Frequently Asked Questions

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Topic 1: Regulatory Review Process

Q. What is the regulatory process AERB follows? Is it based on established regulatory documents?

Over the years AERB has evolved a robust procedure for safety review and issue of consents at various stages of setting up of these facilities in line with the best international practices and International Atomic Energy Agency (IAEA) guidelines. The major elements of AERB's regulatory process are described below:

1.1 Preparation of Regulatory Documents

One of the major elements of AERB's safety supervision process is preparation of safety regulations. These safety regulations of AERB are issued in the form of safety codes and guides. For Nuclear Power Plants, the governing safety document is the AERB Code on Regulation of Nuclear and Radiation Facilities. It spells out the minimum safety related requirements/obligations to be met by a nuclear facility to qualify for the issue of regulatory consent at every stage leading to eventual operation. The Code also elaborates on the regulatory inspection and enforcement to be carried out by the Regulatory Body on such facilities.

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The consenting requirements of NPP are further elaborated and explained in the regulatory Guide 'Consenting Process of Nuclear Power Plants and Research Reactors-AERB/SC/G-1' which gives the required documents to be submitted to AERB, lead-time for submission of such documents for review; review topics/areas for each stage of consent; method for review and assessment; application-formats for various consents; etc. In addition to these documents, there are separate codes and series of guides on siting, design, and operation of NPPs and thematic guides and manuals on various topics such as civil engineering, quality assurance, emergency preparedness, radiation protection and waste management. Similarly, for fuel cycle facilities and radiation facilities, the consenting requirements of NPP are further elaborated and explained in the regulatory Guide 'Consenting Process of Nuclear Fuel Cycle facilities other than Nuclear Power Plants and Research Reactors-AERB/SC/G-2' and 'Consenting Process for Radiation facilities-AERB/SC/G-3). These regulatory documents are available on AERB website www.aerb.gov.in.

The regulatory documents are developed with safety concepts, requirements and methodologies generally consistent with IAEA safety standards and other international nuclear safety regulations, which collectively represent enormous experience in design, construction and operation of these facilities. These are periodically reviewed and revised as necessary, in the light of experience and feedback from users as well as new developments in the field.

1.2 Safety Review and Issue of Consents

The main consenting stages for nuclear facilities are siting, construction, commissioning, operation and decommissioning. At each stage a comprehensive review in a multi-tier structure of safety committees is carried out before issue of consent based on requirements specified in AERB Safety Code on "Regulation of Nuclear and Radiation Facilities" and associated Safety Guides. For siting stage, the review is carried out by Site Evaluation Committee (SEC) followed by second tier review by Advisory Committee for Project Safety Review (ACPSR) which consists of expert members from DAE, IITs,

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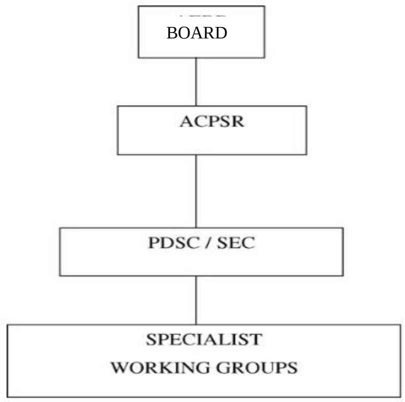
Ministry of Environment & Forests and Central Electricity Authority. The third tier review is carried out by Board of AERB. For construction, commissioning and operation, the first tier review is carried out by Project Design Safety Committee (PDSC), followed by ACPSR and Board. Apart from the laid down regulations, regulatory decisions are also based on operating experience feedback and engineering judgment. For fuel cycle projects, the first tier review is carried out by Design Safety Review Committees (DSRC) followed by review by ACPSR and Board of AERB. Once the nuclear facility gets operational, the review is done first by a plant specific Unit Safety Committee (USC) and thereafter by the Apex Committee known as Safety Review Committee for Operating Plants (SARCOP). A quarterly report to the Board of AERB on safety status of DAE Units is made by SARCOP and is discussed in Board Meetings. Items that are of major safety concern or which involve a significant change in the plant design or configuration are referred to the Board for review and decisions. The Board also reviews and approves major changes in policies and principles for regulation, matters concerning authorisation/reauthorization or restrictions/suspensions on operation of NPPs. AERB Board and its Safety committees also take assistance from Expert Groups constituted for specific purposes.

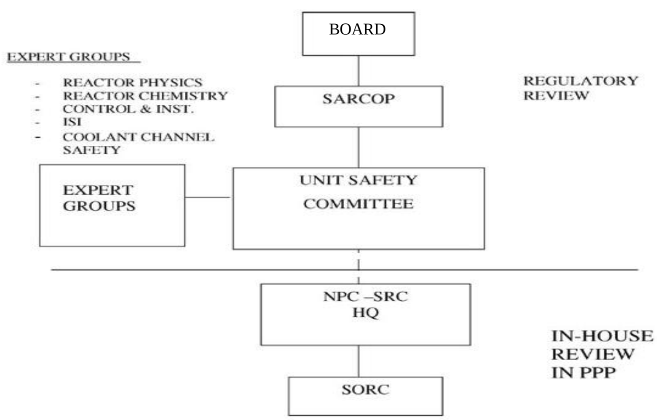
Multitier review based on the radiation hazard potential is also carried out for radiation facilities. Initial inhouse review is followed by review by respective unit level safety committees. Proposals having greater radiation hazard potential undergo a second tier safety review by Safety Review Committee for Application of Radiation (SARCAR) and finally by Board of AERB.

Regulatory Process of Nuclear Power Projects



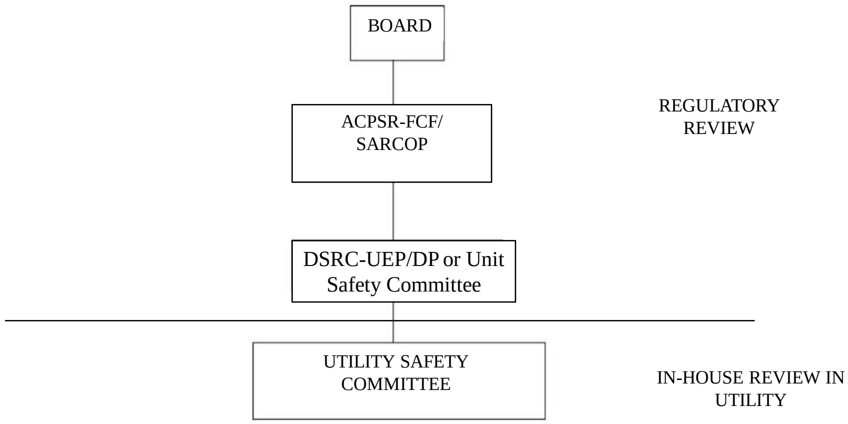
AERB : Atomic Energy Regulatory Board
ACPSR : Advisory Committee for Project Safety Review
PDSC : Project Design Safety Committee
SEC : Site Evaluation Committee

Regulatory Process of Operating Nuclear Plants



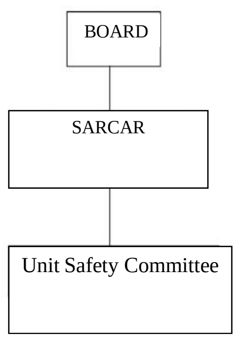
AERB : ATOMIC ENERGY REGULATORY BOARD
SARCOP : SAFETY REVIEW COMMITTEE FOR OPERATING PLANTS
NPC-SRC : NUCLEAR POWER CORPORATION: SAFETY COMMITTEE
SORC : STATION OPERATION REVIEW COMMITTEE

Regulatory Process of Nuclear Fuel Cycle Projects/Facilities



ACPSR-FCF : ADVISORY COMMITTEE FOR PROJECT SAFETY REVIEW FOR FUEL CYCLE FACILITIES
SARCOP : SAFETY REVIEW COMMITTEE FOR OPERATING PLANTS
DSRC-UEP/DP: DESIGN SAFETY REVIEW COMMITTEE FOR URANIUM EXTRACTION PROJECTS/DIVERSIFIED PROJECTS

Regulatory Process of Radiation Facilities



SARCAR: Safety Review Committee for Application of Radiation

Topic 2: Independence, public participation and transparency

Q. It is often alleged that the AERB is not an independent entity since it is under the control of the AEC. If this be so, how can the AERB function in an effective manner?

Internationally it has been recognized that for any regulatory body to be able to function properly it is necessary that it should enjoy "effective independence". This is also stated in the documents of the International Atomic Energy Agency.

The AERB reports to the Atomic Energy Commission, which is a high level policy making body for the all atomic energy matters in the country. The Commission meets typically once in three months or so and does not supervise or look into the day-to-day working of either AERB or any other atomic energy establishment or facility in the country.

Through careful examinations at the highest level, it has also been ascertained that no decision taken by AERB has ever been influenced, let alone being interfered with by AEC and DAE or any of its constituents units. Thus the AERB, in reality, is a totally independent organisation which is free to lay down the safety norms and to enforce their implementation in the nuclear facilities under its purview.

The functional independence of AERB can be described by the following facts:

The Board's advisory committees have members from academic and research institutions, industries and government agencies such as the Ministry of Environment and Forests, Central Electricity Authority, Central Boilers Board, among others. The Board has eminent specialists as members; they take final decisions considering the recommendations of the advisory committees.

AERB is empowered to invite independent specialists for safety review. The technical support organizations (TSO) such as the Bhabha Atomic Research Centre analyze the scientific and engineering issues referred to them. The AERB staff has adequate competence to review such analysis.

Since its inception, AERB has taken several regulatory enforcement actions against units of DAE including nuclear power plants as well non-DAE radiation installations. In extreme situations, AERB has even ordered shutdown of plants, or suspension of activities in projects. Several graded enforcement options are available to AERB to ensure that the Licensee takes timely corrective actions whenever needed. The actions taken by AERB are based on aspects such as safety significance of the deficiency, seriousness of violations, the repetitive nature and/or deliberate nature of the violations. AERB asks utility to take corrective actions like increasing the surveillance, replacement of equipment, revision of procedures, training etc. Actions may also include requiring the plant to incorporate additional features in design or operation, calling for additional test/mockups or analysis etc.

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Enforcement actions by AERB

Several graded enforcement options are available to AERB to ensure that the Licensee takes timely corrective actions whenever needed. The actions taken by AERB are based on aspects such as safety significance of the deficiency, seriousness of violations, the repetitive nature and/or deliberate nature of the violations. AERB directives to shutdown an operating unit or to extend the shutdown in case the unit is already shutdown is an extreme action; there are a few occasions when AERB enforced this measure.

AERB asks utility to take corrective actions like increasing the surveillance, replacement of equipment, revision of procedures, training etc. Actions may also include requiring the plant to incorporate additional features in design or operation, calling for additional test/mockups or analysis etc., Enforcement actions by AERB arise from review of documents submitted by the consentee, findings of regulatory inspections conducted by AERB or based on information it receives from overseas agencies like International Atomic Energy Agency (IAEA) and other regulatory bodies.

Enforcement Actions by AERB in Nuclear Power Plants/Projects

AERB has enforced regulatory actions against nuclear power reactors by restricting power levels, directing design modifications, calling for additional tests or studies or shutting them down when necessary. During its entire history of operation of NPPs, NPCIL has complied with AERB stipulations. AERB remained as a functionally independent organization to take decisions on merit. The list summarizing some of the enforcement actions taken against nuclear power plants is as follows:

Narora Fire Incident 1993

On March 31, 1993, an incident of fire in the turbine building of Unit-1 of the Narora Atomic Power Station took place that resulted in a total loss of power to the unit for over 17 hours. The incident was initiated by failure of two turbine blades in the last stage of the low pressure turbine, which resulted in severe imbalance in the turbo-generator leading to rupturing of hydrogen seals and lube oil lines, leading to fire. The fire spread to several cable trays, relay panels, etc., in a short duration. There was no radiological impact of the incident. AERB constituted an investigation committee, the findings of which set in motion a spate of actions. The most prompt one was to take up immediate inspection of turbines in all the operating NPPs, which was followed by modifications in the Low Pressure turbine blade root design. AERB had also insisted that all NPPs must establish and comply with limits on permissible vibration levels, operable grid frequency range and generator hydrogen make up rate. It also insisted that the NPPs follow a regime of pre-service inspection and in-service inspections for the turbines after specified service periods.

NAPS Unit-2, which was under annual shutdown at the time of fire incident, was not affected by the fire incident. Restart of NAPS- 2 was however permitted by AERB, only after implementation of the recommended modifications. The unit was restarted in November 1993.

Some of the improvements, which were implemented in all the NPPs, were related to cable re-routing, fire zone localisation, system wise review to avoid common cause failure vulnerabilities, improvements in control room ventilation, Turbine Generator (TG) system related improvements and Emergency Operating Procedure/Guidelines and provisions for handling Station Black Out.

Leak from a steam line in MAPS-2

On Sep. 1, 1993 while MAPS-2 was being shutdown for inspection of the turbine generator, a weld joint in a steam line to the deaerator failed. Leaking steam entered, through the gaps in the pipe penetrations, motor control centres and the battery room. At that time, the reactor was operating at a power level of 165 MWe. The steam ingress caused loss of power supply to some of the important equipment. AERB allowed re-start of the unit only after remedial measures, such as fixing enclosures around pipe penetrations to prevent steam leaking into different areas were put in place.

Delamination of the Inner Containment Dome at Kaiga-2 during Construction:

On May 13, 1994, the delamination of inner containment dome occurred while its pre-stressing cables were being tensioned. Based on the initial evaluation report from the AERB inspection team, AERB directed NPCIL to immediately suspend all civil construction activities related to the Inner Containment Structures (wall and dome) of Kaiga Unit-2 and Rajasthan Atomic Power Project (RAPP) Units-3&4, which were the similar units under construction at that time. In addition, NPCIL was instructed not to take up any civil construction activity in the entire Reactor Building of Kaiga Project, Unit-1 without AERB clearance.

Failure of Moderator Heat Exchanger tubes.

Moderator heat exchangers of both the unit of NAPS had developed tube leakages. As a result, active process water systems of both the units got contaminated with tritium thus generating liquid waste. The release of the waste over a period of time had projected to cross 95% of the technical specifications limits on annual waste discharges. The cause of failure appeared to be generic and their root causes were to be established. In view of this, on May 1, 1996, AERB stipulated that both the units of NAPS shall not be operated till root causes are identified and remedial actions are established. Subsequent to this, permission was granted for restarted on May 10, 1996 after successful resolution of the issue. The vulnerable tubes in the moderator heat exchangers were plugged.

Life Management of Coolant Channels in PHWR reactors

The coolant channels being the primary pressure boundary component of PHWR type of reactors attracted several reviews by AERB during the last 20 years. On several occasions, AERB asked the Nuclear Power Plants to carry out extensive in-service inspections which required shutdown of the operating plants.

Falling of one of the doors of Main Airlock at NAPS-2

In September 1999, leak rate test of the containment was progress at NAPS-2. During the test of the primary space of the main air lock, when this space was being pressurized the inner door of the main air lock came out of its frame and fell on the reactor building floor. The incident did not cause injury to any person or damage to any equipment. AERB suspended operation of NAPS-2 pending investigation of the incident and repairs of the failed main air lock door.

Life management of Primary Heat transport System (PHT) feeders

Based on the reports from Canadian reactors, on the problem of thinning of PHT feeder elbows in the later half of nineties, AERB had asked Nuclear Power Corporation of India Ltd. to examine the status of PHT feeders in RAPS and MAPS reactors. The inspections done in RAPS-2 which was during En-Masse Coolant Channel Replacement campaign showed noticeable thinning in some of the feeder elbows. Following this, a detailed exercise of assessment of residual life and repair of some of the feeders was carried out prior to restart of RAPS-2 after EMCCR in 1998. Full-scale inspection and health assessment was carried out in MAPS Unit-2 during its EMCCR in 2003.

In the subsequent years, pursuant to the Periodic Safety Reviews of NAPS and KAPS, AERB recommended instituting a programme for augmented inspections, health assessment and life management of feeders.

Core Shroud Inspections at TAPS 1&2

AERB had directed TAPS to take up inspection of the welds of core shrouds of TAPS units. Core shroud in Boiling Water Reactors like TAPS, is an integral structure of the reactor that gives alignment to the fuel bundles and separates the incoming cooling water from the hot water at reactor outlet. This directive was issued in light of the information that cracks occurred in the core shrouds of some of the Boiling Water Reactors in USA in the early 1990s. Pursuant to this directive, TAPS has been carrying out inspection of the accessible welds of core shrouds in both the units of TAPS since 1996.

