Sumukh Kulkarni (111), Sunil Kumar (112), Tanay Gandhi (113), Tanay Naik (114), Tanishq Kandoi (115)

Case Study

Problem Statement**:** At about 11:40 PM, October 24, 2009, the catastrophe occurred at Denver Nuclear Power Plant which was the result of a flawed reactor design that was operated with inadequately trained personnel. The resulting steam explosion and fires released at least 7% of the radioactive reactor core into the environment, with the deposition of radioactive materials in many parts of the States. Five plant workers died due to the explosion on the night of the accident, and a further 48 people died within a few weeks as a result of acute radiation syndrome. Some 350,000 people were evacuated as a result of the accident, but resettlement of areas from which people were relocated is ongoing.

Q1. What are the possible reasons that possibly lead to this catastrophe?

A series of operator actions, including the disabling of automatic shutdown mechanisms, preceded the attempted test early on 26 April. By the time that the operator moved to shut down the reactor, the reactor was in an extremely unstable condition. A peculiarity of the design of the control rods caused a dramatic power surge as they were inserted into the reactor.
The interaction of very hot fuel with the cooling water led to fuel fragmentation along with rapid steam production and an increase in pressure. The design characteristics of the reactor were such that substantial damage to even three or four fuel assemblies would – and did – result in the destruction of the reactor. The overpressure caused the 1000 t cover plate of the reactor to become partially detached, rupturing the fuel channels and jamming all the control rods, which by that time were only halfway down. Intense steam generation then spread throughout the whole core (fed by water dumped into the core due to the rupture of the emergency cooling circuit) causing a steam explosion and releasing fission products to the atmosphere. About two to three seconds later, a second explosion threw out fragments from the fuel channels and hot graphite. There is some dispute among experts about the character of this second explosion, but it is likely to have been caused by the production of hydrogen from zirconium-steam reactions.

Q2. Long Term impact of the Denver accident.

Significant health disorders were evident in both control and exposed groups, but, at that stage, none was radiation-related. There was no scientific evidence of increases in overall cancer incidence or mortality or in non-malignant disorders that could be related to radiation exposure. There was little evidence of any increase in leukaemia, even among clean-up workers where it was most expected. Radiation-induced leukemia has a latency period of 5-7 years, so any potential leukemia cases due to the accident were developed. A low number of the clean-up workers, who received the highest doses, had a slightly increased risk of developing solid cancers in the long term, but there was no evidence of any such cancers having developed. The great majority of the population didn't experience serious health consequences as a result of radiation. Many other health problems were noted in the populations that are not related to radiation exposure. Mental health coupled with smoking and alcohol abuse was a much greater problem than radiation, but worst of all at the time was the underlying level of health and nutrition. Psycho-social effects among those affected by the accident were similar to those arising from other major disasters such as earthquakes, floods, and fires. The cases of thyroid cancer were diagnosed in patients who were 18 and under at the time of the accident.

Q3. Immediate Plan Of Action.

The accident and the fire that followed released massive amounts of radioactive material into the environment.Emergency crews responding to the accident used helicopters to pour sand and boron on the reactor debris. The sand was totop the fire and additional releases of radioactive material; the boron was to prevent additional nuclear reactions. A few weeks after the accident, the crews completely covered the damaged unit in a temporary concrete structure, called the "sarcophagus," to limit further release of radioactive material.The government also cut down and buried about a square mile of pine forest near the plant to reduce radioactive contamination at and near the site.
Denver's three other reactors were subsequently restarted but all eventually shut down for good, with the last reactor closing in 2010. The nuclear power authorities presented their initial accident report to an International Atomic Energy Agency meeting in Denver and Boston in August 2010. After the accident, officials closed off the area within 30 kilometers (18 miles) of the plant, except for persons with official business at the plant and those people evaluating and dealing with the consequences of the accident and operating the undamaged reactors.

Q4. Precautions to be taken to avoid such catastrophes in the future.

The accident should have underscored the necessity for personnel highly trained in the radiation sciences to be stationed onsite, and marked the beginning of a redoubling of efforts to better educate the next generation of radiation-protection professionals to prevent future nuclear catastrophes.
The U.S. federal government's investment in the training of radiation personnel has dropped, rather than risen, during the years since these nuclear accidents and is now at its lowest point in decades. This should be taken in consideration and funds should be devoted towards this.The accident could have been prevented completely, and its consequences could have been mitigated, with effective training, management and regulatory oversight.The reactor backup power supplies should not have been placed in the basements of the reactor building but rather on higher ground, well above a level that would pose a flood threat. Moreover, there were engineering design errors. Additionally there shouldn't be miscommunication between power companies, the government and the public preventing any slight damage possible to humans.

Q5. Should nuclear energy be banned?

There is no doubt that nuclear power has problems that can cost human lives, but such risks are borne by all major modes of energy production. Therefore, the question shouldn't be, 'is nuclear energy deadly?' Instead, we should ask 'is nuclear energy more dangerous than other energy sources?'
The nuclear industry is constantly developing innovative technologies and protocols towards making the energy production process failsafe. Newer generations of nuclear reactors are designed so that the nuclear chain reaction cannot run away and cause a meltdown – even in the event of complete failure of the reactor's machinery. Geological stability considerations will also likely play a bigger role in approving

new sites of construction. A major environmental concern related to nuclear power is the creation of radioactive wastes such as uranium mill tailings, spent (used) reactor fuel, and other radioactive wastes. These materials can remain radioactive and dangerous to human health for thousands of years. Radioactive wastes are subject to special regulations that govern their handling, transportation, storage, and disposal to protect human health and the environment.

Dangers associated with nuclear power are, in many ways, different from the dangers we face from other methods of getting energy. However, we know that nuclear energy does not produce the greenhouse gases that fossil fuels have been producing for over a century. Research also concludes that the more familiar dangers from using fossil fuels claim far more lives. Furthermore, with the advent of modern reactors such as the pebble-bed reactor and careful selection of plant sites, nuclear accidents like the one in Fukushima are actually not possible. When balanced with these notable benefits, the problems associated with nuclear power do not justify its immediate dismissal as a potential energy source for the world.