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Health Effects of Major Nuclear Power Plant Accidents

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The accidents at Three Mile Island in the USA, Chernobyl in the Ukraine and Fukushima Daiichi in Japan are the most serious nuclear power plant accidents that have occurred in terms of potential public health consequences. This paper gives a brief summary of those consequences.

Three Mile Island On 28 March 1979 at the No 2 Plant (TMI-2) (900MWe) there was a minor loss of steam generator feedwater flow that caused a reactor shutdown, but subsequent operator errors lead to a loss of coolant flow to the reactor core and the melting of about 1/3 of the reactor fuel. The accident was attributed to deficient operator training, although the plant design was such that made it more likely there would be such an accident (no more of this type have been built). Subsequently removal of the fuel was completed by 1991 and the plant placed in long-term monitored storage. The other similar reactor on the same site, TMI-1 (800MWe) continues to operate today.

The accident resulted in some radioactive gases from the melted fuel being vented from the plant. Subsequently, off-site radiation exposures within 16 km were determined to average 0.08 mSv (about the same as a chest X-ray) with a maximum of 1 mSv (about 1/3 of the annual natural background dose). A study of the 30,000 people who lived within 5 miles of the site was kept for 18 years after the accident and no adverse public health effects were found, other than psychological stress immediately following the accident.

Chernobyl On 26 April 1986 Unit No.4 (1000 MWe) at the Chernobyl site was destroyed by an uncontrolled power surge. The initial cause of this accident was a poorly designed and executed test of the plant behaviour at low power. The plant design, unique to the USSR, was also a major contributor and the reactor had essentially no containment building (no more of these plants were built).

The power surge resulted in a fire in the reactor graphite moderator stack that also burned much of the fuel. This led to the largest release of radioactive material from any power reactor accident. All of the noble gases, about 1/2 of the iodine and caesium and about 5% of the remaining radioactive material were released. The fire and winds then spread this material over several countries. Some 160,000 people were evacuated from the surrounding 30 km area. Most of these received 100 mSv or less (natural background radiation is 2-10mSv/yr) whereas some cleanup workers received up to 500 mSv. The reactor has since been encased to retard further releases, and the three other reactors at this site have been closed down.

28 operators and firefighters died from acute radiation exposure and later some 1800 local children were found to have developed treatable thyroid cancer (a disease that could have been prevented by use of stable iodine pills). In 2000 the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reported that other than the thyroid cancers: (a)there was no evidence of any other major public health impact caused by exposure to ionising radiation;(b)no other increases in overall cancer incidence or mortality have been observed that could be associated with radiation exposure; and (c)there was no increase in the incidence of birth defects as a result of the accident. However, the report also says that there was significant disruption to the area downwind of the plant with about 220,000 people from Belarus, the Russian Federation and the Ukraine being permanently relocated. The accident caused serious social and psychological disruption in the lives of those affected and vast economic losses over the entire region. Large areas of the three countries were contaminated, and deposition of released radionuclides was measurable in all countries of the northern hemisphere.

These observations were supported by a 2002 OECD report "Chenobyl, Assessments of

Radiological and Health Impacts." This source concludes with the statement, "Large scientific and epidemiological research programmes, some of them sponsored by international organisations such as the WHO and the EC, are being conducted to provide further insight into possible future health effects. However, the population dose estimates generally accepted tend to predict that, with the exception of thyroid disease, it is unlikely that the exposure would lead to discernible radiation effects in the general population above the background of natural incidence of the same diseases."

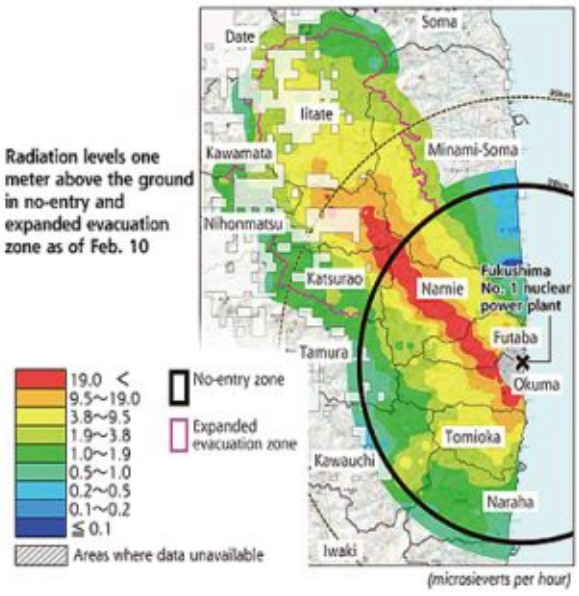
Fukushima Daiichi At 2:46 pm on 11 March 2011 a category 9 earthquake occurred under the ocean floor 130 km east of the city of Sendi on the main island of Honsu Japan. The shock led to much damage to local buildings, but at about 3:42 a 15 m tsunami which hit the coast.. All told the tsunami inundated about 560 sq km, killed over 19,000 people and did much damage to coastal ports and towns with over a million buildings destroyed or partly collapsed.

At the time of the earthquake 11 power reactors at 4 different plants were operating at power in the region, while another 3 (units 4, 5 and 6) at the Fukushima Daiichi plant were shutdown for maintenance. All of the operating reactors shut down automatically when the quake was sensed by their safety systems. However, when the tsunami arrived about an hour later the previously operating Fukushima Daiichi units 1, 2, and 3 were severely damaged (they were designed to accommodate only a 5.7m tsunami) to the extent that their connections to the grid were broken and their backup cooling systems were left inoperable.

Reactors still generate a diminishing amount of heat after shutdown due to the radioactive decay of materials in their cores. This heat is normally removed by the reactor shutdown cooling systems, but in this instance they did not operate because of the loss of electric power. Some relief was obtained from the backup batteries but not for long. Consequently the reactors began to overheat, their fuel began to melt and the zircalloy cladding of the fuel started to react with the available water. This melting released some volatile fission products (namely iodine-131 and caesium-134 & 137) that escaped from the reactor pressure vessels and from spent fuel ponds and was deposited on the surrounding areas.

Government Released New Radiation Readings in Fukushima

February 28, 2012



Residence times to reach dose of 20 mSv
(20mSv is the annual dose limit for radiation workers as recommended by the ICRP)

µSv/hr	Time to reach 20mSv
19	43.8 days
9.5	87.6 days
3.8	220 days
1.9	1.2 years
1.0	2.27 years
0.5	4.54 years
0.2	11.4 years
0.1	22.7 years

The amount of radioactivity released from the plant was substantial – estimated to be about one tenth of that emitted during the Chernobyl accident. The prevailing wind blew much of the

radioactive material from the plant in a northwesterly direction and deposited it as fallout on the ground (see map above). The Japanese government quickly ordered an evacuation of all people within a 20 km radius centered on the plant; and this was later extended on an advisory basis to 30 km. These steps ensured that members of the public that had survived the tsunami were not exposed to excessive radiation levels. The most exposed group consisted of about 100 workers who received levels that may cause delayed health effects, but at a low level of risk when compared with natural incidences of diseases. The net result being that there have been no deaths from radiation exposure as of this data.

As far as the plant is concerned, units 1,2 and 3 were essentially destroyed while unit 4 was also decommissioned for a total loss of 2719 MWe from the grid. Currently the Japanese government as well as the nuclear industry as a whole are engaged in several inquiries to determine ways to protect nuclear plants against low probability high consequence events.

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References

1. World Nuclear Association
2. “Fukushima Daiichi Nuclear Disaster”, Wikipedia