Comprehensive Safety Assessment of TAPS 1&2

TAPS-1&2, the first nuclear power station in India started operation in the year 1969. After the station had completed about 30 years of operation, AERB initiated a comprehensive assessment of safety of TAPS units, for their continued long-term operation. This assessment covered the following aspects:

- Review of design basis of plant systems and Safety analysis, vis-à-vis the current requirements.
- Seismic Re-evaluation.
- Review of Ageing Management and residual life of Systems, Structures and Components (SSCs).
- Review of operational performance.
- Probabilistic Safety Assessment.

The original safety analysis of TAPS was reviewed with respect to (a) adequacy of original analytical techniques, (b) list of events analysed, (c) plant design/configuration changes that have taken place over the years. Based on this review, the safety analysis was redone using current analytical methodologies/computer codes. The Safety Report was also updated to reflect (a) design modifications/back-fits, (b) results of fresh analysis performed and (c) adequacy of coverage.

Based on above studies and assessments, several upgrades such as modification in the emergency power supply system, segregation of shared systems as far as practicable, strengthening of the emergency feed water supply to the reactor, provision of supplementary control centres/points, strengthening of supporting arrangements at some places from seismic considerations, up-gradation of fire protection system, etc. were identified. A number of upgrades were implemented in the plant during the refuelling outages of individual units and in a simultaneous long shutdown of both the units during November 2005 to January 2006.

Special watch on NAPS:

During the year 2003and 2004, NAPS was put under special regulatory watch due to concerns related to

- Higher occupational radiation exposures and Incidences of violation of radiation safety procedures.
- Poor condition of access roads to the plant which could delay evacuations under emergency conditions.
- Inadequate fencing of exclusion zone around NPPs.

These matters were discussed with plant authorities and NPCIL earlier also. Since the progress on these issues was not satisfactory, AERB had decided to put these units under special watch. As per this program, AERB took-up more frequent regulatory inspections of the plant to monitor progress on the identified issues. During the special watch, NAPS made significant improvements in the area of radiation protection and collective dose reduction, NAPS also interacted with Uttar Pradesh state authorities for taking the required actions to improve the condition of access roads. Proper fencing of exclusion zone was done.

KAPS-1 Incident of Regulating System Failure:

On March 10, 2004, there was an incident involving failure of reactor regulating system resulting in uncontrolled increase in reactor power in KAPS-1. During the event, reactor power increased from 75**%** Full Power to 98% Full Power. The incident did not cause any damage to the plant and there were no radiological consequences. The event was rated at level-2 as per INES. The initial investigations and analyses could not adequately explain the reasons for increase in the reactor power encountered during the incident. Noting this anomaly, AERB had asked the affected Unit to be maintained under safe shutdown state till the underlying phenomena that resulted in this event was fully investigated and understood. Subsequent to the investigations, it was observed some of the causes were applicable to the other unit also. In view of this, AERB had stipulated that the operations of both KAPS Units could be permitted only after all the identified short-term measures were completed. As directed by AERB, KAPS Units remained shutdown, for implementation of the identified actions. AERB also prescribed 'formal and elaborate retraining and relicensing of all the frontline operating staff and the station management personnel'. Restart of the units was permitted in the first week of June 2004, after ascertaining the satisfactory implementation of the identified measures. Implementation of the actions arising out of the event was taken up in other units also.

Flow Assisted Corrosion in High Energy Piping:

Following the failure of secondary feed water pipe to steam generator in KAPS-2 in February 2006, AERB asked NPCIL to institute a surveillance programme for monitoring the health of high energy secondary cycle piping in all the operating reactors. Pursuant to this, a comprehensive programme was undertaken by NPCIL in all stations to monitor the vulnerable areas of high-energy piping. As per this, nearly 3000-4000 locations were identified in each NPP, where thickness gauging was undertaken. Programmes have also been established for future monitoring and/or replacements.

Reactor Power Oscillations at Tarapur 3&4

Tarapur Atomic Power Station-4 was operating up to 90 % FP till April 8, 2006. AERB restricted the operation of TAPP- 4 to 50 % FP as bulk neutron power oscillations occurred on a few occasions due to malfunction of Reactor Regulating System (RRS). Specially constituted task teams of experts analyzed the occasional malfunction of RRS and recommended remedial measures. These remedial measures were implemented in TAPP-3 and TAPP-4 progressively.

Incident of PHT Instrumented Relief Valve opening at Narora

On October 4, 2008, an incident of opening of instrumented relief valve of primary heat transport system of NAPS-1 due to rupture of its actuator diaphragm had taken place. The incident resulted in actuation of Emergency Core cooling System, containment box-up and injection of light water into PHT system. AERB permitted restart of the unit only after satisfactory completion of investigations related to the thermal hydraulic behaviour of the system, containment pressurization during the event, operator actions, adequacy of operating/emergency procedures & operator information system and the reasons for opening of IRV among other aspects.

Actions taken based on Industrial safety Issues

- The clearance for excavation for Kaiga Project Units-3&4 was suspended on January 17, 2002 due to two fatal industrial accidents in the month of Nov. 2001 and Jan. 2002. AERB insisted that NPCIL should establish a separate safety organization for the project. AERB revoked the suspension of excavation clearance on January 29, 2002 after NPCIL established the safety organisation and satisfied other requirements as stipulated by AERB. AERB verified the compliance with its stipulations by NPCIL during another special regulatory inspection carried out in February 2002.

- Construction consents for RAPP-5&6 were suspended on June 29, 2007 subsequent to 3 fatalities resulting due to similar conditions occurred in a period of 6 months. Revocation of suspension was done on July 5, 2007 after detailed safety review by AERB of the corrective actions taken by the site and NPCIL.

- The construction related activities at KAPP 3&4 were suspended in 2010, after a fatal accident at the site on 21st February 2010. An inspection was conducted by AERB and a compliance report was submitted by the site. NPCIL also submitted a corporate review plan for the safety management systems at NPCIL sites. Subsequently, a special inspection was conducted by AERB and permission to restart the work was granted.

Besides the major enforcement actions brought out above, AERB has taken several actions based on the findings of its regulatory inspections and safety reviews carried out by AERB. These actions are brought out in AERB annual reports which are available on AERB website (www.aerb.gov.in).

Q. is there public involvement in AERB's regulatory process?

AERB agrees that the regulatory process should have involvement of informed expertise and representative of diverse backgrounds to bring wide spectrum of opinion so that all issues are addressed. To this end, AERB involve experts from outside organization, including those from academic institutions, other ministries (MoEF, CEA, etc) and independent individual experts.

However, the desirability of public participation in review process of AERB has been raised in recent past. In this regard, AERB had also received a request from Konkan Bachao Samiti to allow public participation in the review procedure of AERB. Following this, Chairman, AERB constituted a Committee under the Chairmanship of Prof. S.P. Sukhatme, Former Chairman, AERB to identify approaches for public participation in the existing process for site approval.

The report of the Committee suggested salient elements for incorporation in the existing process. Board noted that two models for public participation were proposed by the Committee. As per Model-1, utility shall submit Nuclear Safety Assessment Report (NSAR) and Radiological Safety Assessment Report (RSAR) containing information on the proposed plant and its impact on public and environment which shall be reviewed by a taskforce of AERB to verify the adequacy of information and its consistency with Site Evaluation Report, Design Basis Information. Subsequently, the utility shall release these documents to public for comments. AERB along with local authorities shall conduct a public meeting and the comments raised by public during the public meeting and the comments received on NSAR and RSAR shall be reviewed by independent Appraisal Committee. The Board of AERB shall finally consider the documents, the review report of Appraisal Committee and also the recommendations of ACPSR for siting which comes to it as part of the existing consenting process. The decision of the Board shall be communicated to utility and public. As per Model-2, instead of AERB organizing the public meeting, a combined public hearing shall be conducted by SPCB/UTPCC on behalf of MoEF and AERB shall participate in the public hearing to address queries coming under its purview and receive comments related to NSAR and RSAR.

Separate interaction of AERB with the public, as suggested in Model-1, would come at a date later than the public hearing conducted by MoEF as per the existing process. While MoEF Clearance is essentially linked to the characteristics of a site and its surroundings alone; the Siting Consent given by AERB is linked to the site characteristics as well as the plant design. Therefore, AERB would be better prepared to answer the comments and queries of the public by setting the date for the public meeting (in Model-1) / public hearing (in Model-2) after the safety review by SEC and ACPSR is over. By then, data related to the site as well as plant design would be almost in final form prior to Public meeting /hearing.

Q. Is AERB transparent in its functioning?

Yes. The highlights of the safety review carried out by AERB and clearances issued, review of significant events and over exposure, radioactive discharges from nuclear facilities, exposure details of workers in nuclear and radiation facilities, industrial safety statistics of DAE units, safety promotional activities, status of international co-operation, safety research being undertaken, enforcement actions taken etc are published in AERB's annual reports and newsletters in a transparent manner as per established practice.

A web-site is maintained by AERB which gives the organization structure, role and responsibilities of the organization and relevant informations about AERB's activities that are updated from time to time. A newsletter is published periodically. Annual reports and newsletters are available on AERB's website www.aerb.gov.in.

In case of any off-normal occurrence at DAE facilities that is of safety concern in public domain, press releases are issued and press conferences are conducted, if necessary. Safety information notices are also occasionally issued by AERB on general matters of safety importance. Senior officers of AERB also give talks on radio and partake in interviews, discussions, etc. on television on nuclear and radiation safety matters for providing information to the society at large.

Topic 3: Safety Aspects of Nuclear Power Plants

Q. What are the safety features in a Nuclear Power Plant?

In nuclear reactors, energy is generated by fission of certain uranium or plutonium nuclei in a continuous chain reaction. In addition to energy, the nuclear fission produces fission products that are radioactive. In order to ensure safe operation of nuclear reactor, three safety functions have to be achieved in sustained manner. These safety functions are :

- Control of fission reaction
- Cooling of the reactor core, and
- Containment of the radioactive fission products

NPPs are designed to fulfill all the above safety functions with very high reliability. This is achieved by providing redundancy and diversity in safety systems. To provide redundancy, the number of equipment/systems is more than what is needed so that failure of an equipment does not impair the function. Further to rule out common mode failure of similar equipment or systems to achieve the same function, another system using a diverse principle is used. All systems and components are designed to be fail safe, i.e. they come to safe configuration in case of failure. Application of these principles to specific safety functions is elaborated in the following paragraphs.

Control of reactor

The reactors are controlled by controlling the population of neutrons by use of neutron absorbers like boron and cadmium. In most of the reactors, the primary control is achieved by the control rods containing boron. These control rods are raised or lowered in the core to regulate the power. For shutting down the reactor the control rods are completely inserted into the reactor. In addition to this shutdown system called primary shutdown system, a secondary shutdown system is provided in reactors which may either have another set of control rods or a liquid addition system to add neutron absorber into the reactor core.

The shutdown systems are designed to be fail-safe. Hence in case of power failure the rods drop due to gravity or the liquid poison is injected due to accumulator gas pressure.

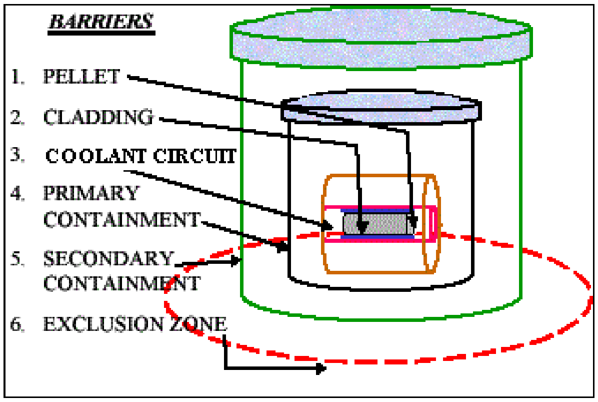
Maintenance of core cooling

During normal operation, heat is generated in the core due to nuclear fission. Even when the reactor is in shutdown state a small amount of heat is generated due to the decay of fission products (decay heat). The intensity of decay heat reduces slowly with time. The reactor therefore needs cooling continuously in all states. To achieve reliable cooling normally two or more coolant circuits are provided. This helps in removal of heat in case of failure of one circuit. To further improve reliability, the coolant pumps are provided with backup power supply from diesel generator and battery banks, which supply power during grid failure. Also the coolant circuits are designed in such a way that they are conducive for dissipation of heat by natural circulation. Hence even when all the sources of power is lost, decay heat removal from the core is ensured.

All the reactors are also provided with emergency core cooling system, which is independent from normal cooling systems. The emergency core cooling system ensures cooling of the core even if there is a leak in the coolant circuit.

Maintenance of barriers that prevent the release of radiation

Radioactive materials are produced in the core of the reactor when fission occurs. Most of these fission products remain within the fuel itself under normal circumstances. However, to further prevent their release to the environment at least three successive barriers are provided. The first barrier is the fuel clad within which the fuel is enclosed. The second barrier is the leak tight coolant circuits. The third barrier is the containment building around the coolant systems. In some of the reactors, a secondary containment is provided for further protection.



As an abundant precautionary measure the place surrounding 1.6 Km from the reactors are declared as exclusion zone where no permanent residence is allowed. All the NPPs develop an emergency prepared plan before start of operation. This includes declaring an low population zone 4 Km around the reactor and 16 Km surrounding is envisaged as emergency planning zone.

Safety features in Indian NPPs

Apart from the first two Boiling Water Reactors (BWR) at Tarapur (TAPS 1&2) which are in operation since 1969, eighteen Pressurized Heavy Water Reactors (PHWR): sixteen of 220 MWe and two of 540 MWe at five locations: Tarapur (TAPS 3&4), Kalpakkam (MAPS 1&2), Narora (NAPS 1&2), Kakrapar (KAPS 1&2), Kaiga (KGS 1 to 4), and at Rawatbhata (RAPS 1 to 6) are now in operation.

Presently four 700 MWe PHWR units are under construction and two 1000 MWe Russian designed Light Water Reactors (LWR) based NPPs are under commissioning at Kudankulam in Tamil Nadu. In addition, a 500 MWe indigenously designed fast breeder reactor (FBR) is under cosntruction at Kalpakkam.

The first two units of 220 MWe PHWR, based on standardized Indian design, were constructed at Narora. The standardized design plants are provided with two failsafe independent and diverse shutdown systems to achieve guaranteed reactor shutdown state with very high reliability. The first shutdown system is gravity driven solid rods, where as the second one passively injects liquid poison in reactor core, besides this reactivity control is done by reactor regulating system for normal operation.

For effective removal of heat form the reactor core under accident condition emergency core cooling system has been envisaged. Being the steam generators at higher elevation than core the reactors can remove heat through thermo-siphon in the event of station blackout. The concrete vault housing the calandria (reactor vessel) is filled with water. This provides a large heat sink against progression of any core melt accident. Availability of large volume of low pressure moderator in the calandria is also an inherent advantage for core cooling in case of an accident.

All the standardized PHWR based NPPs are provided with double containment with inner primary containment of pre-stressed concrete acting as a primary barrier against release of any radioactivity to the atmosphere in the event of an accident. The primary containment is designed conservatively for a pressure much higher than that estimated to occur during the postulated design basis accident. Thus it can prevent releases even in case of certain level of beyond design basis accidents.

For the plants constructed before NAPS (viz. TAPS-1&2, MAPS-1&2, RAPS-1&2), significant safety improvements have been carried out through backfits and safety upgrades based periodic safety reviews and special reviews conducted when these NPPs were approaching the end of their originally proclaimed design life . Major improvements are related to seismic safety, emergency core cooling and ageing management.

India has also witnessed a few significant events at its NPPs, namely a large fire at NAPS in 1993, flooding at KAPS-1&2 in 1994, and tsunami at MAPS-1&2 in 2004. Lessons learnt from these events as also from relevant events at NPPs abroad have been incorporated by appropriate improvements in design and operating procedures.

The two VVER units at Kudankulam and the FBR at Kalpakkam are of advanced designs and besides having all the regular designed features they are incorporated passive air cooled systems for removal of core heat during extreme emergency conditions.

Topic 4: Safety Assessment of Nuclear Power Projects

Q. How Government ensures safety of nuclear power plants?

The basic safety concern in any Nuclear Power Plant (NPP) is to ensure that individuals, society and the environment are adequately protected from harmful effects of radiation. The safety objectives flowing from this concern are:

(i) assured capability to shut-down the nuclear reactor whenever a need for this arises, (ii) adequate cooling of the nuclear fuel during reactor operation as also during reactor shut-down condition, and (iii) ensuring that there is no unacceptable release of radioactive material to the environment even under a highly unlikely accident conditions.

