Fukushima-Daiichi accident and nuclear safety enhancement: IRSN's contribution

IRSN FACT SHEETS

March 2021
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The situation in Japan

- March 11, 2011
  - A magnitude 9.0 earthquake triggered the emergency shutdown of three reactors at the Fukushima-Daiichi power plant and led to the loss of external power supplies. The plant was then powered by emergency generators. The tidal wave following the earthquake destroyed the power plant's cooling water pumping station and led, in particular, to the loss of the emergency generators, depriving the facility of all power supply.
  - The successive loss of the cooling systems of the first three reactors resulted in core meltdown between March 11 and 14, and several hydrogen explosions damaged the reactor buildings. Massive releases of radioactive products into the atmosphere and marine environment occurred, requiring evacuation of the population within a radius of 20 km from the site.
- Ten years after the accident
  - In industrial terms, Tokyo Electric Power Company (Tepco), the plant's operator, stabilized the situation of the facilities but is still managing the consequences of the accident. Decommissioning operations will last between 30 and 40 years. The nuclear fuel must be removed from storage pools and damaged reactors beforehand. In the short term, Tepco must manage 1.2 million m^3 of contaminated water, which increases by 54,000 m^3 per year and will exceed the site's storage capacity in 2022.
  - In environmental terms, the management of 20 million m^3 of waste linked to the rehabilitation of areas contaminated by radioactivity is another challenge. Stored in various locations in the prefecture, it will be transported to a centralized warehouse, the ISF, sized for 30 years of operation.
  - In terms of health, the population of Fukushima Prefecture continue to be monitored by medical services. Their exposure was limited; the first studies carried out do not show any increase in thyroid cancer in children present in the prefecture during the nuclear accident in 2011.
  - In terms of land management, regarding the population's return to areas where the evacuation order has been lifted, the situation is very disparate depending on the municipality concerned, ranging from 0% to 75% but with an average of 22% for the "special decontamination area".

Lessons learned in France for nuclear power plants

The Fukushima-Daiichi accident demonstrated that a nuclear power plant could be exposed to external loads (earthquake, tsunami, etc.) at a level higher than that taken into account in its design. This observation led the French public authorities to request complementary safety assessments of the nuclear facilities.

IRSN, a public expert in nuclear safety and radiation protection, analyzed the results of these safety assessments, in France, and their European equivalent, called 'stress tests'. Drawing upon this analysis, the Institute recommended that the ASN equip nuclear facilities **with a "hard core" of material, human, and organizational resources aimed at, for EDF plants, preventing core meltdowns in the event of an "extreme" natural event and limiting the consequences should a meltdown still occur.**

IRSN's contribution to enhancing nuclear facility safety

- Facility safety is first and foremost based on the compliance of its equipment with its safety standard. As part of the ten-year nuclear safety assessment of the facilities and the consideration of the feedback from the accident of March 11, 2011, IRSN continues performing numerous assessments on this subject.
- As part of these safety assessments, IRSN recommended the implementation of additional safety resources constituting a "hard core" (see diagram below), operational in the event of an extreme external loads. The Institute assessed the levels of natural events to be taken into account, as well as the resources of the hard core. For EDF plants, in particular, it ensured the completeness of the resources implemented to avoid core meltdowns and to limit its consequences in the environment, should one occur. In particular, IRSN relies on its calculation tools and the lessons learned from its research programs. These resources will be gradually deployed on the nuclear fleet. In addition to these fixed resources, there are mobile resources on site as well as those of the Nuclear Rapid Response Force (FARN), which is tasked with taking over the "hard core" within 24 hours in the event of an accident.

Post-Fukushima measurements in figures

Phase 1
Short-term modifications and reinforcements of mobile resources, implementation of the FARN (nuclear rapid response force): **phase completed.**

Phase 2
• Emergency diesel generators (**56** completed out of **56** planned)
• Emergency water sources (**7** completed out of **56** planned, others planned for end-2021)
• Reinforced local crisis centers (**1** currently in service in Flamanville, the other **17** will be entered into service between 2022 and 2026)

Phase 3
Full-scale long-term improvements as part of the fourth ten-yearly inspections of the 900 and 1,300 MWe reactors, currently in place at Tricastin 1 and Bugey 2.

