INTERVIEW

How safe are Indian nuclear reactors? **Dr R. BHATTACHARYA**, Secretary, Atomic Energy Regulatory Board (AERB), Government of India, Director, Information & Technical Services Division & Director, Industrial Plants Safety Division, sought to allay some fears in a talk with **Hasan Jawaid Khan**.

Hasan Jawaid Khan: As per reports, in the case of the Japanese nuclear accident, the spent fuel rods kept in storage pools are creating problems. Are Indian reactors equipped to handle such an eventuality?

R. BHATTACHARYA: Well, the Spent Fuel Storage Bay (SFSB) in Indian PHWRs is equipped with several safety features. Taken together, it's evident that Indian nuclear reactors are sufficiently equipped to prevent and mitigate such eventualities in an effective manner.

In Indian PHWRs, the Spent Fuel Storage Bay (SFSB) structure is designed and qualified based on the maximum earthquake potential of the site. In the Fukushima reactors, the Spent Fuel Pools were located at a height inside the Reactor Building. Whereas, the SFSB is housed at the basement of the Service Building (SB), which is located between the two Reactor Buildings as a common facility for the twin units. Thus, the impact of ground motion would be less severe for SFSB in Indian PHWRs.

The spent fuels are stored under water. The water level maintained in it ensures sufficient shielding cover required above the highest position of spent fuel, and is also a regulatory requirement. The bay cooling system provides for removal of decay heat generated in the spent fuels.

The SFSB is designed as a water-retaining structure based on the 'tank-in-tank' concept. The structure is assured leak tight by providing a steel liner on the inside and concrete wall on the outside. Further, provision for leak detection/monitoring is also built-in in the design.

The equipments for SFSB cooling and purification system are fed by a reliable power supply backed up by emergency diesel generators. Even in case of a remote situation arising due to simultaneous loss of off-site power as well as all the diesel generators, analysis shows that considering the vast size of the bay and much lower burn-up of PHWR spent fuels as compared to LWR, cooling of spent fuel bundles and sufficient water inventory in SFSB is ensured during the situation.

The piping elevations of SFSB are so designed that continuous drainage from the SFSB is always precluded. The draining will stop at an elevation so that sufficient water inventory for cooling and shielding of the fuel bundles is retained inside the bay at all times.

HJK: What are the precautions generally taken around a nuclear reactor to guard against radioactivity affecting people in the vicinity?

R. BHATTACHARYA: Nuclear power plants in India are designed, constructed and operated based on the principle of the highest priority to nuclear safety. During the normal operation, the release of radioactivity to the environment and the public is prevented by incorporating a series of fission product barriers in the system itself. These barriers are: Fuel matrix, Fuel cladding, Primary Heat Transport System, Containment, and the Exclusion zone.

Fuel matrix: The uranium dioxide (UO_2) used for fuel is a ceramic with high melting point and high chemical stability to water at operating condition. So as long as the ceramic fuel does not melt, it will keep a large fraction of the fission product entrapped. During the normal operation all solid fission products are permanently retained in UO_2 matrix and only a fraction of noble gases and volatile products diffuse into the inter space between fuel and cladding.

Fuel cladding: It contains and seals the UO_2 pellets. This forms the second barrier and is designed to withstand stress resulting from UO_2 expansion, fission gas pressure, external hydraulic pressure and mechanical loads imposed by fuel handling.

Primary Heat Transport System: The fuel bundles and coolant are contained in primary heat transport (PHT) system. This is a closed system and forms the third barrier for fission product release.

Containment: The fourth barrier is the containment building that houses the reactor and piping systems. The containment is a leak-tight concrete structure with quick isolation feature and engineered safety features for reducing the peak pressure, overpressure duration and radioactivity release. The containment structures are designed to withstand maximum pressure and temperature generated by postulated accidents and maintain low peak rates consistent with acceptable radiological consequence following the postulated accident conditions.

Exclusion zone: The public habitation is excluded from a zone of 1.6 km radius from the centre of the plant. Although it is not a physical barrier, it helps in atmosphere dilution of any ground level release of radioactivity from the containment, before the radioactivity reaches the public.

To ensure the integrity of each of the barriers, a well-established safety design philosophy is adopted by plant designers, which includes highest safety standards and redundancy in structures, systems and components (SSCs).

