuel pool (in the basic design and the US EPR).
- no hydrogen recombiners or igniters in fuel building to prevent explosions.

A worst-case scenario for the EPR would be the loss of grid power and main diesel generators while the water level in reactor cooling system has been lowered for maintenance (known as “mid-loop” condition). According to the basic design report of the EPR, this will always lead to a core melt accident.

In addition, the documents reviewed by Dr. Hirsch had no indication that detailed plans and measures to control the reactor and the spent fuel pool in case of a sustained blackout have been prepared.

What changes were made to the EPR compared to its predecessors?

Areva has been so complacent about the risk of station blackout that it has actually weakened the precautions compared to the 30-year-old Konvoi design, which is a direct predecessor of the EPR. The number and capacity of back-up systems in the EPR has been reduced compared to the second generation reactor. The changes made incllude:

- Reduced number of back-up generators.
- Back-up diesel generators have to be started manually, potentially increasing the risk of operator error.
- Reduced number of safety systems and functions that can be powered by back-up diesel generators. Unlike in Konvoi, the EPR secondary diesels cannot power:
    - cooling of water in reactor below 100oC to achieve stable cold shutdown
    - injection of water into the reactor coolant system
    - boron injection into the reactor coolant system
    - spent fuel cooling (in the basic design and the US EPR)
- Omitted aircraft-proofing of diesel generator building (there are two separate buildings but neither is aircraft-proof)
- Removed a back-up cooling system for the spent fuel pool (in the basic design and the US EPR)

About the author

Dr. Helmut Hirsch has more than 30 years of experience as nuclear expert. He has been working for the Austrian Federal Government as well as for German state governments and municipal administrations. He is a member of the Austrian Environment Ministry's Nuclear Advisory Board since 1990. Recent work includes technical support for the Austrian monitoring process of the Czech Temelín nuclear power plant and work, as principal investigator for the Austrian Environment Ministry, on the safety of the Isar-1 NPP in Germany. He is member of European working groups on reactor safety.

Background: What can cause a station blackout?

The EPR is being planned in earthquake-prone areas, e.g. Jaitapur in India, and sold as earthquake-proof. Even more importantly, there are many other events besides earthquakes that can cause a station blackout. Emergency diesel generators are often poorly maintained – when grid power is lost, they can fail to start without any external reason. Terrorist acts could also destroy the buildings housing the generators, especially as the diesels in an EPR are not designed to withstand an aircraft crash.

Examples of emergency generator failures

Fukushima was not the only Japanese station where emergency diesels did not work as expected after the East Japan earthquake. Two out of three back-up diesels malfunctioned also at the Tokai 2 reactor[2] and one out of two failed at Onagawa 1[3]. At Higashidori nuclear plant, an April 7 aftershock cut off grid power. Two out of three back-up generators were not operable at the time but the third one started. On April 8, after power had been restored, the third generator started leaking fuel and shut down, leaving the plant completely without backup power[4].

The most severe recent incident happened in Forsmark, Sweden, in 2006. All four back-up diesels of the plant shared a design fault that caused two of them to fail to start when grid power was lost. It appears that a complete station blackout was avoided only due to luck – all four generators could have failed to start. In this case, no cooling of reactor and spent fuel would have been available.[5]

Other European plants where inoperable diesel generators have been found during inspections include Philippsburg in Germany in 2002 and 2004 as well as Tihange in Belgium in 2005.[6]

The US Nuclear Regulatory Commission has repeatedly criticized nuclear operators for failing to maintain the reactors' emergency diesels operable. In September 2009, the Brunswick nuclear station in US was shut down after workers had been attempting to fix an emergency diesel for seven days without success[7]. A review of US Nuclear Regulatory Commission documents submitted by Congressman Edward Markey summarized[8]:

> ***"There have been recurrent prolonged malfunctions of emergency diesel generators at nuclear power plants in the U.S. In the past eight years there have been at least 69 reports of emergency diesel generator inoperability at 33 nuclear power plants. A total of 48 reactors were affected, including 19 failures lasting over two weeks and 6 that lasted longer than a month."***

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2 http://www.guardian.co.uk/world/2011/mar/13/japan-nuclear-plants-fukushima-earthquake

3 NISA/METI April 8, 2011: Failure of emergency diesel generator-A at Unit-1. http://www2.jnes.go.jp/atom-db/en/trouble/individ/power/e/e20110408/index.html

4 Mainichi Apr 9, 2011: Major aftershock highlights fragility of nuclear power plants.

5 http://www.analys.se/lankar/Engelsk/Publications/Bkgr1-07%20Forsmark%20Eng.pdf AND http://www.ippnw-europe.org/commonFiles/pdfs/Verein/Speech_Lars_Hoeglund.pdf

6 Greenpeace: 365 reasons to oppose nuclear power. http://www.greenpeace.org/international/en/publications/reports/nuclearaccidentscalendar/

7 StarNews Sept 21, 2009. http://www.starnewsonline.com/article/20090921/articles/909219948?tc=ar

8 Fukushima Fallout: Regulatory Loopholes at U.S. Nuclear Plants. Prepared by the staff of Congressman Edward J. Markey (D-MA). May 12, 2011.