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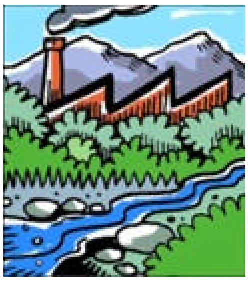

NUCLEAR PLANTS

Nuclear safety: A poor record

Although as yet in India, there has not been a severe accident leading to core meltdown or large radiation exposures to the public, on measures of occupational exposure to workers, and compliance with standards for accident prevention, Indian nuclear plants perform poorly, writes Ashwin Kumar.

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30 March 2007 - Nuclear reactors contain large amounts of radioactive material; this health hazard r in nuclear facilities especially important. An examination of the safety record in India's nuclear facil poor practices and routine accidents, ranging from leaks of oil to complete loss of power in a reacto safety systems to be disabled. Although as yet in India, there has not been a severe accident lea meltdown or large radiation exposures to the public, on measures of occupational exposure to wor nuclear facilities perform poorly. For example in the 1980s, for which data is available, radiation e power plant workers were ten times the world average for each unit of electricity and twice the world each monitored worker. As recently as 2003, there have been accidents involving high radiation e workers.

Despite this record, claims about safe operation are sometimes made by the nuclear establishm Sometimes, claims for safety are based on the technical features of the facilities, which suggest a l The following excerpt from the Nuclear Power Corporation of India (NPC), administered by the De Atomic Energy (DAE), is illustrative: "NPC engineers have shared their expertise internationally by pa safety reviews and inspection of reactors in other countries conducted by the World Association Operators (WANO) and the International Atomic Energy Agency (IAEA). We are continuously updatir systems and procedures even at the cost of short-term economic benefit. Besides, all our plants a constructed, commissioned, operated and maintained under the strict supervision of the AERB."

Notions of safety differ, but what they all have in common is usually claims about the future. In connection between the past record of anomalies and future prospects for safety, one must go beyo presence or absence of accidents to study the factors present.

The 'engineering' approach to safety

To engineers, a safe reactor is usually one which is reliable, meaning that things can be expectec correctly most of the time. Safety is improved by incorporating backup systems to make overall ope reliable, and protection systems to prevent the escalation of accidents. Ultimately, physical barriers public from leakage of radioactive material. Backup devices and physical barriers togethe "redundancy", so called because they are, in the engineers' judgement, not likely to be needed wher is functioning properly but could become important as independent safety measures when som wrong.

In such an approach, it is indeed possible to make reactors operate safely but this depends on everything operating reliably. When the DAE claims that its reactors are designed to operate safely because of the different safety devices, one could immediately ask to what extent these devices are present and operating as they should be. Here, the record is not good. Safety systems have been inadequate in many facilities. For example, the two reactors at Tarapur shared emergency core cooling systems for a long time in violation of standards that required each reactor to have its own system. The reactors at Madras and Rajasthan had been operating for many years without high pressure core cooling systems, which would be needed if coolant is lost during an accident. The need for such systems has been known since the 1970s but the Mad built in the mid-1980s, were operating without them until 2004.

> One problem with nuclear reac that components and subsyste interact in unanticipated ways accidents.

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Often, backup equipment has been part of the design but unavailable during operation. For exam pumps for coolant circulation have on many occasions been unavailable when the operating pumps disabled by external factors such as fluctuations in the grid. Sometimes, even the minimum rec pumps has been unavailable, causing the reactors to be operated at reduced power. In an engineerin this record illustrates poor reliability of backup systems, suggesting that safety is also not as good as The above information about inoperative backup equipment is obtained from International Atomic En reports of operating experience; the DAE is required to internationally report events which involve the reactor. Secrecy in the nuclear program means that problems surface only when an accident has the reactor has to be shutdown. Therefore, the public record is only a weak test for reliability.

Are physical barriers good enough?

Ultimately, reactor designers rely on physical barriers to prevent harm to the public. In most reactor primary vessel that contains the fuel, radioactivity, and heat produced in the reaction. Outside secondary containment building, meant as a physical barrier to prevent leakage of radioactive gases to the environment. Integrity of these barriers is often demonstrated through mathematical models up limit of pressure and temperature; during normal operation and under most accidents, these limits mu

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In some reactor types, there might be accidents for which it is difficult if not impossible to design barriers. For example fast reactors, one of which is being built in Kalpakkam, are vulnerable to a reactivity increase that could lead to explosive breakup of the fuel, leading to high energies that are difficult to physically contain. In fact, once the fuel becomes hot enough to melt, it is difficult to know what will happen next and the effectiveness of protective barriers cannot be guaranteed. Severe accidents apart, the effectiveness of these barriers also depends on their quality of design and construction. While the containment building was being constructed for the Kaiga reactor in Karnataka, its inner shell collapsed due to deficiencies in design. If this problem is widespread, it weakens the case for safety on the basis of "defense-in-depth". Unfortunately, until an accident happens and the barriers are tested, one might never know. And subsequently, attribution might be difficult.

Reliability in design and operations is necessary for safety, but it might not be enough. One problem reactors is that components and subsystems often interact in unanticipated ways to cause accidents complexity"). A classic example is the Three Mile Island accident, in which operators did not know the reactor at the time and performed actions that actually worsened it. Redundancy could sometimes b problem. For example in the Fermi fast breeder reactor in the United States, a safety device meant core in case it melted actually initiated a near meltdown when a part of it broke away and blocked coolant.

While such problems can often be fixed once they are identified, all such interactions might not b before they actually occur. There is plenty of evidence elsewhere of nuclear plant operators being unexpected interactions during accidents. While in some cases, accidents could have still been warning signs had been heeded, that is no consolation to the operators who are trying to fix the re accident is happening or the designers who are trying to build safe systems but cannot understand might go wrong.

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What makes an accident?

Multiple failures must occur at the same time for a severe accident to happen. This has happened in example in the Narora reactor in Uttar Pradesh in 1993. The accident happened when a fire spread cables and shutdown all the safety systems and operators had to intervene manually to shutdown This might appear quite unusual, but the operating records reveal how the conditions leading up were always present.

The fire started when a poorly designed turbine experienced large vibrations and its blades broke vibrations in Indian turbines have happened before, but this was the first time that the blades broke a pipe containing hydrogen, which then leaked and caught fire. Around the same time, oil was le turbine building. Oil leaks too are common in DAE's reactors, but this time the oil also caught fire. through the power carrying cables and disabled them. Backup cables were present but had been pla proximity without being encased in fire retardant sheaths, in violation of international desigr Therefore, they did not function effectively as backups. The accident was preventable, and the D learnt from best practices in cabling design, nor did it heed warnings from the turbine manufacturer fatigue problems, especially significant in Indian reactors where excessive shaking of the turbines h many times.

Nuclear reactors are tightly coupled, which means that there are few alternate pathways to diffus which can often progress very quickly. To ensure safety, the appropriate interventions - whether by automatic safety equipment - must occur quickly and be adequately planned for. This also requires reliability throughout the organisation. **?**

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