To cater to both process failures and equipment failures in the plant, there are safety systems like Reactor Protection System, Emergency Core Cooling System (ECCS) and Containment System. The nuclear power plants are operated by highly skilled and trained operators. The plant operations are strictly governed by technical specifications for operation and the station policies are approved by AERB.

Further, for monitoring of the environment around the nuclear power plants, Environmental Survey Laboratories (ESL) are stationed at each site. The sampling and analyzing of the radioactivity in the environment matrices like water, air, soil, sediment, vegetation, milk etc. are done by these ESLs regularly. Each ESL is equipped with modern nuclear, meteorological and chemical instruments and operated by trained and experienced scientists. Also Environmental Thermo Luminescent Dosimeters (TLDs) are located at various locations surrounding the plant to measure the integrated environmental dose over a period of time.

Moreover, as a measure of abundant caution, prior to the issuance of a license for the operation of a nuclear facility, AERB ensures that the facility has the Site-specific Emergency Preparedness and Response Manuals for radiological emergencies. These Emergency Response plans include the emergency response organisations, their responsibilities, the detailed scheme of emergency preparedness, facilities, equipments, coordination and support of various organizations and other technical aspects. No nuclear power plant can operate without approved and tested emergency response plans which are rehearsed periodically at every site.

HJK: In case of radioactivity leakage what are the steps taken by government agencies and what precautions should the general public be aware of?

R. BHATTACHARYA: An accidental release of radioactivity confined to the exclusion zone constitutes a Site Emergency. An assessment of such a situation would imply that protective measures are limited to the site boundary only.

In case the radiological consequences of an emergency situation originating from NPP are likely to extend beyond the site boundary (exclusion zone) and into the public domain, district government officials have the overall responsibility of deciding and implementing the appropriate protective actions for the public during a nuclear power plant radiological emergency. They are responsible for notifying the public to take protective actions, such as evacuation, sheltering in safe places or taking potassium iodide pills as a supplement. State and local officials base their decisions on the protective action recommendations by the nuclear power plant operators.

Evacuation is an extreme measure taken after evaluating the risks and benefits of this countermeasure in terms of the averted dose. If radiation levels in the affected zone continue to exist beyond acceptable levels, then relocating the affected population is resorted to.

Residents living in the vicinity of a nuclear power plant should increase their awareness about radiation by attending the training sessions conducted by NPP units. In the unlikely event of a nuclear power plant accident, members of public living in vicinity of a nuclear power plant should follow the instructions of the district government officials. These instructions include directions for intake of prophylactics, sheltering or for evacuating to reduce any possible exposure to radiation.

HJK: How would you allay the fears expressed by those opposing the Jaitapur nuclear reactor?

R. BHATTACHARYA: Today's nuclear power plants are designed with very high level of safety. During normal operation the radiological impact from these plants to the environment is negligible. Possibility of accidental release harmful to the public is extremely rare. However, clearance will be given for any project for different stages like siting, construction, commissioning and operation after in-depth review of all safety aspects through a well-established three-tier review system of AERB.

After several unsuccessful efforts with different techniques, the TEPCO staff managed to stop flow of highly contaminated water from Unit 2 to sea

Rajasthan and Kakrapar. NPCIL and AERB may revisit the modifications made to verify their adequacy.

Some design features of PHWRs

On 31 March 1993, a serious fire incident occurred at the Narora Atomic Power Station leading to a "black out" (loss of all power supplies) for 17 hrs. Thermo-siphoning took place. Thermo-siphon refers to a method of heat exchange based on natural convection, which circulates liquid without the necessity of a mechanical pump. It is a physical phenomenon and not an "add on" system. It is obviously a passive method of cooling. Active cooling depends on use of pumps to drive the coolant.

During the incident, there were no fuel failures or related consequences. Based on this experience, NPCIL initiated remedial actions to prevent such incidents in all reactors.

Earlier, BARC scientists led by Dr V. Venkat Raj demonstrated experimentally the thermo-siphoning capability of Indian PHWRs.

PHWRs have an important advantage. PHWR of 220 MW capacity has an inventory of 210 tonnes of heavy water; besides this, the calandria vault has about a few hundred tonnes of ordinary water. Large inventory of heavy water and light water will serve as a possible heat sink in a loss of coolant accident.

Fukushima Accident: Measures taken in India

Soon after the Fukushima accident there was public concern that radioactive material from Fukushima may be carried to the Indian continent by various atmospheric processes and may cause increases in background radiation levels.