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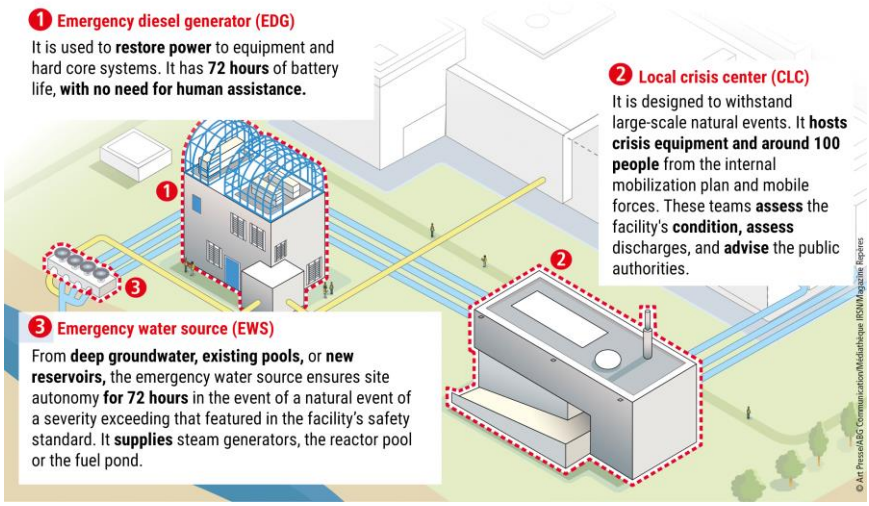
As a public expert, IRSN advances scientific knowledge to manage all nuclear and radiation risks. Through its research, methods, and interactions with all stakeholders, IRSN assesses these risks and their consequences independently. It thus contributes to their prevention, detection, and the limitation of their possible effects, in order to protect the population and the environment.

- With regard to the other civil nuclear facilities, IRSN examined the means proposed by the operators, in particular the definition of the hard core and the new crisis centers, and carried out assessments on the organization of the national task force (FINA).

The three main objectives of the "hard core"

- Prevent an accident with core meltdown
- Limit emissions in case of core meltdown
- Allow the operator to manage the crisis.



Interactions with society

- For several years, the International Commission on Radiological Protection (ICRP) engaged in dialog with the Fukushima prefecture's population, while IRSN carried out various actions with local stakeholders, notably under European projects devoted to the management of post-accident situations, such as SHAMISEN, TERRITORIES, or the French-Japanese SHINRAI project. Analysis of the results demonstrates the importance of the involvement of the various segments of society (citizens, elected representatives, associations and professionals, etc.) in decisions impacting their daily lives (environmental and individual radiation monitoring, health monitoring, socio-economic aspects, etc.) and the implementation of dialog mechanisms between the various stakeholders.
- The lessons learned highlight the complexity of situations and the need to empower citizens to make their choices, for example by encouraging radiation measurement initiatives or by developing the sharing of assessments. With this in mind, IRSN developed the OpenRadiation project, allowing access to and the sharing of the citizen measurements of radiation in the environment or the OPAL mapping tool aimed at raising local stakeholders' awareness of post-accident management.

IRSN's contribution to research on nuclear safety and radiation protection

Following the Fukushima-Daiichi accident, the public authorities launched a call for projects in 2012 on "Research on nuclear safety and radiation protection" (RSNR) financed by the French National Research Agency (ANR). Several research projects have been undertaken by IRSN in this context.

- Nuclear safety research: the Institute has notably managed research projects relating to the risks of dewatering of spent fuel pools (DENOPI project), the improvement of the governance of organizations and networks of nuclear safety stakeholders (AGORAS project), the knowledge of the risk of hydrogen explosions and its management (MITHYGENE project), and the limitation of releases to the environment in the event of a serious accident (MIRE project).
- Radiation protection research: France has conducted particularly active research in this field, benefiting from significant public support as part of the RSNR call for projects. The programs concerned focused mainly on chronic exposure to and contamination with radionuclides, such as caesium 137 or iodine 129. This is the case for programs, such as AMORAD (which aims to optimize the models for predicting the dispersion of radionuclides in the environment and assessing their impact), DEMETERRE (study of phytoremediation techniques for soils contaminated with radioelements), or PRIODAC (repeated prophylaxis with stable iodine in an accidental situation).
- Economic studies: IRSN conducts studies aimed at assessing the economic consequences of a nuclear accident. Created in 2012 by the Institute, the purpose of ARPAGON software is to provide public authorities, at the end of the emergency phase, with options for the management of contaminated areas, including costing. In particular, the costs of accidents and their prevention can be considered.
- Sociological studies: the French-Japanese research project SHINRAI studied the decision-making methods of the authorities in a post-accident context and their impact on the population, with a particular focus on the methods of involving citizens in these decisions. The project allowed a number of assumptions, on which the post-accident policy defined by the institutions was based, to be compared with the actual experience of the Fukushima-Daiichi accident and to learn from it.

Find out more

• On IRSN research programs:

https://en.irsn.fr/research• On the situations covered in "Fukushima, ten years on":

www.irsn.fr/Avis-2021-1

• On the French-Japanese research project SHINRAI:

https://en.irsn.fr/news/irsn-publishes-study-social-consequences-311-nuclear-accident-fukushima-prefecture• On the initiative of dialog with the population of the Fukushima prefecture: