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Web| Jul 25, 2003
Opinion

Reprocessing: The Cons

India's Worst Radiation Accident underscores the likelihood of future, and potentially more severe, accidents with significant risks to occupational and public health and the environment. It also adds to the economic arguments against reprocessing of spent nuclear fuel.

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The reprocessing of spent nuclear fuel is a highly complex operation. Over and above the intricacies involved in any large chemical plant, reprocessing is also complicated by the highly radioactive nature of the process materials. As one would expect in such involved operations, reprocessing plants and their associated infrastructure have experienced numerous accidents around the world. The accident (or incident, as the nuclear establishment likes to refer to such events) at the Kalpakkam Reprocessing Plant on January 21, 2003, which was described by the director of the Bhabha Atomic Research Centre as "the worst accident in radiation exposure in the history of nuclear India", is the latest among these. It underscores the likelihood of future, and potentially more severe, accidents with significant risks to occupational and public health and the environment. It also adds to the economic arguments against reprocessing.

Reprocessing is done in order to recover plutonium and uranium from the spent fuel that has been irradiated in nuclear reactors. Due to the high levels of radioactivity in it, spent fuel generates large amounts of heat. So it is first stored in water filled pools for cooling. After cooling, the fuel rods are chopped up and dissolved in acid. Different chemicals are then added to separate out different elements, which are then converted to different chemical forms for ease of storage. For civilian applications, plutonium and uranium are converted to solid oxides.

All of these different processes produce large amounts of chemical and radioactive wastes, which have to be managed carefully. Waste is usually classified into low, medium and high level waste depending on the radioactivity level or concentration. Low level waste is either released into the environment or mixed into a bitumen (asphalt) matrix. Medium and high level wastes are concentrated and stored in steel tanks. At Kalpakkam, these tanks are placed in underground vaults in the so-called Waste Tank Farm. On January 21 three employees who entered that region were exposed to extraordinarily high radiation doses. The cause is said to be the failure of a valve that led to high level waste entering a tank designed to hold low level waste.

There are several aspects of the January 21 event that are worth noticing. The first is that despite quality control measures a valve failed. That such failures occur, and with reasonably frequency, is not something that nuclear authorities acknowledge often. In facilities like reprocessing plants with complex interactions between sub-systems, such relatively small failures could lead rapidly to a major accident. The 1979 accident at the Three Mile Island nuclear reactor in the United States was triggered in part by the failure of a relief valve to close. Fortunately that did not occur in this case.

Second is that there were no monitoring mechanisms for radioactivity levels. This represents a shocking failure of the authorities at both the design level and at implementation. The failure also raises the disturbing possibility that the radioactivity of the waste products that are routinely released into the environment (the atmosphere and the sea) is not monitored and that these releases may, on occasion, carry higher levels of radioactivity than planned causing increased radiation exposure to the public.

Third and finally, the BARC employees association claims that they had made numerous attempts to have safety features installed and appropriate procedures followed, but on every occasion the authorities had cited "emergency" conditions as a reason for not acting accordingly. Several accidents in a variety of arenas have been caused by such disregard by the authorities. A classic example is the 1986 Challenger space shuttle explosion. Engineers working for NASA had repeatedly warned against a launch that day because of unusually low temperatures but higher authorities discounted these warnings out of concern that further delays could seriously damage the credibility of the shuttle program.

Given the complicated nature of the reprocessing plant and the many associated facilities involved, there is a wide spectrum of credible accidents. Broadly speaking one can classify the more serious accidents into fires, explosions and criticality accidents.

Fires: There are a number of inflammable materials in a reprocessing plant, in particular organic solvents and zircaloy (the zirconium-based alloy used to clad the radioactive fuel elements in reactors). Some of the materials used for packaging radioactive waste are also inflammable. Any of these could catch fire, potentially leading to the release of radioactivity. One instance was the 1997 fire at the Tokai reprocessing plant in Japan. The fire started in the section where low level wastes from reprocessing were fixed in asphalt (bitumen). After ten hours of burning, the fire triggered an explosion. Thirty-seven workers received varying radiation doses, mostly from internal exposure to radioactive cesium. Radioactivity levels increased measurably up to tens of kilometers from the site of the accident.

Explosions: Some of the chemical reactions that take place during reprocessing produce explosive mixtures. The high radiation levels also cause the disintegration of chemicals that can sometimes produce hydrogen, which is again explosive. The last major explosion occurred at Russia’s Tomsk reprocessing plant in April 1993 when reactions between the nitric acid and organic solvents produced large volumes of a gaseous mixture that eventually exploded. Radioactive fallout from the explosion spread widely and was detected even as far away as Alaska.

Explosions could also occur in tanks that store high level radioactive waste from reprocessing. Due to the heat produced by radioactive decays, such tanks have to be constantly cooled and loss of cooling could cause drying out and creation of an explosive residue. One prominent example occurred in September 1957 at the Mayak facility in the Soviet Union when a tank containing high level waste underwent a large explosion (estimated to be between 25 and 100 tons of TNT equivalent) and ejected 70-80 tons of highly radioactive waste with a total radioactivity of 20 million curies into the atmosphere. Radioactive fallout settled along a 400 km long swath of land, covering an area of over 20,000 square kilometers, much of which still remains uninhabitable. The collective radiation dose to the resident population before it was permanently evacuated was nearly 6000 person-Sv. This collective dose would be expected eventually to result in about 300 cancer deaths according to standard estimates of mortality from radiation induced cancer.

Criticality: Also serious are criticality accidents where fissile materials like enriched uranium and plutonium are allowed to reach a concentration where an uncontrolled chain reaction like that in a nuclear bomb results (but with much less energy produced). The letter from the BARC Employees Association warns the authorities of the potential for such accidents at Kalpakkam. Their warning is not without basis; there have been over twenty criticality accidents at nuclear facilities around the world. An example is the accident that occurred in 1999 at the Tokaimura fuel fabrication facility in Japan. The accident occurred because workers put fuel enriched to 16 per cent uranium-235 in a container meant to hold fuel for light water reactors, which is usually only enriched to 3-5 per cent. This set off a chain reaction, resulting in elevated radiation exposures to several hundred workers and members of the public, including three workers who received large exposures, one of whom subsequently died from acute radiation sickness following a radiation dose of about 16 Sv (1600 rads). Similar events have occurred in reprocessing plants, for example at the Idaho Chemical Processing Plant, USA in 1959.

These safety issues must be balanced with the two primary justifications offered for reprocessing. The first justification offered is that it produces plutonium that could be used to build nuclear weapons. The reasons for not acquiring nuclear weapons are sufficiently well known and have been elaborated elsewhere (see for example *Prisoners of the Nuclear Dream*, edited by M. V. Ramana and C. Rammanohar Reddy, Orient Longman, 2003). In any case the Kalpakkam reprocessing plant is ostensibly operated for civilian purposes.

The second justification offered by the Department of Atomic Energy is that India's uranium resources are limited and that reprocessing is needed to supply startup plutonium for breeder reactors that may be used to convert India's large resources of thorium into chain-reacting uranium-233. But the saga of breeder reactors around the world has been one of tall promises and poor performance. The French Superphenix reactor, for example, cost more than twice as much as an ordinary reactor of similar capacity and operated at an average of about 6.6% of its rated capacity. Fast breeder reactors also have serious safety risks. They generate a large amount of heat in a very small volume and use molten metals, such as liquid sodium, to remove the heat. Since sodium is opaque and burns on contact with air or water, sodium leaks are dangerous. Further, designing reactors and their maintenance to take these properties into account has made them costly to build and maintain.

Breeder reactors are also uneconomical because of the high cost of plutonium that is used as fuel in such reactors. The high cost of plutonium, in turn, is because of the high cost of reprocessing. The total lifecycle cost of the Rokkashomura reprocessing plant being constructed in Japan, for example, is projected by the Japanese utilities at about $130 billion. They are asking for a government bailout. The Japanese reprocessing plant is expected to recover on the order of 130 tons of plutonium during its useful life. On that basis, the cost of extracting a gram of plutonium with this plant will be about $1000. For comparison, the world market price of U-235 in natural uranium is today about $4 a gram. The cost of fabricated uranium fuel used in the heavy water reactors at Kalpakkam is about Rs. 16.50 a gram.

To summarize, reprocessing has very substantial risks and costs, while possessing few, if any, benefits. All this adds up to a strong case against the continued pursuit of reprocessing.

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