NORTHERN ARIZONA UNIVERSITY
Department of Mechanical Engineering

ME 476C Mechanical Engineering Design 1

Icebreaker Project

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Introduction:

The Fukushima Daiichi nuclear disaster happened in Fukushima nuclear plant in Japan. It was caused by the Tōhoku earthquake and tsunami on March 11, 2011. The earthquake shut down the emergency generators which led to the subsequent failure of the coolant system for the nuclear reactors. The following tsunami flooded the basement in which the emergency generators were placed, which caused the equipment failure. Without the coolant system, the nuclear reactor started overheating and melting down. After the shell of the reactor became damaged, the radioactive materials started leaking out, which is still occurring to this day. The Fukushima nuclear disaster has been considered as the largest disaster since the Chernobyl disaster of 1986. Thousands of people who lived near the plant were evacuated. An increase in radiation has been detected by the countries around the Pacific Ocean. Currently in Japan, the underground water is contaminated by the radiation. The second largest nuclear accident in the history of the world has and will continue to have an impact on the people of Japan.

Chain of Events:

On March 11, 2011 the Tohoku earthquake hit off the east coast of Japan. Reactors 4, 5 and 6 had been shut down for inspection, unfortunately reactors 1, 2 and 3 were operating when the earthquake hit. Immediately after the earthquake reactors 1, 2 and 3 were shutdown. Without power being supplied from the reactors the emergency diesel generators kicked in. After the earthquake hit there was a tsunami approximately 13 meters in height. Fukushima power plant had only designed a 5.7 meter tall seawall to block tidal waves which was insufficient. The water flooded the basement were the emergency diesel generators were stored. The flooding effectively disabled the generators and the cooling pumps of reactors 3 of 4 went out. This caused the active reactors 1, 2 and 3 to overheat; this overheating reacted with the water and Zircaloy creating hydrogen gas. On March 12 the hydrogen ignited causing a powerful explosion at Reactor 1. Two days later a second explosion occurred at Reactor 3 followed by a third and final explosion on March 15th.

After the accident officials advised people within 20-30 km to stay indoors. The estimates for the total amount of radioactive material dispersed into the air from the Fukushima disaster was 520 PBq, which is about 11% of the amount that came from the Chernobyl disaster. Roughly 18.1 PBq of radiation leaked into the ocean. Since Fukushima lies along a coast with a strong current the radioactive material is expected to spread to a much greater radius than ever seen before.

Design Flaws:

There were many contributors that eventually led to the Fukushima Nuclear Disaster. According to, The Wall Street Journal, there is a particular design flaw that essentially led to the Fukushima Nuclear Disaster.

It was known that some senior engineers at Tokyo Electric Power Company knew that the five nuclear reactors had a potentially dangerous design flaw. The nuclear power plant in Fukushima, Japan was in the middle of its full upgrade. TEPCO had not completed its full upgrade to all of its nuclear reactors before the tsunami hit. The upgrade to the power plant consisted of moving the backup diesel generators and electrical switches into the more heavily fortified reactor building.

When the tsunami hit the power plant, four of the six nuclear reactors failed because seawater breached the lightly protected turbine buildings. When the seawater entered the building and flooded the switches, the cooling system failed. After the cooling system failed, radioactive fuel melted down the reactors and created explosions which led to the largest radiation release in history.

The design of the Fukushima Nuclear plant was made in the 1970s. Since then, there had been many chances to fully upgrade the design, but no actions were made. “The company, known as TEPCO, had opportunities over the decades to retrofit the oldest reactors. They blame a combination of complacency, cost-cutting pressures and lax regulation for the failure to do so” (Shirouzu & Dawson).

Reactions:

1.) On March 11, 2011 the Japanese government was in a nuclear emergency. The nuclear emergency was due to earthquakes that caused a 15 meter high Tsunami.
2.) The nuclear reactors were automatically shut down due to the Earthquake but the reactors were exposed to the Tsunami.
3.) The event was rated 7 out 7 on the International Nuclear Event Scale. Level 7 is major accident, resulting in a large release of radioactive material with dangerous effects on human health and the environment.
4.) 100,000 people were evacuated from their homes to prevent deaths or sickness from the radiation. There have been no recorded deaths or illness but the government is still delaying the return of the residents.
5.) It took over two weeks for Japan to make the three reactors 1, 2, 3 stable by cooling them with sea water.
6.) Nearly 6 months after the Tsunami, Fukushima was being cooled with recycled water and the temperatures had dropped to about 80 ^{0}C. Not until mid-December, was the facility classified as cold shutdown.

Suggestions for Prevention of Nuclear Meltdowns:

The largest reason for the Fukushima Daiichi Nuclear Power Plant disaster was the failure of the emergency generators and the subsequent failure of the cooling systems for the reactors. The failure of the emergency generators could have been avoided by moving away from the coast and areas that are known for seismic activity.

- High quality design, material selection, and construction.
- Equipment which prevents operation disturbances and human error.
- Monitoring and testing to detect equipment failure.
- Redundant safety measures and containment systems.
- Ability to confine damage to individual systems, sections, and reactors.

Containment Methods:

- Lead sarcophagus around the reactors like Chernobyl.
- Ice Wall around the reactors that would stop ground water contamination.

Conclusion:

The Fukushima nuclear disaster was started by a natural disaster. The human factor also played an important role in the occurrence of this accident. The Lack of necessary protection for the nuclear reactor and multiple emergency response systems made Fukushima nuclear plant more susceptible to disaster. Improper reactions to the emergency situation led to the eventual melt down of reactors one through three. These are the lessons to be learnt from the Fukushima nuclear disaster. Even though nuclear energy plays an important role in the world precautions and other green energies should be looked into to ensure this type of disaster does not happen again.

References

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