To meet these objectives, the NPPs are designed using (a) principles of defence-in-depth whereby there are multiple barriers against release of radioactivity, (b) fail-safe design wherein any component or service failing would result in the reactor automatically coming to a safe shutdown state and (c) redundancy, diversity and physical separation criteria such that failure of a single component or a single train of components or any common cause failure like flood or fire does not jeopardise safety.

Prior to grant of siting consent, evaluation of the proposed site is carried out as per the requirements laid down in AERB's Code on Siting of nuclear power plants. All the characteristics of the proposed site, the impact of the plant on site and impact of site on plant (viz. effect of external events such as earthquake, flood etc) on plant are checked against the norms specified in the code.

Towards granting clearance for start of construction, a detailed review of the plant design, design basis of the reactor and all its auxiliary systems and also safety analysis for Normal Operation, Anticipated Operational Occurrences, Design Basis Accidents and Beyond Design Basis Accidents is carried out. These analyses are based on a set of Postulated Initiating Events, both internal and external to the plant, as prescribed by AERB. Special emphasis is also given on industrial and fire safety aspects at this stage.

Commissioning is the process by which constructed plant components and systems are brought into service and are tested to ensure that their performance is in conformance with the design intent. Commissioning consent is given in a number of sub-stages and at each sub-stage reports of commissioning test results of various systems are reviewed prior to grant of the consent as specified in the relevant AERB Safety guides. Technical Specifications for Operation, which lays down various parameters for safe operation of the plant is revised based on the commissioning experience and approved by AERB. Licensing of Operations Manpower, and approval of Radiation Protection Procedures and Emergency preparedness plans by AERB is carried out prior to initial fuel loading of reactor.

After successful demonstration of operation at rate power level and review of the various results, license for continued operation at power is issued by AERB for a period of 5 years. After this, AERB establishes the system of regulatory review and assessment by way of reporting obligations and periodic safety review in accordance to the “Code of practice on safety in nuclear power plant operation”. Compliance to the regulatory requirements is verified by conducting periodic regulatory inspections.

Q. Safety Assessment of Operating Nuclear Power Plants

The operational performance and significant events are reviewed and the required modifications are implemented by the utility. Analysis of internationally reported events and their applicability to Indian NPPs is also checked and accordingly the systems, procedures and aspects related to training & safety culture are further improved. Some of the important events from which lessons learnt were

Three Mile accident, Chernobyl accident and Narora Fire incident. The Fukushima event review has been completed by AERB Expert Committee and its Report has been accepted by Board and AERB. Certain actions have been asked to be taken by the operating plants immediately/time bound manner.

Each station is required to plan and prepare annual budget for collective exposure of occupational workers and get it approved by AERB. The budget preparation takes into account the operational experience, in-service inspections, surveillance checks, bi-ennial maintenance activities and any other major upgrades planned.

The safety review of operating plants comprises of the following major elements:

(1) Review of periodic reports submitted by the plant.

(2) Review of off-normal occurrences of safety significance.

(3) Periodic regulatory inspections as per prescribed procedure.

(4) Review of proposals for modification in hardware, control logics, plant configuration and procedures.

(5) Reports of Special Investigation Committees and/or special regulatory inspections following an event of major safety significance.

(6) Brief but comprehensive periodic safety review every 5 years.

(7) Elaborate periodic safety review every 10 years.

Under the existing legal framework, AERB issues license for operation of NPPs for a period of five years. The renewal of license is issued by AERB based on periodic safety reviews as specified.

AERB conducts a brief but comprehensive safety review every 5 years for all plants, towards Renewal of their Authorisation for operation. For all plants detailed and comprehensive Periodic Safety Reviews (PSR) are also done every 10 years. AERB safety guide on "Renewal of Authorisation for operation of NPPs" provides guidelines for carrying out a comprehensive Periodic Safety Review (PSR). After completion of such safety reviews, the authorisation for nuclear power plant operation is granted for a period of 10 years. The Periodic Safety Review considers the cumulative effects of plant ageing and irradiation damages, results of in service inspection, system modifications, operational feedback, status and performance of safety systems and safety support systems, revisions in safety standards and technical developments, radiological protection practices, etc. These comprehensive reviews are intended to further ensure a high level of safety through out the life of the plant. Following these reviews, a number of NPPs have undergone such safety upgrades.

Regulatory Inspection and Enforcement

Depending upon the requirements, AERB staff carry out periodic regulatory inspections as well as special unannounced inspection to review safety status and verify compliance with regulation.

Generally for operating NPP, these inspections are carried out twice a year. For NPP under construction and commissioning, the inspection are carried out once in every three months or more often as necessary. Special monthly inspections are carried out w.r.t industrial safety during construction and commissioning of nuclear power plants. During regulatory inspection, documented evidences for compliance to the regulatory requirements/consent stipulations are inspected. Besides routine regulatory inspections, AERB also carries out special regulatory inspections with specific objectives as deemed necessary. Such inspections are carried out subsequent to a safety significant event or after major modifications in the plant and forms the basis for considering clearance for restart of the unit.

During regulatory inspections, if major non compliances or serious lapses of safety regulation are observed, appropriate enforcement actions are taken. Depending on the seriousness, these actions could range from shutdown of plant till rectification of deficiencies, suspension or withdrawal of license.

Licensing of Operators

Licensing of plant personnel is another important aspect of the AERB's responsibilities. It is a mandatory requirement that personnel in operational positions at nuclear facilities should be formally licensed and qualified for various levels by the AERB. The entire process is exhaustively documented in two manuals, “Licensing Procedure for Operating Personnel” and ‘QA Manual for Station Licensing Examination’. The competence requirement and the depth of knowledge and skills for each operational position are verified through a series of performance and knowledge checks prescribed in these manuals. Final verification is done through a written examination followed by certification by the AERB Committee. The licenses are valid for a period of 3 years and have to be renewed thereafter according to a prescribed procedure.

Review of Radiation Exposures and environmental releases

Under the enabling provisions of Atomic Energy (Radiation Protection) Rules, 2004, AERB specifies through orders and directives, the dose limits for the radiation workers as well as for the members of public. AERB has prescribed an annual dose limit of 30 mSv for radiation workers and a limit of 100 mSv over a period of five consecutive years. For members of public, AERB has specified a dose limit of 1 mSv in a year. AERB has also specified an investigation level at 20 mSv/year for occupational exposure and reviews the circumstances under which any radiation worker in the country has been exposed to more than the investigation level. Finding the root cause for high exposures and suggesting remedial measures to reduce such exposures in future is the prime objective of such review.

Environmental surveillance of all operating plants under Department of Atomic Energy is done by an Environmental Survey Laboratory at each site. These laboratories are established well before the plant goes into operation to enable collection of data on account of background radiation. The radiological impact due to operation of these plants is assessed on a continuous basis by collection and analysis of samples of items of diet, i.e., vegetables, cereals, milk, meat, fish, etc. Limits for radioactivity release to the environment through both gaseous route and liquid route is given in the technical specifications of each plant and approved by the regulatory body. The gaseous discharges are done through the stack. Liquid radioactive wastes are discharged after adequate dilution. Solid radioactive wastes are disposed in tile holes or in concrete trenches and buried. A separate authorization for disposal of solid, liquid and gaseous wastes is issued by AERB to each NPP under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.

Safety Performance of Indian NPPs

The success and effectiveness of Indian regulatory process can be gauged from the history and statistics of safe operation of the nuclear facilities in India. Till date, there has not been any event in any of the nuclear power plants of India which has resulted in adverse radiological impact on the environment. As per the International Nuclear and Radiological Event Scale (INES), events are rated in the scale 1 (anomaly) – 7 (major accident) depending on the radiological release and its impact. The Chernobyl and Fukushima accident were rated at Level -7. Out of 156 events reported fro mIndian NPPs in the last five years, 140 belonged to Level -0 (i.e no safety significance) and remaining 16 were of Level 1. The two major events of Indian Nuclear Power Plants which has happened so far are the fire incident in turbine building at Narora Atomic Power Station (INES Scale 3) and Power Excursion in Kakrapar Atomic Power Station (INES scale 2). In both these events, there had been no radiological impact on the workers, public or the environment.

The monitoring of doses to the workers, public and environment assure that safety practices in various aspects of NPP operation are well implemented. The average dose received by the workers in Indian NPP is only a fraction of the dose limit. The public dose due to environmental releases from NPP is only 1-2% of the limit.

Failures at nuclear power plants

In avoiding severe accidents the nuclear industry has been very successful. In over 14,000 cumulative reactor-years of commercial operation in 32 countries, there have been only three major accidents to nuclear power plants - Three Mile Island, Chernobyl, and Fukushima.

- Three Mile Island (USA 1979) where the reactor was severely damaged but radiation was contained and there were no adverse health or environmental consequences

- Chernobyl (Ukraine 1986) where the destruction of the reactor by steam explosion and fire killed 31 people and had significant health and environmental consequences. The death toll has since increased to about 5
- Fukushima (Japan 2011) where three reactors (together with the spent fuel pool of the fourth) suffered major damage due to loss of cooling after a huge earthquake and a tsunami hit the plant.

At Fukushima Daiichi in March 2011, subsequent to a massive earthquake, the three operating reactors shut down automatically, and were being cooled as designed by the normal residual heat removal system using power from the back-up generators, until the tsunami struck them an hour later. The emergency core cooling systems then failed. The Fukushima accident showed new concern about the capacity of NPPs to deal with extreme natural events.

These three significant accidents occurred during more than 50 years of civil operation. Of all the accidents and incidents, only the Chernobyl and Fukushima accidents resulted in radiation doses to the public greater than those resulting from the exposure to natural sources. The Fukushima accident resulted in some radiation exposure of workers at the plant, but not such as to threaten their health. Apart from Chernobyl, no nuclear workers or members of the public have ever died as a result of exposure to radiation due to a commercial nuclear reactor incident.

Safety of Indian NPPs against External Events of Natural Origin

The AERB safety codes prescribe that the design of structures, systems and components of NPPs shall include consideration of the highest specified intensity of the postulated natural events or other external events; and consideration of the radiological consequences of such events.

As per AERB requirements, no NPP shall be located at a site that falls under seismic zone–V, which has a potential to generate earthquakes beyond Magnitude-7. In addition, it is also verified that no earthquake generating faults are located within 5km radius of the site. For evaluation of design basis ground motion for NPP, site specific studies are carried out within a region of 300 km. The older generation nuclear power plants, viz TAPS 1&2, RAPS 1&2, and MAPS 1&2 have been re-evaluated in recent years with respect to the site specific ground motion as applicable to new NPPs. Based on the findings, the structures, systems and components have been modified/ strengthened as necessary. These include provision of new emergency diesel generator buildings, modifications of battery banks, strengthening of masonry walls etc.

Flooding potential at an NPP site is considered in design irrespective of whether the NPP site is inland or coastal. For a coastal site, the design basis flood level is estimated considering maximum tsunami wave height or the combined effect of a cyclone and rainfall. Though flood levels at NPP sites on the east coast due to 2004 tsunami were lower than these estimated design basis flood levels, AERB recognized the need for a more rigorous treatment of tsunami hazard for coastal NPP sites including assessment of worst case scenario from various tsunamigenic sources, as applicable. For an inland site, the hazards are evaluated based on probable maximum flood in the water body near the site along with maximum rainfall, and, flood caused from any failure of an upstream dam.

Q) The names of atomic power stations of the country, as on date, whose life will expire in near future and the steps taken to avoid the risk of radio activity emitted from these power stations;

There are no atomic power stations in the country, as on date, whose life will expire in near future. All nuclear power plants, whether new or old, are operated as per the elaborate safety requirements laid down by the Atomic Energy Regulatory Board. With this, possibility of release of radioactivity from these plants beyond the limits specified is extremely remote. In fact, the actual releases are only a small fraction of the specified limits.

Tarapur Atomic Power Station Unit-1&2 (TAPS-1&2), Rajasthan Atomic Power Unit-1 (RAPS-1) and Madras Atomic Power Station units-1&2 (MAPS-1&2) are the old atomic power units in the country that are commissioned during the late sixties to early eighties period. All these units have been thoroughly refurbished based on their detailed ageing assessment. Several safety upgrades have also been incorporated to bring them in line with the current safety standards. After these actions, all units except RAPS-1, have been brought back into operation after detailed safety review and clearance by the Atomic Energy Regulatory Board (AERB).

RAPS-1 is kept shut down since October 2004 and a techno-economic assessment is in progress to decide on its future. Even for this unit which is under an extended outage, appropriate safety measures are in place as approved by AERB.

Details of safety upgradations in TAPS 1&2, RAPS 1&2 and MAPS

Detailed ageing assessments are conducted after the nuclear power plants have operated over considerable time periods and appropriate actions, as determined by these assessments, are then implemented. These include safety upgradations to ensure that the plants meet current safety standards. For example, a comprehensive safety assessment of our oldest NPP, viz., the Tarapur Atomic Power Station units–1&2 was carried out after completion of its 30 years of operation. Review of its design basis, safety analysis, probabilistic safety assessment, seismic re-evaluation and inspections related to ageing management were performed. Based on the review, TAPS carried out required upgradations in several of the plant systems. These include:

i. Construction of a separate seismic qualified building for housing the emergency diesel generators.

ii. Replacement of the existing 3 x 350 kW diesel generators with 3 x 800 kW capacity diesel generators.

iii. Unit-wise segregation of 250 V DC and 48 V DC panels and battery banks.

iv. Provision of supplementary control room.

v. Unit-wise partition of cable spreading room.

vi. Unit-wise segregation of shutdown cooling system and separating the fuel pool cooling system from shutdown cooling system.

vii. Provision for independent stand-by Control rod Drive hydraulic system pumps for both the units.

viii. Installation of strong motion seismic instruments.

The activities of upgradations and commissioning were reviewed by AERB and found satisfactory. AERB authorized the plants for operation for a further period of 5 years, i.e., up to March 2011. A similar review exercise will be conducted again in 2011 before the plant is allowed to operate further. In addition extensive regulatory inspection covering all areas having safety implications is conducted every six months. If these inspections reveal any shortcomings, appropriate actions are taken. Regulatory Inspections combined with Periodic Safety Reviews at all operating plants provide a high degree of assurance of safety.

Similar safety assessments have also been done for the Rajasthan Atomic Power Station units–1&2 and the Madras Atomic Power Station units–1&2 that were commissioned during early seventies and early eighties, and appropriate actions including safety upgradations have been implemented in these units also.

A sound safety philosophy in design and operation, comprehensive periodic safety reviews and timely & appropriate ageing assessments and implementation of required actions emerging from such assessments ensures safe operation of new as well as old plants. These measures ensure that radioactivity releases from our nuclear power plants are always kept well within the permissible limits.

Q) Whether the safety and the life of the fast breeder test reactor at Indira Gandhi Centre for Atomic Research has been reviewed in view of the re-classification of seismic zones in Tamil Nadu and in the post-tsunami context?

Yes. The seismic re-evaluation of the fast breeder test reactor (FBTR)has been taken up. Detailed criteria for seismic re-evaluation of the FBTR have been developed and further work in this direction has been taken up. As per experience of seismic re-evaluation of several older nuclear power plants, no significant deficiencies in safety related structures and components of FBTR are expected.

As FBTR is located sufficiently away from the sea coast, it will not be affected by any tsunami event based on present design criteria. It is to be noted that the tsunami event of 26 December 2004 did not have any effect on FBTR.

Details of seismic re-evalaution

The latest revision of Indian standard "Criteria for Earthquake Resistant Design of Structures", IS 1893 (2002) (parts 1 to 5) places various part of India into four seismic zones ranging from Zone II to Zone V; Zone V representing highest level of seismicity. There existed five seismic zones (Zone I to Zone V) as per the earlier revision of the standard, IS 1893 (1984).

In the revised standard 1893 (2002), changes were made in the seismic zonation map of India based on the data and information on Indian seismic environment obtained after 1984. Zone I as per the earlier version was merged with Zone II. Considering higher seismicity, some areas in Zone II (like Chennai/Kalpakkam region) were placed in Zone III.

The Indian standard IS 1893 (2002) (parts 1 to 5) covers provisions for design of buildings, liquid retaining tanks, bridges and retaining walls, industrial structures including stacks, and dams and embankments, whereas the assessment of seismic hazard for nuclear power plant sites is conducted based on the AERB Safety Guide "Seismic Studies and Design Basis Ground Motion for Nuclear Power Plant Sites" (AERB/SG/S-11, 1990). AERB Guide calls for detailed site specific seismo-tectonic assessment for arriving at the design basis ground motion parameters. As per the Guide, the safety related structures of nuclear power plant are to be designed for an earthquake, whose mean return period is 10,000 years, while the return period of design basis earthquake as per IS 1893 (2002) is 475 years.

The Fast Breeder Test Reactor (FBTR) was designed and constructed in early eighties. Hence a need was felt for seismic re-evaluation of FBTR and this work is presently under progress and is likely to be completed in about one year time from now.

However, based on experience with seismic re-evaluation of several older nuclear power plants including those in India, it can be stated that any significant deficiencies in seismic design of major structures and components of FBTR is not likely. The retrofitting requirements, if any, are expected to be limited to minor components like pipe supports, cable trays, etc.

Q) In what way the Department of Atomic Energy has enhanced the safety measures at our atomic power plants

Safety of our Nuclear Power Plants (NPPs) is reviewed on a continuing basis in the light of national and international operating experience and new research findings and requisite measures are implemented for safety enhancement as necessary.

During the past few years, detailed safety reviews of our older plants viz. TAPS-1&2, RAPS-1&2, MAPS-1&2 and NAPS-1 was conducted. Based on these reviews several retrofits and safety upgrades including measures for improving seismic safety were incorporated in these units. Similar work is now being undertaken for NAPS-2.

Some of the important upgrades implemented in our pressurized heavy water reactor based NPPs were replacement of all the pressure tubes and feeder pipes, incorporation of supplementary control rooms, introduction of high pressure coolant injection in the emergency core cooling system and physical separation of redundant trains of power and control cables. These safety improvements for NAPS-1 were carried out during 2006-2007.

For TAPS-1&2 (Boiling Water Reactor), a comprehensive safety review & assessment was conducted for their continued long term operation. The activities undertaken were: review of design basis and safety analysis vis a vis current requirements, seismic reevaluation, review of ageing management & residual life of systems, structures & components and probabilistic safety assessment. Based on the above studies safety system upgrades & modifications were carried out. These systems included the electrical system, shutdown cooling system & retrofitting of supplementary control room. TAPS-1&2 were subsequently authorized for continued operation.

In the area of seismic safety improvements, a seismic reevaluation was conducted for all the older operating NPPs. The required corrective measures for meeting the seismic requirements were then carried out. The structures, system & equipment of safety systems & safety support systems were then qualified by seismic margin assessment methods. All the newer plants are built to current seismic safety standards.

Post Fukushima accident, a safety assessment of all the NPPs in India has ben carried out and the recommendations of AERB are being implemented in a time bound manner.

Q) The measures taken by Government to prevent any Chernobyl like accident while using the radioactive fuel on a large scale

Comprehensive safety norms in the form of safety codes and guides for Siting, Design, Quality Assurance and Operation have been established by the Indian Atomic Energy Regulatory Board (AERB) for our Nuclear Power Plants (NPP). Apart from detailed technical considerations, these norms also include the defence in depth philosophy. The defence in depth criterion ensures that there are a number of barriers and several layers of safety elements to ensure that there is no significant release of radioactivity in the public domain even in the highly unlikely event of an accident in the nuclear power plant. Further, these safety norms have been developed based on safety requirements laid down by other advanced countries and the safety standards documents of the International Atomic Energy Agency as well as our own experience during the last over three decades of operation of nuclear power plants.

All the safety requirements are strictly enforced and periodic safety reviews are also carried out to ensure compliance. The plants are operated by well qualified and trained personnel only, which further enhances the assurance of safety. The safety record of nuclear power plants in India has been excellent.

All these measures preclude the possibility of any Chernobyl type accident in Indian nuclear power plants.

Q) What was the impact of the 2004 "Tsunami" on nuclear reactors?

The Tsunami waves caused by the massive earthquake hit the east coast of India on the morning of December 26, 2004. There has been concern about the status of the nuclear reactors located on the east coast of India. As of now, in addition to operating units MAPS-1&2, a Fast Breeder Reactor is under construction at Kalpakkam. At Kudankulam in the South Penninsula, 2 VVER type reactors are also under construction. The status of reactors in the wake of Tsunami strike on December 26, 2004 is as follows:

At the time of the incident, Unit-2 of the Madras Atomic Power Station (MAPS) was operating at its authorised power and Unit-1 of the MAPS has been under long shutdown since August 2003. Seawater entered the pump house through the intake tunnel, and the water level in the pump house increased up to Condenser Cooling Water (CCW) pump stool level. This resulted in tripping of Condenser Cooling Water pumps. On observing this, the control room operator tripped the turbine and consequently the reactor tripped on high pressure in pressurised heat transport (PHT) system. Cool down of the PHT system was initiated by opening the steam discharge valves. One process seawater pump was kept in service, providing cooling water for the process water system. Class IV electrical power supply was available through out the incident. Two emergency diesel generators were started and kept operating as a precautionary measure. Reactor was brought to a safe shutdown state.

There was seawater inundation (about 0.5 m) over the ground/road upto the east periphery of the turbine building. There was no entry of seawater in the reactor building, turbine building and the service building.

To assess the impact of Tsunami waves, a team of senior inspectors from Atomic Energy Regulatory Board (AERB) visited the nuclear reactors at Kalpakkam on 29 December 2004. The AERB Team inspected all the important areas of the plant including the reactor building, the control room, the turbine building, the pump house, jetty, firewater pump house and outer peripheral areas of the service building. All systems, services and structures were found to be in good condition. All radiological conditions in the plant were normal and there was no release or discharge of radioactivity from the plant. The AERB team also noted that the operator response to the event was satisfactory. AERB team concluded that the NPP did not suffer any damage. Based on the AERB inspection, Unit-2 of MAPS was allowed to resume operations. The Unit-2 was restarted on January 2, 2005 and remains operational.

The Fast Breeder Test Reactor (FBTR) at Indira Gandhi Centre for Atomic Research (IGCAR) at Kalpakkam and associated facilities were also inspected by the team. There was no incidence of seawater ingress into these areas. The FBTR, which was shutdown at the time, was subsequently restarted on January 5, 2005.

At the construction site of the Fast Breeder Reactor (FBR 500 MWe) Project, concreting of foundation raft was in progress. The Tsunami flooded the foundation raft pit and quite a few of the civil construction equipment were submerged in seawater. Due to an advance warning by an alert construction worker, all the workers involved in the concreting job escaped from the pit before it could flood.

There were no injuries or fatalities inside the premises of MAPS and at IGCAR. But there were some casualties in the Kalpakkam township which is a residential area for the plant workers. The township is situated quite close to the seacoast about 7 km from the Power Plant site. A number of houses situated towards the seaward side suffered damage and fatalities. This was the situation throughout the east coast. The tourist resort town of Mahabalipuram and the Tamil Nadu State capital Chennai were also affected by the Tsunami and suffered fatalities.

There was no impact of Tsunami on the Kudankulam nuclear power plant site (KK-NPP). During the event, the maximum water level rise was 2.0 m above Mean Sea

Level (MSL) which is well below the Design Basis Flood Level (DBF) of 7.5 m above MSL for the site. It is concluded that an adequate margin against flooding at the site for external event such as Tsunami exists at KK-NPP.

Q) The details of criteria/norms fixed for inspections of NPP

Regulatory inspections are carried out in the important areas that include, Nuclear Safety, Health Physics, Waste Disposal and Industrial Safety. These inspections are carried out as per the detailed guidelines given in AERB Safety Guide, SG/G-4 titled 'Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities'. The detailed inspection procedure and checklist given as per AERB Safety Manual AERB/NMP/SM/G-1 are followed during the inspections. A typical regulatory inspection is carried out by a team of about 5 AERB officials over a 3-4 days period.

Q) How is safety assessment of Kudankulam nuclear power plant being carried out?

AERB is carrying out detailed safety review of the KudanKulam Nuclear Power Plant (KK-NPP), imported from Russia, as per the established practice even though the Russian Regulatory Body, GAN has carried out required review and certified that the plants are licensable in their country.

The safety review of KK-NPP which is a Pressurised Water Reactor (PWR) based plant is being carried out in AERB for the first time utilizing the experience available for review of indigenously built Pressurised Heavy Water Reactors (PHWR); expertise available in BARC and other DAE units, reputed academic institutes in the country and former employees of DAE units and AERB.

AERB constituted an Advisory Committee in the year 1994 which discussed the safety requirements as stated in the Technical Assignment document prepared by NPCIL and other project related aspects. Subsequently, consequent to the revival of the project, AERB constituted the Advisory Committee for Project Safety Review of Light Water Reactor (ACPSR-LWR) in 1999 and also formed KK-Co-ordination Group (KK-CG). ACPSR-LWR constituted twenty Specialists Groups for in-depth review of all the chapters of the Safety Analysis Report

(SAR) of the project and a few specialized topics such as design of reactor pressure vessel, materials specific to Russian design, water chemistry, etc. The ACPSR-LWR, KK-CG and associated Specialist Groups reviewed aspects related to quality assurance, design safety, safety analyses, construction, commissioning, operation, etc. ACPSR-LWR also discussed in detail various observations/recommendations made by GAN during review of SAR and IAEA reports on VVER-1000 design. Multi-tier safety review process (I-level review by KK-CG and SGs, II-level review by ACPSR-LWR and III-level review by Board of AERB) has been followed for issue of major regulatory consents.

NPCIL had submitted an Application in January, 1988 requesting Clearance for Siting of 2 x 1000 MWe Russian VVERs. The application along with relevant documents were reviewed by various Safety Review Committees of AERB as per the multi -tier review practice followed in AERB. Accordingly, in November 1989, AERB granted Clearance for Siting for 2 x 1000 MWe VVERs at Kudankulam Site. In June 2011, following the established multi-tier safety review, the unit was permitted to carry out ‘hot run tests’. The main objective of 'Hot-Run' is to verify the conformance of systems with specified design requirements without actual loading of the fuel. Consequent to the Fukushima event, NPCIL had constituted Task Forces to review the safety status of various nuclear plants including KKNPP. NPCIL submitted the interim report of the KKNPP task force in June, 2011. The task force had identified various short term and long term measures to be incorporated in KK NPP to take care of extreme natural events. This interim report was reviewed by AERB. NPCIL’s action plan for implementation of various measures post Fukushima accident will be reviewed by AERB prior to issuing clearance for loading of fuel in the reactor.

Topic 5: Radioactive Waste Management and Environmental Safety

Q) The methods of disposal of atomic waste being adopted in India?

Nuclear fuel cycle and radiation facilities generate gasesous, liquid as well s solid waste containing varying levels of radioactivity. In order to regulate and control the generation and disposal of radioactive wastes from nuclear and radiation facilities. Atomic Energy (Safe Disposal of Radioactive Wastes) Rules 1987 (GSR-125) which was promulgated to have a uniform national policy in accordance with international practices. Chairman, AERB is the Competent Authority to enforce these rules. The waste disposal rules cover aspects ranging from the processes resulting in the generation of radioactive wastes to conditioning, storage and disposal of such wastes. As per these rules, it is mandatory for every installation generating radioactive waste to obtain an authorisation from AERB for disposal of the waste.

Established procedure for issuance of authorisation is in vogue. Accordingly, the applicant has to submit information regarding the process, estimated volume and radioactivity contained in the waste, equipment and systems provided to monitor and control the radioactive materials and to reduce releases, safety devices incorporated to contain the effluents and control their releases during normal and anticipated operational occurrences, methods of conditioning, treatment and disposal, location of disposal site, availability of trained personnel, etc.

The authorisation process involves assessment of the radioactive waste management systems, evaluation of data on waste quantity and activity, evaluation of radiation protection measures provided for waste management operations, characterisation of wastes, assessment of radiological impact on the public and environment, etc.

After due assessment, AERB grants authorisation to perform activities for the safe disposal or transfer of radioactive materials under GSR-125. The authorisation stipulates the limits on the quantity, concentration, nature and rate of release, monitoring requirements and record keeping. The records should contain details such as, quantity, physical state, chemical characteristics, mode of disposal, concentration of radioactive material, site of disposal, data on periodic surveillance around the disposal site, etc. The facility has to maintain this record and it shall be subject to regulatory inspection by AERB from time to time. Quarterly and annual summary of these records is also required to be sent to AERB. Special authorisation are required to be obtained from AERB for disposal of waste arising from any special operations.

A system of safe disposal of radioactive wastes and its appropriate regulatory control is in place in India, to ensure that radioactive wastes disposal does not cause any undue hazard to the working personnel, public and the environment.

Routine radiological surveillance is instituted for (a) the waste disposal areas (b) environment in their vicinity and (c) underground water. The radioactivity discharged to the environment through atmospheric, aquatic and terrestrial routes are monitored and accounted to ensure that authorised limits are not exceeded. Environmental Survey Laboratories (ESL) have been established at all nuclear power plant (NPP) sites to monitor the environment for any radioactivity due to releases from the NPP. Thousands of samples of different environmental matrices, milk and food items are analysed every year to confirm that radioactive releases are within the prescribed limits.

India considers spent fuel as a resource. It is currently stored safely at each Nuclear plant site. Indian nuclear programme envisages reprocessing of spent fuel to recover plutonium and depleted uranium. The high level waste arising will be disposed off as per international practice. Technologies such as vitrification of high level wastes (rendering radionuclides indispersible by incorporating in glass matrix) exist in India.

A system of safe disposal of radioactive wastes and its appropriate regulatory control is in place in India, to ensure that radioactive wastes disposal does not cause any undue hazard to the working personnel, public and the environment.

Q) Whether any study has been conducted or proposed to be conducted to ascertain the effects of these plants on people staying nearby?

Environmental surveillance at all NPPs is carried out by an Environmental Survey Laboratory at each site. These Laboratories are established well before the plants go into operation to enable collection of data on account of background radiation. The radiological impact due to operation of the plants is assessed on a continuous basis. Limits for radioactivity release to the environment through both gaseous and liquid routes are prescribed in the technical specifications of each plant and approved by AERB. The radioactive gaseous wastes are discharged through a tall stack to ensure appropriate dispersion in the atmosphere at a height. Liquid radioactive wastes are discharged to the nearby water bodies after adequate dilution. Solid radioactive wastes are buried in earth trenches or tile holes or concrete trenches that are provided at each site.

> Monitoring over several years in the past has indicated that the radiation received by persons residing in the vicinity of the station is only a very small fraction of the dose limit of 1 mSv/ year prescribed by AERB.

Conventionally, radiation dose committed to a member of public at the boundary of the exclusion zone (fenced area of about 1.6 km radius around the plant) is used as one of the measures of environmental impact of a NPP. This radiation dose is estimated based on measurements of radionuclide concentrations in the items of diet, i.e., vegetables, cereals, milk, meat, fish, etc and intake of air and water.

Topic 6: Safety in uranium mining and milling (and around tailings pond)

Q) Is the Government aware that radioactive waste from three government owned uranium mines has put about 50,000 people in Jharkhand's Jaduguda at risk with serious radiation related health problems;

Q) Is the government aware that on studying 9000 people in five villages near the mines owned by the Uranium corporation of India Limited (UCIL), researchers found congenital deformities, sterility, spontaneous abortions and cancer alarmingly high among the tribals.

Q) What is the government doing to stop the company from dumping waste from mines in open fields and transporting uranium ore in uncovered dumpers; and

People in Jharkhand's Jaduguda area are not at any risk with radiation related health problems due to uranium mining by Uranium Corporation of India Limited (UCIL).

At the uranium mines and the uranium ore processing mills, following safety measures are in place:

- Personnel and workplace radiation monitoring by experts of Bhabha Atomic Research Centre and review by Atomic Energy Regulatory Board;
- Discharge of wastes from the uranium ore processing mill only after monitoring and conforming to the statutory discharge norms;
- Regular environmental radiation surveillance;
- Access control around the trailing ponds;

- Measures like impervious lining of tailings ponds and soil capping of trailing ponds that are not in use now;
- Periodic medical examination of occupational workers.

Waste from uranium ore processing mills (trailings) is stored in properly engineered trailing ponds under the control of UCIL. Transportation of uranium ore is done by trucks covered with tarpaulin to avoid any spillage.

Following additional precautions are adopted for the trailing ponds,

- Proper access control and fencing all around,
- Collection of seepage water through the garland drain around the ponds and its treatment before discharging,
- Regular radiation monitoring

DAE has in place a well organized workplace and environmental monitoring programme for radiation and other parameters with potential for impact on health. Environmental Survey and Health Physics Unit (ESL/HPU) set up at site by the Bhabha Atomic Research Centre from inception of the mining and ore processing operations (since 1965 in case of UCIL) monitors safety at the mines, mill and surrounding environment.

The radiation levels in the mine and mill is well within the prescribed limit and actual exposures of workers to radiation are only a fraction of the prescribed limit. At such low levels no radiation related ill effect on health is expected.

Average radiation level at the nearby villages varies in the range of 0.08 - 0.17 micro-Gray/hour. This is comparable to the background radiation levels of 0.1 to 0.13 micro-Gray/hour at Tatanagar railway station (25 km, North-West), 0.08 to 0.13 micro-Gray/hour at Ghatsila (25 km, East), (0.15 to 0.21) micro-Gray/hour at Musaboni (20 km, East) etc.

In view of media reports brought out from time to time regarding alleged ill-effects of radiation around uranium mining facilities in Jharkhand, a medical survey of inhabitants within 2 km of UCIL facilities was carried out in 1998-99 by a team of doctors and scientists from BARC, Bihar Government and Tata Main Hospital, Jamshedpur. Seventeen settlements from 8 villages comprising of about 3400 inhabitants were examined. The team “was convinced and unanimously agreed that the diseases pattern cannot be ascribed to radiation exposure in any of these cases”.

The villages around the uranium mines, mills and tailings ponds have been surveyed from time to time by various agencies appointed by Government and the reports show that the incidence of diseases including cancer in these areas is comparable to that of national average. A health survey of 598 villagers residing near Jaduguda was carried out between January-December 2006, which included 152 males, 217 females, and 229 children below the age of twelve. As per the survey results-

- No case of congenital malformation and mental retardation was detected.
- No cancer cases were found.
- The number of infertility cases amongst married women is 2, which is well below the national average.
- The villagers suffer from conventional heath problems, which could be seen in any village with similar socio-economic conditions.

There were many such studies. None indicated that any one is suffering from health effects due to radiation from uranium mining and milling operations.

In this regard, it can be noted that on a petition [Ref.(C) No 188/1999] with respect to control of radiation arising out of uranium waste, in April 15, 2004 the Honourable Supreme Court has dismissed it based on the affidavit filed on behalf of Chairman, Atomic Energy Commission, that adequate steps have been taken to check and control the radiation arising out of the uranium waste.

Q) Is the Banduhurang open cast mine facility left un-fenced and unguarded?

Entire Banduhurang open cast mine area is under the supervision of CISF guards to prohibit unauthorized entry.

Standard write-up on safety in uranium mining and milling

1.0 Introduction:

Uranium Corporation of India Limited (UCIL) is carrying out uranium mining activities mainly at Singhbhum thrust belt of Jharkhand and Cuddapah basin at Andhra pradesh. At Singhbhum belt, five underground mines, namely, Jaduguda mine, Narwapahar mine, Bhatin mine, Turamdih mine, Bagjata mine and one opencast mine - Banduhurang mine are under operation. Mohuldih underground mine is under development. At Cuddaph basin, two underground mines, one at Tummalapalle , Andhra Pradesh and one exploratory mine at Gogi, Karnataka by Atomic Minerals Directorate for Exploration and Research (AMD) are under development. Two uranium ore processing plants (mills) including tailings ponds are operational at Singhbhum belt, one at Jaduguda and one at Turamdih. One new ore processing plant at Tummalapalle is under construction. UCIL is planning for carrying out mining and milling of uranium ore at Lambapur and Peddagattu, Andhra Pradesh and Domiasiat, Meghalaya, Gogi, Karnataka and Rohil, Rajasthan.

Ore from the operating mines at Jaduguda, Bagjata, Bhatin and Narwapahar is being transported by trucks with proper cover to Jaduguda mill and from Turamdih mine, Banduhurang mine and Mohuldih mine to Turamdih mill to produce yellow cake. Ore from Tummalapalle mine will be processed at Tumallapalle mill when it will be in operation.

In the process of uranium ore processing, almost the entire mass of the mined out ore in combination with the reagents used get generated as mill tailings. The tailings contain the decay products of uranium originally present along with small concentration of unrecovered uranium. Coarse parts of tailings are sent to underground mines for filling voids. Fine parts of tailings are sent into special engineered structures known as tailings pond after pH adjustment. There are three tailings ponds for disposal of wastes from Jaduguda mill. Out of these, two ponds have now been filled to their capacities and the third pond is in service.

Water management system of UCIL includes barrage, pump house, effluent treatment plant (ETP) etc. The treated effluent from ETP after conforming the discharge norms is led to a nearby storm drain, which is finally leading to Kharkhai river.

Directorate General Mine Safety (DGMS) looks after the safety aspects of mining operations whereas Atomic Energy Regulatory Board (AERB) looks after the radiological safety aspects of uranium mines and industrial and radiological safety aspects of mills.

2.0 Radiological Safety of Uranium mine and mill workers

Radiological monitoring of uranium mines and mill is carried out by the Environment Assessment Division (EAD) of BARC stationed at Jaduguda and Narwapahar. Area monitoring programme of uranium mines and mill includes periodic radiation level survey, collection of air samples for estimation of radon and its daughters and long lived alpha activity. In addition periodic surface contamination level survey is carried out at uranium mill. Personnel monitoring of uranium mines and mill workers is done by thermo-luminescent dosimeters (TLDs) for estimation of external dose and by solid state nuclear track detectors (SSNTDs) for estimation of internal dose. Bioassay of uranium mines and mill workers is carried out for estimation of radium body burden using radon in breath analysis techniques and for estimation of uranium intake by urine analysis. All bioassay results of uranium mines and mill workers are within the prescribed limits. The average individual dose of uranium mine and mill workers for the last 5 years is shown below.

Average annual dose per person for units of UCIL:

Units	Average annual dose per person (mSv)				
	2006	2007	2008	2009	2010
Jaduguda Mill	1.93	1.77	1.95	2.19	1.71
Jaduguda Mine	5.47	5.24	4.92	4.95	3.99
Narwapahar Mine	5.23	5.77	4.41	3.64	4.83
Bhatin Mine	4.62	5.52	5.00	5.34	3.72
Turamdih Mine	6.60	6.05	4.63	6.24	7.01
Banduhurang Mine	0.68	0.56	0.85	1.46	1.32
Bagjata Mine	1.12	1.89	2.73	2.44	1.64

AERB has prescribed the annual dose limit of 20mSv for five years block with a maximum of 30mSv in a year. It can be noted that the average annual doses received by UCIL workers is well within the limit and at such low levels no radiation related ill effect on health is expected.

AERB carries out regulatory inspection of UCIL facilities twice in a year to ensure compliance of norms and stipulations. AERB's safety committee for UCIL operations carries out safety review from time to time and recommends safety measures to further reduce the doses to as low as reasonable achievable. The measures taken by UCIL over the years include enhancement of ventilation system, mechanization in the handling of radioactive substances, improvement in house keeping, use of personal protective equipment by workers and regular health check up of workers. Any new project of UCIL starting from mine development, siting of ore processing plant etc. are reviewed by AERB committees in a three-tier review system.

3.0 Radioactive Waste Management

Uranium mining and milling generates wastes in three forms, i.e., solid, liquid and gas. AERB gives authorization for safe disposal of radioactive wastes and prescribes limits for disposal of solid, liquid and gaseous wastes, both in terms of quantity and activity.

1. Solid wastes generated due to mining are stored in the form of waste dump. Every such waste dump is designed according to the guidelines of DGMS. Wastes rocks

from uranium mines contain some amount of radioactivity. As part of radiation protection programme, proper fencing, drainage, access control etc are provided which is also reviewed by AERB.

2. Mine water after treatment is re-circulated back for process use. Mill generates tailings that are transported to tailings pond in the form of slurry. In the tailings pond, solids settle down whereas, liquid is treated in effluent treatment plant (ETP). Only treated effluents conforming to discharge limits are discharged into the environment. Sludge generated in the mine water treatment plant and in the ETP is sent to the tailings pond.

3. Mine exhaust air from underground mines contain radon and its progeny. Separate gaseous discharge limits for each of the underground mines are prescribed by AERB. The gaseous emissions from grinding and milling section of uranium mill are passed through wet type venturi-scrubber before being discharged to the environment. The air from the product precipitation area is vented out through pre-filters and HEPA filters.

4. At tailings pond the fine tailings from the slurry obtained from ore processing settle down and the clear supernatant is directed to an effluent treatment plant (ETP). The treated effluent from ETP conforming to the regulatory norms is discharged to the environment.

Environmental survey laboratories of BARC stationed at Jaduguda and Narwapahar carry out periodic monitoring of the wastes discharged from UCIL facilities. Annual returns of waste generated and disposed off by UCIL are submitted to AERB under the provisions of the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 and are reviewed periodically.

4.0 Safety in Tailings Management:

4.1 *Pumping of tailings*

The large volume and low specific activity mill tailings are pumped through MS rubber lined pipelines into tailings pond. In order to avoid precipitation of manganese, the tailings are first neutralized and pumped at an alkaline pH. Round the clock patrolling all along the tailings pipelines is carried out to ensure there is no leakage of tailings. In this regard, AERB has also recommended for pressure monitoring in the pipelines carrying tailings so that leakages if any can easily be identified. About 1 meter height earthen bund along the tailings pipelines has been constructed in specified areas to prevent leakages, if any, going to public domain.

4.2 *Integrity of Tailings Pond*

Since the tailings pond contain large volume of tailings having low specific activity, it is important to ensure the integrity of the embankment and control of seepage of activity to ground water. During the design review by AERB, detailed analysis of structural stability under worst case meteorological and seismic conditions is carried out and accordingly the embankment is designed. During construction, it is ensured that the permeability of the bed is maintained below 10^{-9} m/sec (which is considered to be almost impervious) to avoid migration of radioactivity into groundwater. Spillways are constructed to collect the surface run off. The concept of defence in depth has been introduced in the latest design of tailings ponds by having a check dam as a secondary containment structure at Turamdih. The tailing ponds are fenced to prevent unauthorized access.

5.0 Radiological Monitoring of the Environment and Public

Environmental survey laboratories of BARC stationed at Jaduguda and Narwapahar carry out periodic monitoring of the surrounding environment of uranium mines, mills and tailings pond. The environmental monitoring programme includes external gamma radiation survey, measurement of radon and its daughters, radioactivity in samples of soil, surface water, ground water and flora and fauna. In addition environmental TLDs are placed at various locations in the surrounding environment to assess the integrated background dose. The environmental monitoring results are shown below. No elevation in the background dose or radon levels has been observed.

Environmental dose rate:

Integrated dose rate measured using TLD (µGy/y)		
Near tailings pond (pump hose)	Chatikocha (0.2 km SE of tailings pond III)	Jamshedpur (25km NW)
1214	937	948

Radon levels:

Average radon levels (Bqm^{-3})	
In and around tailings pond	Surrounding areas of uranium mines and mill
33-96	28-91

These measured level are having values that are near the background values and are way below the permissible limits.

Detailed studies have been carried out to estimate the dose to the population living close to the Jaduguda tailings pond. It was established that beyond the fenced area around the tailings pond, there is no additional external exposure. The additional exposure to the population living close could only be of the order of 0.05mSv per year from radon. The intake of water from the Gara river and food items from the area may contribute nearly 0.1mSv per annum. It may be noted that the dose to the member of public specified by AERB is 1mSv per annum over and above the natural background.

6.0 Occupational health safety of workers

The health of workers is periodically monitored by UCIL as a part of the periodical medical examination as per the provisions of Atomic Energy (Radiation Protection) Rules 2004 and Atomic Energy (Factories) Rules, 1996 alongwith that required by the Mines Act, 1952. AERB reviews the occupational health safety data for all the mines and mills of UCIL periodically. The results show clearly that there is no incidence of disease attributable to the radiation exposure of workers of the uranium mines and mill.

7.0 Health surveillance of nearby population

In view of media reports brought out from time to time regarding alleged ill-effects of radiation around uranium mining facilities in Jharkhand, a medical survey of inhabitants within 2 km of UCIL facilities was carried out in 1998-99 by a team of doctors and scientists from BARC, Bihar Government and Tata Main Hospital, Jamshedpur. Seventeen settlements from 8 villages comprising of about 3400 inhabitants were examined. The team "was convinced and unanimously agreed that the diseases pattern cannot be ascribed to radiation exposure in any of these cases".

The nearby villages around the uranium mines, mills and tailings ponds have also been surveyed from time to time by various agencies appointed by Government and the reports show that the incidence of diseases including cancer in these areas is comparable to that of national average. A health survey of 598 villagers residing near Jaduguda was carried out between January-December 2006, which included 152 males, 217 females, and 229 children below the age of twelve. As per the survey results-

- No case of congenital malformation and mental retardation was detected.
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- The villagers suffer from conventional heath problems, which could be seen in any village with similar socio-economic conditions.

In this regard, it can be noted that on a petition [Ref.(C) No 188/1999] with respect to control of radiation arising out of uranium waste, in April 15, 2004 the Honourable Supreme Court has dismissed it based on the affidavit filed on behalf of Chairman, Atomic Energy Commission, that adequate steps have been taken to check and control the radiation arising out of the uranium waste.

Topic 7: Safety in beach sands processing

Q) Kindly inform whether minerals Garnet, Ilmenite, Rutile, Zircon, Sillimanite are radioactive materials.

Garnet, Ilmenite, Rutile and Sillimanite are not considered as radioactive materials. Zircon, due to incorporation of radionuclides of uranium and thorium chain decay series in its crystal structure, is considered as Naturally Occurring Radioactive Material (NORM). Mineral separation and physical or chemical processing of any or all of these minerals result in enhancement of the monazite content in the left-over sands (waste) after recovery of the values.

Q) Kindly inform the average number of spontaneous nuclear transformations taking place per unit time.

The activity concentrations of ^{238}U and ^{232}Th series radionuclides in commercialzircon fall mostly in the ranges 2 – 4 Bq/g and 0.4–1 Bq/g, respectively. (Source: IAEA Safety Series No.51). Typical activity concentration of Th-232 in monazite (which invariably remain associated with Garnet, Sillimanite, Zircon, Ilmenite, Rutile and Leucoxene) is in the range 40 - 600Bq/g. (Source: IAEA Safety Series No.49)

Q) Whether the radioactive material mixed in the sand leads to mental health problem, cancer and kidney failure ?

Naturally occurring beach sands along the southern coast contain the radioactive monazite. Epidemiological studies on the cancer incidence rate carried out in these areas indicate no cases of health problems, cancer or kidney failure in these areas which can be attributed to the background radiation levels. After preferential separation of other heavy minerals from beach sands, the left over sand contain enhanced concentration of monazite. It is stipulated that prior to disposal of these monazite enriched tailings, it should be mixed with quartz rich sand or topped with quartz rich sand so that there is no increase in the background radiation levels.

Q) What is the maximum percentage of monazite mixed with the sand which will not create any problem to the local people or the labours?

As such, AERB has not prescribed any safe limit for monazite in sand. This is because monazite in beach sand varies from place to place. The beach sand of Orissa contain around 0.1%- 0.2% monazite while that in Tamilnadu contain generally around 2-3%. It is therefore stipulated that prior to disposal of monazite enriched tailings (obtained after preferential separation of other heavy minerals), it should be mixed with quartz rich sand before backfilling (if quantity of monazite enriched tailings is large and monazite concentration in tailings is < 5% or stored in trenches and topped with quartz rich sand (if quantity of monazite enriched tailings is less and monazite concentration in tailings is > 5%) so that there is no increase in the background radiation levels.

Q) Whether any special steps have been taken for mining of the materials which contain monazite?

Generally, beach sand mining employs either beach sand washings collection or dredging of beach sands and inland placers. No special requirements are stipulated for mining of beach sand containing monazite. However, the background radiation levels of the mining areas are periodically monitored.

Q) Whether the monazite mineral can be used as fuel in the Nuclear reactors?

Yes, monazite contains thorium and traces of uranium, which is being recovered for its use in nuclear reactors. Thorium will be utilized at a later stage.

Q) Whether radiation in the areas of Chinnavilai, Periyavilai, Arokyapuram, Melmidalam and Keezhmidalam of Kanyakumari district causes cancer, abnormalities such as Down's syndrome and mental illness explained in the news item?

Epidemiological studies carried out in naturally high background radiation areas (NHBRAs) indicate no cases of cancer or any other abnormalities that can be attributed to the background radiation levels.

Q) Is it true that once changes occurred in the gonads the DNA is affected and has a multiplayer effect as its is carried down through generations-which was told by the marine biologists Mr. R. S. Lal Mohan on the above news item?

Yes, the changes in the DNA can be carried down to next generations. However, international agencies like International Commission on Radiological Protection (ICRP) has taken these factors into account while recommending the dose limits to workers and public. In line with these recommendations, AERB has prescribed a dose limit of 1mSv to the members of the public above the natural background.

Standard write-up on beach sand minerals regulation

India s blessed with some of the very precious minerals namely titanium bearing minerals (ilmenite, rutile, leucoxene), zircon, garnet, sillimanite and monazite. These minerals have wide applicability in various commercial as well as strategic sectors. Hence these minerals were regarded as prescribed substances under the Atomic Energy Act, 1962 and their mining and processing were carried out solely by the units of Department of Atomic Energy (DAE).

However, in 1995, to boost up the mineral exploitation of non-strategic minerals (such as garnet and sillimanite) the prescribed substance list included only ilmenite, rutile, leucoxene, zircon and monazite. Consequently a Policy on Exploitation of Beach Sand Minerals (BSM) was notified by the Government of India in 1998 which for the first time encouraged the participation of private players in the field of beach sand mining and mineral separation.

A few facilities in Tamilnadu and Kerala forayed into the business. However, along with garnet, these facilities were also interested in separating out the titanium bearing minerals, which were still listed as prescribed substances. Hence, these facilities needed a licence from the DAE under the Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substance) Rules, 1984. In the process of issuance of licence, the applications were referred to Atomic Energy Regulatory Board (AERB) for assessment of the radiological safety aspects and only after grant of a 'No Objection Certificate' from AERB, licences were issued by DAE to these facilities.

The titanium bearing minerals (ilmenite, rutile, leucoxene), garnet and sillimanite are not radioactive minerals. Hence, naturally there were queries and doubts raised on the need of assessment by AERB from radiological safety angle. Well *prima facie*, it may seem so. However, all these beach sands minerals remain invariably associated with the radioactive mineral monazite which is the source of thorium and uranium. The preferential separation of other heavy minerals results in enhancement of the monazite content in the left over sands generally referred to as tailings.

Atomic Energy Regulatory Board took an independent assessment of all these facilities and a special Committee was constituted in 2004 with experts from AERB and BARC to evaluate the radiological safety aspects in these facilities. In view of the unregulated disposal of the monazite enriched tailings which can cause undue exposure to the members of the public, it was decided that all these facilities warrant radiological safety regulations.

In 2007, DAE decided to further delist the titanium bearing minerals and zircon from the list of prescribed substance to encourage effective utilization of these valuable minerals and their value addition. As a consequence, these facilities no longer required licence from DAE and hence, the process of radiological assessment by AERB also got stopped. The participation of private players started increasing and many facilities started mushrooming in the coastal stretches running down from Maharashtra to Kerala on the western peninsula and from Orissa to Tamilnadu on the eastern peninsula.

Hence, to take stock of all these Beach Sand Minerals Facilities especially with respect to disposal of monazite enriched tailings, a gazette notification was issued in May 2009 specifying the requirement of licence from AERB under the Atomic Energy (Radiation Protection) Rules, 2004. Subsequent to it, the detailed licensing procedure along with the requisite application forms were prepared and circulated by AERB.

Till date AERB has licensed seventeen BSM facilities and many other applications are under review. Based on the raw material input and monazite enriched tailings generated, the private BSM facilities can be categorized into four major categories.

Firstly, there are facilities carrying out mining and mineral separation of beach sands and producing ilmenite and/or garnet. Such facilities generate large quantities of monazite enriched tailings and the monazite content in these tailings is generally <5%. These facilities have therefore been recommended to mix these monazite enriched tailings with silica rich tailings prior to their disposal in the backfilled sites so that the background radiation level does not increase.

Secondly, there are a few facilities carrying out mining and mineral separation of beach sands and producing ilmenite, rutile, garnet, zircon and silimanite. Such facilities generate relatively less quantities of monazite enriched tailings and the monazite content in these tailings is generally 10-25%. These facilities have therefore been recommended to keep the monazite enriched tailings in trenches located within their premises and to top them with silica rich tailings so that the background radiation level does not increase.

Thirdly, there are certain facilities procuring ilmenite for value addition. Such facilities prior to chemical processing of ilmenite subject it to further physical separation for purification and in the process generate small quantities of monazite enriched tailings and the monazite content in these tailings is generally about 5%. These facilities generally sell these tailings to other parties who further recover the other associated mineral values.

Finally, there are facilities which procure the monazite enriched tailings for recovery of the other heavy minerals present in these tailings. Such facilities generate small quantities of monazite enriched tailings and the monazite content in these tailings is generally 10-25%. These facilities have therefore been recommended to keep the monazite enriched tailings in trenches located within their premises and to top them with silica rich tailings so that the background radiation level does not increase.

Some of the important regulatory requirements in these facilities with respect to radiological safety are designation of AERB approved Radiological Safety Officers, periodic radiation monitoring of the workplace, the waste disposal sites, identifying the radiation prone areas with caution boards etc. Records of quantities of monazite enriched tailings disposed/stored and the monazite content in the tailings and records of the dose received by the plant workers are to be maintained and periodically reported to AERB in prescribed formats. Any changes or deviation from the licensed conditions also needs to be immediately informed to AERB.

Inorder to facilitate the availability of qualified radiological Safety Officers, special five day training cum certification course pertaining to radiation safety in Beach Sand Minerals facilities was organized by Indian Association of Radiation Protection (IARP) in collaboration with the Safety Research Institute of AERB at Kalpakkam. Thus, efforts have been put forth by AERB in bringing the large sector of beach sand mineral facilities under radiological safety regulation and continuous efforts are being made to streamline these regulations so that the valuable minerals resources of India can be utilized effectively without any undue radiological exposure to the workers and the public.

Topic 8: Fukushima Nuclear Accident

Q) What happened at Fukushima Nuclear Power Plants?

A massive earth quake and Tsunami hit Japan on March 11, 2011. The combined effect of earthquake and Tsunami led to a serious accident at the Fukushima Daiichi Nuclear Power Plants (NPPs), resulting in severe damage to four out of six nuclear reactors located at the Fukushima Daiichi site. The operating NPPs (Units-1, 2, 3) at Fukushima-Daiichi got automatically shut down following the earthquake. The units-4, 5 & 6 were already in shutdown at the time of the event. The tsunami that followed about half an hour after the earthquake resulted in loss of off-site power and damage to the emergency power supply systems. Thus there was a complete loss of onsite and offsite power. The power could not be restored for a long duration and hence the plant operators could not achieve the essential safety function of maintaining adequate cooling of the radioactive fuel in the reactors and spent fuel storage pools. Inadequate cooling of the radioactive fuel led to overheating, resulting in series of developments including release of radioactivity and generation of significant amount of hydrogen from metal-water reaction. The hydrogen generated through metal water reaction exploded in the secondary containments of units-1&3. An explosion took place in the suppression chamber of unit-2. The loss of cooling to spent bay of unit-4 led to fire, damage to stored fuel & building and release of radioactivity.

Q) what were the actions taken by Government?

AERB closely monitored the progression of events based on the information through various agencies, such as International Atomic Energy Agency (IAEA), Nuclear Energy Agency (NEA), Nuclear and Industrial Safety Agency (NISA) of Japan, etc and also through media reports.

AERB convened a Board Meeting to review the safety of Indian NPPs vis-à-vis the event at Fukushima NPP. The Board members were apprised of the accident and status of the Fukushima plants, and also about the safety provisions existing in Indian NPPs for prevention of accidents of that nature. AERB Board reviewed future course of action for ensuring safety of Indian NPPs.

Immediate meeting of Safety Review Committee for Operating plants (SARCOP), which is an apex safety review committee of AERB, was convened to take stock of the safety measures available at all the operating nuclear power plants to deal with such accidental conditions. The Committee reviewed the margins for external events, extended Station Black Out (SBO) conditions, loss of Ultimate Heat Sink and external events beyond design basis, severe accident management provisions, safety of spent fuel pool and offsite emergency preparedness in all NPPs. The identified actions by SARCOP are being followed by the respective unit level Safety Committees and SARCOP.

There were public concerns about the impact of this accident on environmental conditions in India due to the radioactivity releases from Fukushima NPPs. Considering the geographical location of India with respect to Fukushima, Japan and the prevailing wind conditions towards the east direction and also based on detailed internal review, AERB concluded that there would not be any radiological impact in India due to the radioactivity release from Fukushima, Japan. To confirm this and to rule out any adverse impact, AERB kept a constant vigil on the online radiation data at 28 locations across the country provided by Indian Environmental Radiation Monitoring Network (IERMON). As expected, there was no increase in the radiation levels above normal backgrounds at any location. This information was regularly uploaded on the AERB website to allay undue fears that might arise in the public.

In the context of this accident, it is recalled that for Indian NPPs due care is taken to locate them away from areas having major seismic activity. AERB ensures that the designs of the NPPs incorporate adequate margins and provisions against such natural events of specific magnitude, which are based on conservative criteria. Some of the older plants [Tarapur Atomic Power Station(TAPS)-1&2, Rajasthan Atomic Power Station (RAPS)-2 & Madras Atomic Power Station (MAPS)-1&2] were designed for seismic considerations prevalent at that time. Subsequently, these units were re-evaluated with respect to the site specific acceleration levels. Based on the findings, some of the structures, systems and components were strengthened. These modifications included provision of new emergency diesel generator buildings, anchoring of battery banks and control room panels, strengthening of masonry walls, strengthening the supports for cable trays and ventilation ducts, etc.

Following the Fukushima accident, AERB has asked NPCIL to carry out a comprehensive reassessment of safety against external events and emergency mitigation measures at all the NPPs. The license for operation of TAPS-1&2 and MAPS-1&2 were valid till March 2011 and December 2010 respectively. NPCIL had submitted the applications for renewal of license for operation of these units for the next five years. Pending the reassessment of safety and emergency mitigation measures at these NPPs, the permission for operation of these units were granted with limited validity.

A new inspection checklist has been prepared and Special inspections of some of the nuclear power plants were carried out to review and assess the systems in light of Fukushima nuclear accident.

Further to this, AERB has taken several proactive measures post the Fukushima Nuclear Accident such as constituting an in-house monitoring cell to follow the events at Fukushima continuously and keep a close vigil on the radiation/contamination levels in Japan and India, issuing series of press releases to keep the public informed, providing daily updates on AERB website on radiation levels recorded by Indian Environmental Radiation Monitoring Network (IERMON) for 9 locations encompassing whole of India, safety status of the Fukushima units, the occupational exposure to workers and radiation and contamination levels at different prefectures of Japan.

AERB coordinated with and advised the Food Safety and Standards Authority of India (FSSAI) regarding testing of food items for contamination and for taking a decision related to import of Food items from Japan. With respect to screening of passengers coming from Japan, AERB informed National Disaster Management Authority

(NDMA) that there was no such requirement.

Chairman, Vice Chairman and Secretary, AERB issued statements at regular intervals addressing the concerns from journalists and electronic media regarding safety of Indian NPPs and also the impact of Japan incident. Through IAEA, a team of international nuclear safety experts from 12 countries including India, conducted a preliminary mission to find the facts and identify the lessons from the accident. Shri S.K. Chande, Vice-chairman, AERB was the Indian representative in the team.

AERB constituted a high level committee on March 19,2011 under the chairmanship of Shri S. K. Sharma, former Chairman, AERB comprising experts from Central Water and Power Research Station, Indian Institute of Tropical Meteorology & IIT (Madras) apart from BARC, NPCIL & AERB to review the safety of Indian Nuclear Power Plants (NPP) against external events of natural origin.

Committee noted that it is mandatory for reactor operators in India to be engineering graduates with induction training and periodic license renewals through rigorous qualifying tests and interviews. In some other NPP operating countries there is no requirement of engineering degree for reactor operators. Thus, the NPP operators in India are better placed to handle off-normal situations in the plant.

All NPPs in India undergo Periodic Safety Reviews (PSR) following the procedure prescribed in AERB regulations. These reviews are done based on current safety standards. For older NPPs special safety reviews are carried out. A large number of safety upgrades have been implemented over the years in our NPPs, especially in the old units, based on the outcome of the various safety reviews mentioned above. The committee noted that these upgrades have substantially enhanced the safety of our NPPs including their capability to withstand natural events.

The design, operating practices and regulations in India have inherent strengths, particularly in case of pressurized heavy water reactors (PHWR) to deal with the external natural events and their consequences. NPCIL has already taken interim safety measures to enhance safety of the two older boiling water reactors at

Tarapur in light of the Fukushima accident. The measures include provisions for continuous reactor cooling under extended SBO and preparatory work for inerting the containment with nitrogen to avoid hydrogen explosions.

The submarine faults capable of generating tsunamis are located at very large distances of more than 800km from the Indian coast. Thus, unlike in the Fukushima case, the possibility of simultaneous occurrence of an earthquake and a tsunami at our NPPs, is almost non-existent. The requirements for siting and design of NPPs with respect to postulated design basis natural events, as specified in AERB safety regulations, are found to be appropriate and sufficiently conservative.

However in the light of Fukushima experience Committee made several recommendations to further enhance the safety features of NPPs. The committee has submitted its report on 31st August 2011. The report is available on AERB website. Even while Committee's deliberations were in progress, NPCIL has proactively initiated work towards implementation of the recommendations of the committee and those from its own review and has drawn up an action plan for this work. It is also seen that pending implementation of permanent design improvements which require procurement of materials, components etc. and working out detailed engineering, some interim arrangements for meeting the intent of the recommendations have already been made.

SARCOP and unit level Safety Committees of AERB are periodically following up the identified improvements for strengthening the safety of NPPs against severe external events of natural origin related to augmentation of source of power supply and water, provision for hydrogen management and venting of containment, establishment of more conservatism in assessment of design basis external events, re-assessment of postulated flood levels and tsunami at costal sites, assessment of consequences for extended station black out and implementation of provisions to ensure adequate level of plant safety during such scenario, establishment of severe accident management guidelines for operators to take action under accident condition, creation of an emergency facility for housing essential personnel for a minimum period of one week, enhancement of capabilities to treat large quantities of liquid waste, etc. In addition to the above, the emergency preparedness plan for all NPPs site is also being improved. Necessary steps are being taken by AERB to ensure implementation of the recommendations made during these reviews appropriately at all NPPs in a time bound manner.

Whether Government has reviewed the safety measures in atomic plants after Japanese tsunami and radiation from Japanese atomic plants as a result thereof?

The safety measures in the nuclear power plants are being separately assessed by NPCIL and AERB.

The Board of AERB as well as Apex Safety Review Committee of AERB, SARCOP had convened an immediate meeting after the Fukushima nuclear accident to take stock of the safety measures available at all the operating nuclear power plants to deal with such accidental conditions. Special inspections of some of the nuclear power plants were carried out to review and assess the systems in light of Fukushima nuclear accident. The comprehensive reassessment of safety measures of all nuclear power plants in India is in progress.

In addition, AERB has constituted a High Level Committee chaired by a former Chairman of AERB and having experts from Department of Atomic Energy as well as other national agencies dealing with the areas of seismicity/earthquake, tsunami, cyclones, river flooding etc to review

- The capability of Indian Nuclear Power Plants to withstand earthquakes and other external events such as tsunamis, cyclones, floods, etc.
- Adequacy of provisions available to ensure safety in case of such events, both within and beyond design basis.

The High Level Committee of AERB submitted its report in August 2011. The report is available on AERB website. The Committee has observed that the existing designs, regulations and practices followed in India for Nuclear Power Plants have inherent strengths to deal with external natural events and their consequential events safely. To further strengthen the safety, the AERB Committee made certain recommendations. Recommendations of the AERB Committee are being pursued with the utilities for their implementation. A summary of the findings of the Committee is given in the Supplementary Note.

It may also be noted that following the nuclear accident in Japan, radiological monitoring at various locations in India is carried out to asses any radiological impact on India. No increase in background radiation level or any noticeable contamination has been observed.

Whether Indian atomic plants are safe against natural disasters like tsunami? If not, the measures taken to strengthen and ensure the safety in post Japanese scenario?

Whether it is also a fact that due to happenings in Japan it has become necessary to strengthen the nuclear plants?

All the reactors in India are designed to withstand the effects of earthquake and tsunami of specific magnitudes which are decided based on conservative criteria.

As part of periodic safety review process AERB had earlier carried out a detailed safety assessment of all the old plants in India. Based on these assessments several upgrades in safety measures such as provisions of additional diesel generators for providing emergency power supply were made.

It may also be noted that emergency preparedness plans are existing for all Nuclear Power Plants in India with respect to plant, site and off site consequences. These emergency plans are periodically rehearsed to see that mitigation measures in the event of an unlikely situation are in place.

However, the natural events resulting in a serious nuclear accident at Fukushima Daiichi NPPs had challenged some of the key assumptions considered in siting and design of the NPPs. Following this accident, it was decided to re-visit the safety provisions in Indian NPPs and to evaluate the capabilities of the Indian nuclear plants to withstand natural events of severe magnitude. Necessary reviews in this regard have been completed independently by NPCIL and a high level committee constituted by Chairman, AERB.

During these reviews, the existing design provisions at NPPs are generally found to be adequate for handling the design basis external events. However, certain improvements have been identified for strengthening the safety of NPPs against severe external events of natural origin.

These are related to augmentation of source of power supply and water, provision for hydrogen management and venting of containment, establishment of more conservatism in assessment of design basis external events, re-assessment of postulated flood levels and tsunami at costal sites, assessment of consequences for extended station black out and implementation of provisions to ensure adequate level of plant safety during such scenario, establishment of severe accident management guidelines for operators to take action under accident condition, creation of an emergency facility for housing essential personnel for a minimum period of one week, enhancement of capabilities to treat large quantities of liquid waste, etc. Necessary steps are being taken by AERB to ensure implementation of the recommendations made during these reviews appropriately at all NPPs in a time bound manner. In addition to the above, the emergency preparedness plan for all NPPs site is also being improved.

The proposals for some of the identified upgradations are already under review in AERB. Necessary steps are being taken by AERB to ensure implementation of the recommendations made during these reviews appropriately at all NPPs in a time bound manner.

Whether all preventive measures suggested by the expert groups have been accepted by the Government? If so, the details thereof and the progress made in implementation of these preventive measures?

All recommendations of the AERB Committee have been accepted by the Board of AERB for further pursuance. AERB has asked NPCIL to devise and submit necessary action plans by end of November 2011 for implementation of the various recommendations made by the AERB high level committee. Necessary steps will be taken by AERB to ensure implementation of the recommendations appropriately in a time bound manner, at all the nuclear plants.

Whether the union government has sent any expert team to Japan to study about cause and consequences and death/damages occurred due to atomic reactor plants accidents/incidents due to Tsunami?

The fact finding mission of International Atomic Energy Agency (IAEA) which visited Fukushima comprised of Vice Chairman, AERB as one of the experts in the team. As a member and participant in IAEA and other International Fora, India has been receiving information about the accident, assessment of causes and its consequences. As per currently available information, there has been **no serious** adverse health effect due to radiation from this accident.

Whether it is a fact that the nuclear plants in the country can withstand any disasters?

No. AERB safety codes and guides lay down siting and design requirements for Nuclear Power Plants (NPPs) to ensure their safety against the natural events like earthquake, flooding due to tsunami or cyclone or rainfall. These requirements are conservative and ensure safety of NPPs from the natural events of certain magnitude that are expected to occur at a site. Prior to granting permission for operation of a NPP, AERB carries out in-depth review of its design to ensure compliance to all regulatory requirements.

Some of the old NPPs (TAPS-1&2, RAPS-2 & MAPS-1&2) were not initially designed from seismic consideration. These plants have also been re-evaluated with respect to the site specific acceleration levels during their periodic safety reviews. Based on the findings of this re-evaluation, some of the structures, systems and components in these plants have been modified / strengthened. Also, as per the original design of these NPPs, emergency diesel generators were located at elevation lower than the expected flood level. Subsequently, additional diesel generators have been provided at higher elevations in these NPPs to provide emergency power supply in case of flood.

Whether Government is conducting any safety assessment exercise for the nuclear plants in Tarapur (which is 40 year old) and those in Kota, Madras and Narora which are around 30 years old?

Yes. AERB issues operating license to a Nuclear Power Plant (NPP) for a period of five years. Renewal of license is based on comprehensive safety review of the reports submitted by the nuclear power stations. These reviews are carried out to ensure high level of safety (in line with current standards) throughout the plant life. The NPPs in India (including the older ones TAPS-1&2, RAPS-1&2, MAPS-1&2 and NAPS-1&2) have undergone substantial safety enhancement over their operating period based on the periodic safety reviews.

Supplementary Note **REPORT OF AERB COMMITTEE TO REVIEW SAFETY OF INDIAN NUCLEAR POWER PLANTS AGAINST EXTERNAL EVENTS OF NATURAL ORIGIN**

Chairman, AERB constituted a committee on March19, 2011 to review the safety of Indian NPPs against external events of natural origin, in the light of the Fukushima accident. The committee has submitted its report on 31st August 2011.The committee observed that the design, practices and regulations followed in India have inherent strengths, particularly in case of pressurized heavy water reactors (PHWR) that account for 18 out of the 20 currently operational NPP units in India, to deal with the external natural events and their consequential events safely. The committee noted that NPCIL has already taken interim safety measures for 2 boiling water reactors (BWR) at Tarapur (TAPS-1&2) in light of the Fukushima accident like preparatory work for inerting of the containment and provisions for augmenting reactor cooling. Highlights of the committee's observations, conclusions and recommendations are given below.

It is mandatory for reactor operators in India to be engineering graduates with induction training and periodic license renewals through rigorous qualifying tests and interviews. In some other NPP operating countries there is no requirement of engineering degree for reactor operators. Thus, the NPP operators in India are better placed to handle off-normal situations in the plant.

All NPPs in India undergo Periodic Safety Reviews (PSR) following the procedure prescribed in AERB regulations. These reviews are done based on current safety standards. For older NPPs special safety reviews are carried out. A large number of safety upgrades have been implemented over the years in our NPPs, especially in the old units, based on the outcome of the various safety reviews mentioned above. The committee noted that these upgrades have substantially enhanced the safety of our NPPs including their capability to withstand natural events.

The submarine faults capable of generating tsunamis are located at very large distances of more than 800km from the Indian coast. Thus, unlike in the Fukushima case, the possibility of simultaneous occurrence of an earthquake and a tsunami at our NPPs, is almost non-existent.

The requirements for siting and design of NPPs with respect to postulated design basis natural events, as specified in AERB safety regulations, are found to be appropriate and sufficiently conservative. However in the light of Fukushima experience it is considered prudent to further enhance this conservatism through better treatment of uncertainties in data and computational procedures. The revised estimates after so generated may be considered for inclusion in AERB regulations.

The Fukushima accident has shown that occasionally the magnitude of natural events can be higher than what is considered in design. It is therefore prudent to make additional design provisions such that at least the basic safety functions for the NPPs are not impaired even under beyond design basis natural events (or extreme events). Towards this aim it is recommended that the parameters for each postulated extreme natural event be defined conservatively using the best available analytical methods. While design basis external events should govern the design of SSCs, functionality of the most safety relevant SSCs should still be maintained under extreme events.

Seismic signal based automatic reactor trip is presently provided in NAPS and KAPS only. In other operating units, seismic alarms are provided and in the event of an earthquake the reactor has to be tripped manually. Seismic signal based automatic reactor trip should be implemented in all reactor units.

A major lesson learned from the Fukushima experience is that capability to cool irradiated fuel in the reactor core and in the spent fuel storage facilities must remain available in the event of SBO as also in the face of beyond design basis natural events.

Design provisions exist in PHWRs to cool the reactor core, with the plant in hot shutdown state, even under extended SBO. The efficacy of this design feature got amply demonstrated during the 17 hours long SBO caused by the turbine hall fire incident at Narora unit-1 in 1993. To cater to the extended SBO, the committee recommended that a reliable back-up provision should be made for PHT make-up and assured operability of the fire water system should be ensured even during a flooding event.

In the case of 2 BWRs (TAPS-1&2), core cooling under SBO can be maintained up to about 8 hours and thereafter it must be made up. Some of the safety systems including class III power supply system in TAPS-1&2 does not meet the currently revised flood level at this site and hence flooding has the potential to cause SBO. A detailed study is hence necessary to identify the design improvements to rectify the above deficiencies and the identified corrective actions must be implemented at the earliest.

The heat load from irradiated fuel stored to design capacity in the spent fuel storage pools is much less and the inventory of water in the pools much larger at our NPPs in comparison to the corresponding heat load and water inventory in the spent fuel storage pools at Fukushima NPP. Consequently, for the Indian NPPs, submergence of the fuel in the pool water is assured for a time period of at least one week under SBO, even with the most conservative assumptions on the quantum of decay heat from the stored fuel and without any credit for operator action.

Flood level assessment has been made for the Indian coast based on a tsunami generated from a sub-sea earthquake caused by the Andaman-Nicobar-Sumatra fault and takes into account, in a most conservative manner, the fault parameters and the directivity of tsunami propagation towards the Kalpakkam coast. The work done so far indicates that the maximum postulated flood level at Kalpakkam coast is likely to get revised upwards and consequently the corresponding design improvements for MAPS will have to be considered. The Prototype Fast Breeder Reactor at this site is likely to remain unaffected due to this revision as its grade level is sufficiently high. For all other coastal NPP locations there will be no change in the maximum postulated flood level.

A beyond design basis external event may disable the facilities available at the NPP site for monitoring and control of important reactor parameters. It may also result in physical isolation of the site such that it may not be possible to receive outside help for a considerable period of time. Creation of an emergency facility at each NPP site which will remain functional under such conditions is therefore recommended.

In spite of all the safety features provided, the extremely remote possibility of an accident leading to partial or total melting of fuel in the reactor core, called severe accident, due to unforeseen reasons should still be deterministically taken into consideration. In the area of severe accident management significant progress has been made in our country in the recent past in terms of analysis and R&D work. This should be expeditiously translated into design provisions together with related procedures for the operating as well as under construction PHWRs. In the case of TAPS-1&2, preparatory work for inerting the primary containment, for management of any hydrogen escaping from the reactor pressure vessel in case of a severe accident, has been taken up. Similarly, work on development of severe accident management guidelines has also been initiated. These tasks should be completed on priority.

The committee has also made some other recommendations for further enhancement of safety of our NPPs. These are available in the report. The committee noted that even while its deliberations were in progress, NPCIL has proactively initiated work towards implementation of the recommendations of the committee and those from its own review and has drawn up an action plan for this work. It is also seen that pending implementation of permanent design improvements which require procurement of materials, components etc. and working out detailed engineering, some interim arrangements for meeting the intent of the recommendations have already been made.

Topic 9: Mayapuri Radiological Incident

Q) Whether there was an incident of radiation leak from Cobalt 60 in Mayapuri in the NCT of Delhi? Whether any enquiry has been conducted into the incident? What effort have been made to stop the recurrent of such incident in future?

In April 2010, a message was received by AERB from Indraprastha Apollo Hospital, Delhi stating that one person, aged 32 years, owner of a scrap shop was admitted to hospital with symptoms indicative of suspected exposure of radiation. AERB officers visited the scrap shop of the patient immediately with radiation detection equipments and identified the radiation source as Cobalt-60, used mainly in industry for radiography and in teletherapy for cancer treatment.

Subsequently, scientists from AERB, Bhabha Atomic Research Center (BARC), Narora Atomic Power Station (NAPS) and National Disaster Response Force (NDRF) conducted surveys of the area and identified 8 radioactive sources. These sources were placed in lead shielded flask and were sent to NAPS for further examination and safe disposal. In a subsequent survey in neighbouring areas, two more radioactive sources were recovered from one nearby scrap shop. In another incident, a small Cobalt-60 radiation pencil was recovered from the owner of another scrap shop in the same market after he was admitted to hospital. All the sources were safely transported in shielded flasks to NAPS.

Based on the investigations carried out at the site of incident, discussions with the affected personnel and the inspections carried out at NAPS by officers of AERB, Board of Radiation and Isotope Technology (BRIT) of Department of Atomic Energy (DAE) and Delhi police, it was established that the cobalt-60 sources recovered from the Mayapuri scrap market in Delhi were from an old gamma cell made by Atomic Energy Canada Ltd which was purchased by the Chemistry Dept of Delhi University in 1969. The gamma cell was being used by a chemistry professor till he retired. Since then it was lying unused for more than 15 years till it was auctioned in Feb 2010 by Delhi University and reached the hands of the scrap dealer who purchased it through this auction. The whole event got unfolded when the gamma cell was dismantled by local workers at the metal scrap shop, leading to the highly radioactive Cobalt-60 pencil sources coming out of the cage and causing unwarranted high exposure.

In the above incidents, 11 sources were recovered and 7 persons were found to be affected by radiation injuries. They were medically treated in various hospitals of Delhi. Unfortunately one of them succumbed to death. Other six were progressively discharged from the hospitals. AERB issued a show cause notice to the Delhi University for the lapses on its part and in the interim, advised the university to suspend forthwith all activities involving the use of radiation sources. Delhi university responded to the show cause notice and undertook all the corrective measures stipulated by AERB. After compliance with all the stipulated regulations, Delhi University was issued licence only for handling low activity sources.

This was the first fatality in the country due to radiation exposure. AERB immediately issued periodic press releases to allay the apprehensions of the public and apprise them of the situation in perspective.

AERB took this incident very seriously and carried out a thorough introspection post accident. Several actions were initiated by AERB to reinforce and further strengthen its regulatory enforcement mechanism, which are subsequently elaborated.

A public notice was issued by AERB through leading newspapers about the legal/statutory and regulatory requirements of possession, handling and disposal of radioactive sources stating clearly that possession of radioactive sources without proper license/ authorization / registration is an offence. AERB received responses from various users. Details provided were cross checked and inspections were carried out.

All the Indian source suppliers were contacted to give details of the sources supplied by them to verify the existing inventory with AERB. Various ministries like Ministry of Steel, Ministry of Health and family Welfare, Ministry of Coal, Ministry of Power etc. and UGC were requested to issue circulars to the units under them to come forward with details of used/disused sources. All the users of the sources were informed with the help of print media to furnish information on sources in their possession.

AERB advised all concerned industries in India to carry out a thorough radiation check on incoming metal scrap as also on the finished and packaged products before releasing them for export. This has been done through awareness programmes conducted by AERB with the help of industry associations like the All India Induction Furnace Association, Engineering Export Promotion Council (EEPC) of India and the Leather Export Council of India. Information articles on the subject by AERB staff have also been published in the newsletters of some of the associations.

A campaign had been undertaken by AERB and University Grants Commission to bring awareness among Educational & R&D Institutes regarding requirements for safe handling and disposal of radioactive sources. Guidelines and stipulations have been issued regarding the use and disposal of radioactive sources and making the training on radiation emergency management to be part of curriculum in medical education.

The academic, medical and R&D institutions were sensitized to undertake inventory of radiation sources under their possession and review their existing safety procedures. Series of awareness/training programmes were conducted at various universities (e.g. University of Delhi, Banaras Hindu University etc.) handling radioactive material for research and training activities. Several awareness programmes were also conducted in the fields of Industrial Radiography, Oil Well Logging, Nucleonic Gauge, Gas Mantle Manufacturing Industries, Diagnostic Radiology, Medical Cyclotron Facilities, Transport of Radioactive Material and Research Facilities handling radioactive material.

Installation of portal monitors at all sea/air entry ports of India for compulsory checking of all imported consignments for any presence of radioactive contamination had been recommended. A variety of Radioactive Material Detection equipment is being installed at various Border points – seaports, airports and landports by the concerned agencies.

Further efforts were made to bring legacy sources (which may have been in existence from periods when regulatory controls were still in the evolving stage) under regulatory control by scanning old records. AERB Data base system of records on source inventory is being further strengthened. In addition to above, as a part of its compliance assurance programme, AERB has significantly increased the number of inspections for radiation facilities.

To make the regulatory process more effective, AERB has established Regional Regulatory Centres (RRCs) at southern and eastern region. Memorandum of Understanding (MOU) were also signed with State Governments for setting up of Directorate of Radiation Safety (DRS) for the purpose of regulation of medical diagnostic X-ray installations in the sates of Madhya Pradesh, Punjab, Chattisgarh, Tamilnadu and talks are in progress with other states as well. DRS is now functioning in the states of Kerala and Mizoram.

Based on lessons learnt from this experience, the system of response to radiation source related emergencies is further strengthened in collaboration with National Disaster Management Authority (NDMA).

Topic 10: Other Significant Events

Q) How are significant events reported to international community?

It is obligatory for all NPPs to report to AERB, all safety significant events occurring in a Plant. These reports are discussed in detail in the AERB Safety Review Committees to identify deficiencies in plant systems, procedures and human performance. Implementation of the recommendations of Safety Committees is then closely followed-up. Review of the incidents may also reveal weaknesses in plant equipment, personnel and procedures. These are appropriately corrected, not only in that particular plant, but also in all plants where relevant, towards strengthening the defense-in-depth and adequacy of safety margins.

AERB uses the International Nuclear Event Scale (INES) of IAEA to categorize the events in accordance with their safety significance. This scale has been devised to facilitate a common understanding between the nuclear community, the media and the public. In this scale, events are classified at seven levels. The lower levels (1-3) are termed as incidents, and the upper levels (4-7) as accidents.

In our NPPs there were some events at Level 1, there were only two events at Level 2 in the last five years. In fact, in the history of NPP operation in India, there has been only one event at Level 3 and four at Level 2. All the other events are at Level 1 or 0 indicating no impact on safety.

The Level 3 event was the Fire Incident in the Turbine Generator Building of Narora Atomic Power Station. This event did not result in any death or injury and there were no radiological consequences either. It was rated at Level 3 due to degradation of defence-in-depth on account of loss of power supply due to damage to power and control cables from fire. A large number of safety improvements, arising out of detailed review by AERB, were implemented at all NPPs. The improvements resulted thorough checking of Turbine blades and revised lay out of power and control power supply cables.

Q) Whether the Government is aware about the incidents of drinking water contamination at various atomic power stations in the country? The action taken/proposed to be taken by the Government in this regard?

Yes. There has been an incident of radioactive contamination of drinking water at Kaiga Generating Station, Karnataka in November 2009.

The Incident of consumption of tritiated drinking water by some workers at the Kaiga Generating Station (KGS) occurred on 24th November, 2009. This was noticed during the routine urine sample analysis of workers that is carried out regularly at all nuclear power plants that use heavy water. Atomic Energy Regulatory Board (AERB) deputed two of its officers to KGS who, along with the plant authorities, investigated the incident.

A drinking water cooler was found to be the source of this tritium contamination and this water cooler was isolated immediately. The tritium contamination was limited to this particular water cooler only and all other sources of drinking water were checked and found to be free of any such contamination. Later investigations revealed that it was a malicious act (addition of small quantity of tritiated heavy water to the cooler) by some unidentified person.

Bioassay samples (urine) of all plant personnel were analyzed and 86 persons (29 regular and 57 temporary workers) were found to have tritium uptake above investigation limit (IL) i.e. 4 MBq/l, the maximum uptake being 146 Mbq/l. As a result of the tritium uptake, two persons marginally exceeded their cumulative AERB specified dose limit of 30mSv, their doses being 32.1 and 37.4mSv.

Subsequent to this incident following actions were taken by the station (NPCIL) and AERB:

1) Bioassay samples of all radiation workers in the plant were carried out.
2) All the affected persons were subjected to whole body counting

and were found free of any other internal contamination.

3) The personnel having received tritium uptake of more than 2.5 IL were referred to hospital for further medical advice.
4) Samples of all drinking water sources were analyzed and were found free of contamination.
5) All the drinking water coolers in the controlled areas were secured.
6) Administrative measures were taken to prevent misuse of tritiated heavy water.
7) Two senior officers from AERB visited the plant immediately after the incident for investigation and spot assessment.
8) The incident was reviewed by Safety Committee for Operating Plants (SARCOP), the apex committee of AERB for operating NPPs. The Committee after review instructed NPCIL to prepare a comprehensive programme for protection against misuse of hazardous materials at NPPs and expeditiously implement the same at all the nuclear power stations. All NPCIL units have taken steps to safeguard hazardous materials to prevent their misuse.

Q) Whether it is a fact that four employees working at atomic plant in Kakrapar, Gujarat were exposed to radiation on 30 May, 2011? nature and extent of the loss caused to the employees by the radiation; and whether any effective steps have been taken to avoid such incidents in future?

Yes four contract workers working at Kakrapar Atomic Power Station (KAPS) were exposed to radiation on 30 May, 2011.

Kakrapar Atomic Power Station (KAPS) is a twin unit station with 220 MWe Pressurized Heavy Water Reactors. Refueling of these reactors is done when reactor is on-power. The spent fuel bundles discharged from the reactor are transferred to spent fuel storage bay (SFSB) through the Spent Fuel Transfer Duct (SFTD). The duct is normally covered with thick hatch blocks to provide adequate shielding.

On May 30, 2011, Unit-2 of KAPS was operating at 98% Full Power. A painting job was planned in SFTD area. Formal permission called radiological work permit was issued for the painting job after taking clearance from engineer-in-charge of refueling operations. This permit was issued to carry out painting work between 09.15 hrs and 13.00 hrs in the SFTD area. No spent fuel bundle was being transferred when the painting work started. However, at around 12.00 hrs, refueling operator in the control room inadvertently discharged spent fuel bundles to SFSB through SFTD after refueling. On hearing noise from the SFTD, workers in the area got alerted and they rushed out of the SFTD area. However, four workers who were carrying out the job got exposed to radiation and received 90.72 mSv, 66.81 mSv & 58.70 mSv, and 23.23 mSv radiation dose. The radiation doses to the workers were higher than the prescribed annual regulatory limits stipulated by Atomic Energy Regulatory Board (AERB).

Even though the exposures received by the persons involved in the work exceeded the limits prescribed by AERB, the dose received were well below the levels that can cause any immediate health effects or functional impairment. Any possible health effects at the dose levels received by the persons in this incident are considered insignificant.

AERB deputed two of its officers to investigate the circumstances leading to the incident, radiological safety aspects and other relevant factors. During Safety reviews done in AERB, it was noted that the event occurred due to inadequate/improper planning of the housekeeping and painting work in the SFTD and failure to establish appropriate procedure for control of fuel transfer operations while the painting work was in progress. After investigation of the event policy changes have been made with respect to controlling the opening of the shielding hatch blocks of SFTD and a ban on refueling operations during the period when the shielding blocks are open. AERB has also asked all the NPPs to review this event and reinforce the procedural controls to obviate similar events / failures.

Q) Whether it is a fact that weapon-grade uranium was seized on 8th December, 2004 brought by the two persons in Bareilly, Uttar Pradesh, if so, from

where;? the agencies which has inspected, seized these uranium plates? why it took so many days to police to 'Bareilly' to refer this matter to this agencies; whether it is also a fact that these uranium plates were stolen from Narora Atomic Power Station?

On learning that a uranium bar was seized by the police in Bareilly on December 8, 2004, the Atomic Energy Regulatory Board (AERB) officials asked the senior superintendent of police, Barielly to send this metal piece to Bhabha Atomic Research Centre (BARC) for testing. The report of the chemical and isotopic analysis carried out at BARC showed that the bar is made of Depleted Uranium (DU) containing 0.21% Uranium-235 and the balance Uranium-238. The piece weigh about 220 grams, has a density of 19.2 g/cm^3 and its dimensions are 8.1 cm x 2.5 cm x 0.6 cm thick. Two circular holes of diameter 8 mm and 6 mm and a small semicircular hole are drilled in the plate and there is a defaced inscription on the piece reading 'unauthorize ….. lterations'. There is a small gamma dose rate on the surface of the piece of 0.01 mSv/h which reduces to background at a short distance of 40 cm. Such low dose rates are to be expected on natural or depleted uranium pieces of this size and weight.

For making an explosive device, highly enriched uranium (concentration of more than 90% of uranium-235), is required. Hence, the depleted uranium, as in the seized bar, cannot be used for such purpose. The radiation level on the piece is too small to cause any significant radiation/health hazard, even with prolonged exposure. Thus the material piece seized by Barielly police does not pose any security threat or radiation hazard of any significance.

Depleted uranium, being a high density material, is used as shielding material in the imported industrial radiography cameras and radiotherapy units in hospitals, and as counter-weight in aircraft. Strips of depleted uranium of the shape of the seized piece are used in some aircraft as balancing counter-weights in their wings, rudder and elevator components. Such pieces used in aircraft carry the inscription "unauthorized alteration prohibited". There could be 50 to 150 such pieces of varying length in an aircraft depending on its size. From the shape and size of the seized piece, it appears that the piece could be a part of a counter-weight used in an aircraft.

The depleted uranium counter-weights used in aircrafts are not to be transferred to scrap dealers. These are to be returned to the manufacturers or to the agencies licensed to process/dispose of such material. This information is provided in the maintenance manuals of the aircrafts and the maintenance agencies are aware of this aspect. In the past, the aircraft maintenance workshops in the country have contacted AERB and BARC whenever there was a need for disposal of such pieces and these were disposed off by BARC in their waste disposal facilities. However, apart from the disposal part, there are no other regulations for exercising any control on use of this material in shielding or as counter weight in aircraft in view of the insignificant radiation hazard.

The exact source of DU plate seized by the police in Bareilly is not known so far. Information about DU and the insignificant radiation hazard from this material was provided by AERB to the Bareilly police as per their request.

All nuclear materials including natural and depleted uranium are appropriately accounted. All the radiography cameras and radio-therapy units used in India are registered with AERB. Once the cameras lose their useful life, these are deposited with BARC for safe disposal. Similarly, the DU parts from an aircraft are being disposed off by the aircraft maintenance agencies through BARC, as described above.

Q) Whether it was revealed after seizure of 750 gram uranium in U.P. and, If so, the reaction of the Govt. thereof?

There was a report in a section of the press on June 1, 2007 that about 700 grams of a material suspected to be uranium, was seized by the Lucknow police. AERB deputed two officers to Lucknow to investigate the matter. The material was checked using sensitive radiation detection instruments which revealed that the material was not uranium. Later, the material was tested at BARC, Mumbai to identify its chemical composition. The test results showed that the material seized by Lucknow Police is an organic ion exchange resin and does not contain Uranium. Also, it was not an explosive material. The ion exchange resins are used for purification of solutions and are also used in chemical laboratories.

Q) Whether attention of the Govt. has been drawn to the breaking off Blue Lady Ship which contains massive amount of radioactive materials besides toxic wastes like asbestos and heavy metals in Indian waters? Whether concerned authority has taken cognizance of the risks involved in letting such a decommissioned ship stay in Indian water?

The Gujarat Maritime Board (GMB) vide their letter dated August 3, 2007 requested AERB to inspect for presence of any radioactive material on board. The ship beached at Alang, Sosia Ship Breaking Yard, was inspected on August 14, 2007 by an AERB official together with two officers of GMB. No radioactive material except 12 ionization based smoke detectors was found on board the ship. Similar detectors are commonly used in civil buildings for fire detection.

The smoke detectors were removed from the ship and handed over to GMB authorities for safe disposal.

The GMB authorities were advised that in future ionization based smoke detectors should also be included in the inventory of radioactive material present in the ship issued by the Master of the ship, as no radioactive materials are permitted on ships that are to be broken down.

Q) whether it is a fact that for the last few years a large number of foreign dead ships have been brought to Indian ports for ship breaking;if so, whether Government has taken note of security and other hazards involved in this activity?:

The ships arriving at the Indian Ports for breaking should not contain radioactive substances. AERB should be consulted if there is any suspicion that the ship may have radioactive material on board.

Ionization based smoke detectors are commonly used for fire detection in civil buildings. These detectors use a very small amount of radioactivity (0.9 mieri curies of Amercium-241). These are exempted from regulatory control during normal use. However, the disused sources have to be disposed off in a safe manner. The inventory of radioactive material present in the ship and issued by master of ship at the time of selling/breaking should mandatorily include the list of ionization based smoke detectors and other products containing radioactive material if any, present in the ship.

Q) whether the attention of the government has been drawn to the news item captioned '53% of X-rays are of little use in diagnosis' as per the study conducted by the International Atomic Energy Agency because of malfunction of X-ray equipment, in appropriate technology and lack of expertise?If so, whether the government agrees with the findings of the IAEA? What are the steps government proposes to take to improve X-ray diagnosis in the light of the above findings.

Yes, Government is aware of the report of IAEA. The report is based on the study of a number of under-developed countries of Africa, Asia and Eastern Europe where appropriate controls on the quality of X-ray machines and expertise of X-ray technologists do not exist.

A survey on patient doses in radiographic examinations in 12 countries in Asia, Africa and Eastern Europe, covering 45 hospitals was done in phases by IAEA from August 2005 to December 2006.The objective of the study was to survey image quality in radiographic examinations and to perform comparisons with diagnostic reference levels. The study indicated that the fraction of images rated as poor was 53%. After implementation of quality control programme, the image quality improved upto 16 percentage points in Africa, 13 in Asia and 22 in East European countries. Patient doses varied by a factor of upto 88%, although the major doses were below diagnostic reference levels. Patient doses were found to be similar to doses in developed countries and patient dose reduction ranging from 1.4% to 85% were achieved. The study concluded that poor image quality constitutes a major source of unnecessary radiation to patients. Comparison with other surveys indicates that patients dose levels in these countries are not higher than those in developed countries.

In India, the quality of the X-ray units are ensured at the manufacturing level. The X-ray equipment manufacturers have to obtain Type Approval from AERB and Bureau of Indian Standards (BIS) to ensure the quality of the equipment. This applies to all indigenous and imported X-ray machines. Quality assurances tests are performed by the manufacturers and verified by AERB and BIS before Type Approval is issued. Only the Type Approved X-ray machines are permitted to be used. The layout plans of the X-ray facility are also approved by AERB. Registration of the X-ray machines and licensing of the X-ray facilities by AERB is necessary and this is issued only after the plan approval of the X-ray facility and ensuring that qualified manpower is available with the institution.

Periodic training programs on radiation safety are conducted for medical radiographers. Public awareness programs are also conducted periodically to educate the public and the workers associated with medical diagnosis about radiation safety and safe work practices.

Already steps have been taken by our Atomic Energy Regulatory Board (AERB) in this direction.

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Q) Steps taken by Government for safety and security of radioactive sources used in nuclear medicine?

Unsealed radioactive sources are used in medicine for diagnostic and therapeutic purposes. Presently, there are 170 nuclear medicine facilities in India. AERB grants license to these facilities after making safety assessment from radiological safety point of view. Necessary security measures are ensured through designated Radiological Safety Officer (RSO) by AERB at the time of issuance of license for the use of radioactive sources by medical institutions. Mechanisms are also in place to attend to any emergency involving radioactive sources.

License for operation of nuclear medicine facilities is issued only after ensuring compliance of the regulatory requirements stipulated in 'AERB Safety Code on Nuclear Medicine Facilities'. The radioisotopes are transported in standard packages in accordance with the regulations of safe transport of radioactive materials. The licensee, i.e., the facility owner has to ensure physical security of radioactive sources in his possession using prudent measures.

Due to small quantities of radioactivity involved and short half-life of radioisotopes used, the nuclear medicine facilities do not have a potential to cause any significant radiological harm to the working personnel or to the public at large. It is for this reason that AERB has not laid down requirements on any special security arrangements for transportation and use of radioisotopes in nuclear medicine facilities. Recently a concern was expressed by Delhi police authorities about the security of radioactive sources in nuclear medicine centres in Delhi and a response on the above lines was provided by AERB. However, the matter will be further discussed in a specialists' committee being constituted by Delhi police.

Q) Steps taken to prevent Contamination in Steel Products Exported From India.

In the recent past there were some instances of rejection and return of steel products exported from India as they were found to be contaminated with trace quantities of radioactive materials. Though the radioactivity level in the steel products was found to be too low to pose any significant hazard to the handling personnel or to the users or public at large, such contamination is undesirable. Atomic Energy Regulatory Board (AERB) investigated these incidents and found that the steel products were made in a foundry near Mumbai through recycling of imported metal scrap which contained some disused radioactive source. Earlier, some incidents of radioactive contamination in the export consignments of steel products were reported from Kolkata area in 2005.

AERB has taken a series of actions to senstise the various stakeholders to take appropriate preventive actions to avoid such incidents in future. The actions include the following:

1. Conducted awareness program for "All India Induction Furnace Association" in their Annual General Body meeting in November 2005 in Delhi.

2. Held a meeting with Engineering Export Promotion Council (EEPC), Kolkata whereafter the EEPC published a newsletter in their bulletin on, "Radioactive Contamination in Steel".

3. Addressed Leather Council of India, Kolkata on this issue.

4. Arranged awareness programmes for large number of steel exporters through EEPC, Kolkata in 2007.

5. Investigated the reported events of contamination and visited the identified steel foundries and steel mills where the radioactive contamination occurred and advised them to have a mechanism of monitoring all the incoming and outgoing material for radioactive contamination. Also the contaminated material was segregated for safe disposal.

6. Another meeting was held with EEPC (Western Region) in Mumbai in November 2008 wherein the members of EEPC were sensitized about this problem.

7. Concerned Ministry has been advised to arrange for installation of portal monitors at the entry ports to scan all the containers of metal scrap for radioactive contamination.

8. Participated in the meeting on the subject conducted by Ministry of Steel in March 2009 wherein officers from Directorate General of Foreign Trade, Customs and EEPC were also present.