New Generations: The advanced boiling water reactor

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After the 1979 Harrisburg (US) accident the nuclear industry faced a serious decline in selling nuclear power plants. The 1986 Chernobyl disaster made it even worse, several countries decided not to build any new nuclear power plant. Since the early eighties, industry has started with the development of so-called inherently safe reactors.

(487.4833) Laka Foundation - The Advanced Boiling Water Reactor (ABWR) was one of the first reactors being mentioned as a new-generation reactor. New engineering concepts were used to improve safety and it was a follow-up of earlier General Electric (GE) boiling water reactors. The first design work for the 1,350-MW ABWR already started in 1975. That was four years before the catastrophe in Harrisburg, after which more and more nuclear companies started desperately to develop an ultimately safe, inherently safe, reactor. The consortium that started the development of the ABWR consisted of GE (US), Ansaldo (Italy), Asea-Atom (Sweden), the Hitachi and Toshiba (Japan), and some other smaller companies.

Safety

The differences between an ABWR and the earlier GE BWRs are small. Main risk with any reactor is a loss of coolant followed by a melt down of the reactor core by overheating. One possibility of losing cooling water is the breaking of pipes of the cooling circuit. In earlier BWRs there were small pumps outside the reactor vessel with pipes connected to it for the transport of hot water at the reactor top to the bottom of it. This system was meant to mix more hot and more cool water in the reactor. In the ABWR, 10 of these internal circulation pumps are now located inside the reactor vessel. This would reduce the risk of ruptures at the vessel connections. However, the placing of the pumps inside the vessel increases the exposure to intensive internal neutron radiation.

The reactor itself is situated low in the contaimment structure to reduce earthquake damage. Emergency cooling systems would be simpler and of new developments. However, they remain active systems, which keeps them dependent on electrical power and therefore subject to electrical failing risks. When the emergency cooling system is activated, cold water will be pumped into the reactor. When cold water reaches the overheated uranium fuel, the reactivity will be increased, rapidly leading to the production of more heat and the possible meltdown of the fuel.

The containment of the ABWR is equipped with a so-called overpressure relief device. In case of a serious accident in the reactor, large amounts of radioactive steam are released from the reactor. The high-explosive hydrogen gas is formed that can explode when it contacts the oxygen in the containment building. This is followed by a huge pressure on the containment building. To prevent the breaking of the containment building, the overpressure relief device is built in. Gas will escape from the reactor building, reducing the pressure on the containment. But of course this gas is contaminated by radioactive isotopes from the reactor and will be released freely into the environment.

Besides smaller improvements to safety the reactor can never be protected against external accidents like a crashing airplane or explosions. In such a case great damage could be done to the reactor, leading to the release of radioactivity.

US certification

In January 1997 the ABWR was one of the first reactor designs in the United States that got the final design certification from the US Nuclear Regulatory Commission (NRC). This certification was meant to give the reactor a kind of overall-safety approval. For the US, this meant that when a utility is planning to build such a reactor, no consultation is possible for citizens on general safety issues. Only site-specific issues can be brought in at the licencee procedure. The bringing up of general safety issues or shortcomings was to be done at hearings before the certification. But according to NIRS, that process was too stacked against those willing, and the issues were too complicated and abstract. As no utility in the US is planning to build a reactor, it is expected that certification would be used for export reasons. In this way GE hopes to make the process of building the ABWR in other countries much easier.

Japan

As the Japanese companies Hitachi and Toshiba are main partners in the development of the ABWR (and the market for the US failed), it was decided to build the first ABWRs in Japan at the now world’s largest nuclear power station in Kashiwazaki-Kariwa. The first five reactors were of the GE BWR-5 type. The construction of the sixth unit, an ABWR, was started in 1991. The 1356-MW Kashiwazaki-6 was first critical in December 1995 and cost 430 billion Yen (3.3 billion). In a February 1996 incident, the reactor was shut down after a pump stopped functioning. Some months later, on August 24, the reactor was shut down when high concentrations of radioactive iodine were found in the coolant water, up to 500 times the normal value.
In December 1996 the Kashiwazaki-7 ABWR went critical. The opening of the seventh reactor and the fact that the station reached the status of the þworld’s largestþ, was reason for local officials to give more attention to the raising amount of radioactive spent fuel being stored at the complex. They fear becoming a nuclear waste dump permanently as a planned storage facility in the northern Aomori region faces problems due to accidents at other nuclear sites. But the local officials also said they were not willing to force the citizens of the Aomori region to accept the waste if they are not willing to. In July 1997, two to three liters of radioactive steam escaped from the Kashiwazaki-7 reactor into the air.
However, Japan was planning to build some more 15 ABWRs it can be doubted whether these plans would ever be realized. The nuclear industry is in deep crisis after several accidents and authority failures the last years.

Conclusions

The ABWR was said to be the first advanced boiling water reactor to be operated. However, the differences with the older BWRs are so small that such a classification may be only for propagandistic reasons. There are several elements in the design that still pose a threat to safety, like the possibility of failing emergency systems, the possibility of a reactor excursion when adding cold water, influences from outside, etc. Future prospects are unsure as only ABWR are being planned in Japan. But this country faces an uncertain nuclear future. For other countries it is likely, when they are planning new reactors anyway, they would choose for more recent developed reactor types.

Sources:

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