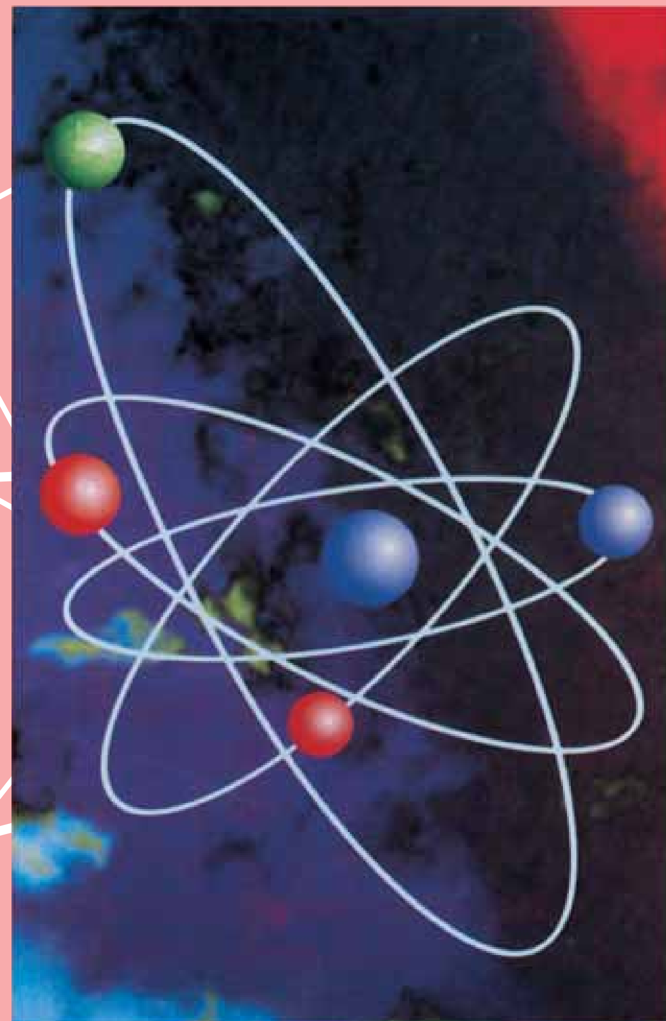
Annual Report 2006-2007



AERB

ATOMIC ENERGY

ATOMIC ENERGY REGULATORY BOARD

The Atomic Energy Regulatory Board (AERB) was constituted on November 15, 1983 by the President of India by exercising the powers conferred by Section 27 of the Atomic Energy Act, 1962 (33 of 1962) to carry out certain regulatory and safety functions under the Act. The regulatory authority of AERB is derived from the rules and notifications promulgated under the Atomic Energy Act, 1962 and the Environmental Protection Act, 1986. The mission of the Board is to ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to health of people and the environment. Currently, the Board consists of Chairman, Vice-Chairman, three Members and Secretary.

AERB is supported by the Safety Review Committee for Operating Plants (SARCOP), the Safety Review Committee for Applications of Radiation (SARCAR), Advisory Committees for Project Safety Review (ACPSRs), Advisory Committee on Radiological Safety (ACRS), Advisory Committee on Industrial and Fire Safety (ACIFS), Advisory Committee on Occupational Health (ACOH) and Advisory Committee on Nuclear Safety (ACNS). The ACPSRs recommend to AERB issuance of authorizations at different stages of projects of the Department of Atomic Energy (DAE), after reviewing the submissions made by the project authorities based on the recommendations of the associated Project Design Safety Committees.

SARCOP carries out safety surveillance and enforces safety stipulations in the operating units of the DAE. SARCAR recommends measures to enforce radiation safety in medical, industrial and research institutions, which use radiation and radioactive sources. AERB receives advice on development of safety codes and guides and on generic nuclear safety issues from ACNS. ACRS, ACIFS and ACOH advise AERB on safety matters relevant to their fields of specialization. The administrative and regulatory mechanisms in place ensure multi-tier review of all safety matters by experts in the relevant fields available nationwide. These experts come from reputed academic institutions, R&D organizations, industries and Governmental Agencies.

AERB has a Safety Research Institute (SRI) at Kalpakkam, which carries out research in various safety-related topics and organizes periodically, seminars, workshops and discussion meetings.

AERB has seven technical divisions. Chairman, Vice-Chairman and Directors/Heads of Divisions and Director, SRI constitute the Executive Committee, which meets periodically and takes decisions on important matters related to the functioning of the organization. AERB enforces the following Rules issued under the Atomic Energy Act, 1962:

- Atomic Energy (Radiation Protection) Rules, 2004.
- Atomic Energy (Working of Mines, Minerals and Handling of Prescribed Substances) Rules, 1984.
- Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.
- Atomic Energy (Factories) Rules, 1996.
- Atomic Energy (Control of Irradiation of Food) Rules, 1996.

GOVERNMENT OF INDIA

ANNUAL REPORT 2006-2007

ATOMIC ENERGY REGULATORY BOARD
NIYAMAK BHAVAN,
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MUMBAI-400 094.
Website : www.aerb.gov.in

THE FUNCTIONS OF THE ATOMIC ENERGY REGULATORY BOARD

- Develop safety policies in nuclear, radiation and industrial safety areas.
- Develop Safety codes, Guides and Standards for siting, design, construction, commissioning, operation and decommissioning of different types of nuclear and radiation facilities.
- Grant consents for siting, construction commissioning, operation and decommissioning, after an appropriate safety review and assessment, for establishment of nuclear and radiation facilities.
- Ensure compliance of the regulatory requirements prescribed by AERB during all stages of consenting through a system of review and assessment, regulatory inspection and enforcement.
- Prescribe the acceptance limits of radiation exposure to occupational workers and members of the public and approve acceptable limits of environmental releases of radioactive substances.
- Review the emergency preparedness plans for nuclear and radiation facilities and during transport of large radioactive sources, irradiated fuel and fissile material.
- Review the training program, qualifications and licensing policies for personnel of nuclear and radiation facilities and prescribe the syllabi for training of personnel in safety aspect at all levels.
- Take such steps as necessary to keep the public informed on major issues of radiological safety significance.
- Promote research and development efforts in the areas of safety.
- Maintain liaison with statutory bodies in the country as well as abroad regarding safety matters.

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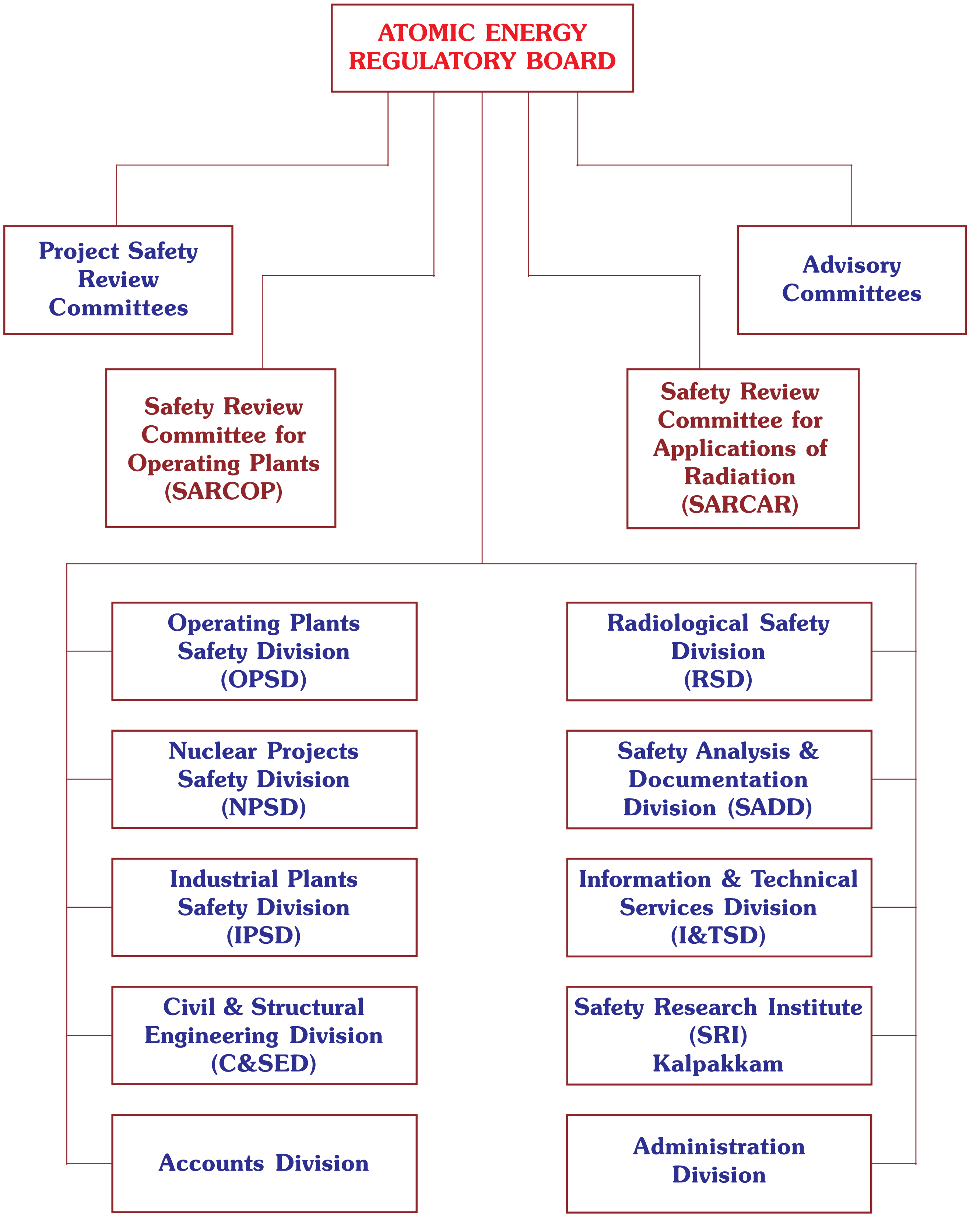
GENERAL

1.1 COMPOSITION OF THE BOARD

1.	Shri. S. K. Sharma, AERB	...	Chairman
2.	Shri. S. K. Chande, AERB	...	Member (Ex-Officio)
3.	Dr. K.A. Dinshaw Director, Tata Memorial Centre, Mumbai	...	Member
4.	Dr. K.V. Raghavan Chairman, Recruitment & Assessment Centre, Defence Research & Development Organisation, Ministry of Defence, Delhi	...	Member
5.	Prof. J.B. Joshi Professor and Director, University Institute of Chemical Technology (UICT) University of Mumbai, Mumbai	...	Member
6.	Dr. Om Pal Singh, AERB	...	Secretary

1.2 ORGANISATION CHART OF AERB



1.3 SUMMARY

A large number of nuclear and radiation facilities in operation and projects under construction in India are under the regulatory purview of AERB. Presently, there are 17 nuclear power units in operation and 6 under construction. Two more units, KAPP-3&4, each of 700 MWe Pressurized Heavy Water Reactor (PHWR), are planned at Kakrapar and their Site Evaluation Report (SER) is under review at AERB. AERB carried out its fucntions with the support of its secretariat and specialist committees under the guidance of the Board. The Board met three times during the year; on 28th August 2006 at Tarapur, on 15th December 2006 in Mumbai and on 23rd March 2007 at Jaduguda. During the meetings at Tarapur and Jaduguda, the members also visited the various facilities at these sites.

Board Meeting at Tarapur Site in Progress
(Sitting from L to R: Dr. K.A. Dinshaw, Shri S.K. Chande, Shri S.K. Sharma, Dr. Om Pal Singh, and Dr. K.V. Raghavan)

Safety Review of Nuclear Projects

For the nuclear plants under construction, authorizations were issued for first approach to criticality of Tarapur Atomic Power Project unit-3 and Kaiga Generating Station unit-3. Clearance was given for erection of major equipment for Kudankulam Nuclear Power Project unit-1. Clearances were also given for construction of reactor vault upto 26.715 m elevation and spent fuel storage bay of Prototype Fast Breeder Reactor (PFBR) and Interim Fuel Assembly and Storage Building (IFSB) for assembling and storing first two core loadings of PFBR. Siting clearance was given for Fast Reactor Fuel Cycle Facility (FRFCF) being built to meet fuel reload requirements of PFBR. Clearance was also given for construction of Head End Facility (HEF) of Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP). Pre-licensing review of Advanced Heavy Water Reactor (AHWR) was completed.

Safety Review of Operating Plants and Fuel Cycle Facilities

All the nuclear power plants, research reactors and fuel cycle facilities functioned safely. Authorization was issued for reprocessing of the spent fuel pins of Fast Breedor Test Reactor (FBTR) with burn up upto 100 GWd/t in lead mini cell facility. In R&D units, clearance was given for construction of Medical Cyclotron facility at Variable Energy Cyclotron Centre (VECC), Kolkata and authorizations were issued for commissioning of stages 3, 4 and 5 of 15 MeV DC accelerator and 12 MeV microtron and for siting of radiation processing facility for agricultural products at Indore. Authorization was issued for rehabilitation of old Zirconium Sponge Plant (ZSP), and setting up of Chlorination Plant in the newly rehabilitated ZSP building of Nuclear Fuel Complex (NFC) in Hyderabad. Authorization was issued for siting and construction of Technology Demonstration Plant (TDP) of Heavy Water Board (HWB) for recovery of uranium from phosphoric acid and for production of sodium di-uranate at Rashtriya Chemical and Fertilizers, Chembur, Mumbai. For Uranium Corporation of India Limited (UCIL), authorizations were issued for construction of Tailings Pond for Turamdih Mill as also for Tummalapalle Mill. For Indian Rare Earth Limited (IREL), Orissa Sand Complex (OSCOM), authorization was issued for siting of Monazite Processing Plant.

Safety Surveillance of Radiation Facilities

A total of 202 devices were issued type approval, 3 medical cyclotrons and 2 industrial gamma processing plant were issued license for operation and 378 Radiological Safety Officers (RSOs) were licensed. Over 2300 licenses were issued for procurement of radiation sources and over 181 authorizations were issued for disposal of 3071 spent sources. A total of 331 certificates of registration were issued to diagnostic X-ray installations. Three registration certificates for Type-A packages were issued, 9 validity certificates of approval of design-B package were renewed and 1 approval for the design of Type-B package was issued. Regulatory Inspections (RI) were conducted in various radiation facilities and 7 unusual occurrences related to loss or misplacement of radiation sources were investigated.

Industrial Safety

There were 7 fatal accidents at various construction sites. These accidents were investigated and several remedial measures were taken, including conduct of monthly inspections at all construction sites, to prevent such accidents. Regulatory Inspections for industrial and fire safety aspects were strengthened at various projects for immediate rectification of the unsafe conditions. Job Hazard Analysis (JHA), preparation of safe working procedures and use of field check list on JHA were made mandatory for all hazardous works at sites.

Regulatory Inspections

A total of 23 inspections were carried out in the operating plants and research facilities. In nuclear projects, 6 inspections were carried out. In addition, 59 inspections were carried out on aspects dealing with industrial safety. This was on account of introduction of monthly inspections for plants under construction since September 2006 towards ensuring adequate level of industrial safety at construction sites. Six inspections were also carried out on civil engineering aspects.

Regulatory Documents and Safety Studies

A total of 9 new safety documents have been published; the total number of safety document published so far being 120. Safety studies were conducted at AERB, Mumbai and at the Safety Research Institute, Kalpakkam in the areas of event analysis of Indian PHWRs and VVER-1000, Probabilistic Safety Assessment (PSA), reactor physics, radiological safety and environmental safety.

International Cooperation

In the International Cooperation Program, the eighth nuclear safety cooperation meeting with USNRC was held in USA. Another important event was the meeting of IAEA's International Nuclear Safety Group that was hosted by AERB in Mumbai in March 2007. AERB Staff also participated in activities of IAEA like Incident Reporting System, International Nuclear Event Scale, Commission on Safety Standards and Coordinated Research Programs.

Training/Workshops/Seminars-Programs

Nine training programs were organized for industrial radiography and nuclear medicine professionals. Workshops/Seminars were organized on topics like containment structure of Indian Nuclear Power Plants (NPPs), safety and security of industrial radiography sources, radiation safety and regulations in nuclear medicines, regulatory requirements of accelerator safety as part of safety promotional activities. A discussion meet was organized on application of PSA of NPPs to share the experience and the progress made in different utilities. As part of promotional activity in industrial safety, DAE safety and occupational health professional meet and national symposium on industrial and fire safety-2006 were also organized.

Public Information

Information on major activities of AERB was disseminated through annual reports, newsletters and press releases and by posting information on AERB website. Required measures were taken to implement the 'Right To Information Act-2005'.

ISO Certification

Recognizing the importance of quality in regulatory system, AERB obtained ISO 9001 – 2000 certification for Quality Management System in AERB for its core activities of consenting processes, regulatory inspections of nuclear and radiation facilities and development of safety documents.

CHAPTER 2

SAFETY SURVEILLANCE OF NUCLEAR FACILITIES

2.1 NUCLEAR POWER PROJECTS

2.1.1 Project Safety Review

Presently a total of 6 nuclear power units are under construction and one unit (KGS-3) is under commissioning in India. The units under construction are: 3 units (KGS-4, RAPP-5&6) each of 220 MWe capacity PHWRs; 2 units (KK-NPP-1&2) each of 1000 MWe capacity PWRs VVER type, and 1 unit of liquid sodium cooled PFBR of 500 MWe capacity. Though the design of VVER type reactors is proven in Russian Federation and some other countries, this is for the first time that reactors of this type are being constructed and reviewed in India.

Two units of PHWRs (KAPP-3&4), each of 700 MWe capacity, proposed to be located at Kakrapar near the 220 MWe units KAPS-1&2, are under review for siting consent. Design of KAPP-3&4 would utilize the experience gained during design, construction, commissioning, operation and safety review of TAPP-3&4.

AERB has been following the well-established practice of multi-tier review process for safety review of nuclear projects starting from siting through commissioning stages. The Site Evaluation Committee (SEC), PDSC, Civil Engineering Safety Committee (CESC) and associated Specialist Group (SG) /Working Groups (WG)/Task Forces (TF), carry out the first-tier review. In the case of KK-NPP, an in- house KK Co-ordination Group (KK-CG) along with Specialists Groups (SGs), carried out the first-tier review. The corresponding Advisory Committee for Project Safety Review (ACPSR), which includes specialist members from the Ministry of Environment and Forests, Central Boilers Board, Central Electricity Authority and Educational/ Research Institutes and Members from BARC, NPCIL and AERB perform the second-tier review. The third-tier review is carried out by the Board. The safety review process is supplemented by regulatory inspections for verifying compliance of the requirements prescribed by the safety committees and those specified in various codes, guides and standards of AERB.

During 2005-2006, AERB issued authorizations for the operation of TAPP-4 upto 90 % Full Power (FP). TAPP-3 achieved first criticality on May 21, 2006 and after successful completion of mandatory commissioning tests, AERB authorized raising of power in stages upto 85 % FP.

Review of SER on KAPP-3&4 by SEC-700 has been completed.

The safety review of two nuclear fuel cycle facilities designed by IGCAR, IFSB for PFBR and DFRP continued during the year. AERB granted clearances for construction of IFSB and for construction of HEF for DFRP on August 30, 2006 and September 04, 2007 respectively. IGCAR is also designing FRFCF to meet fuel reload requirement for PFBR and to close the fast reactor fuel cycle. AERB issued siting consent for FRFCF in September 2006.

AHWR, with an objective to develop the technology for utilization of thorium in India, is under design at BARC. The specially constituted committee PLDSC-AHWR completed the pre-licensing design safety review of AHWR and issued its report.

Table 2.1 lists the number of meetings held by various safety committees during the year. In addition, a number of meetings of SGs, TFs and WGs constituted by PDSC/CESC/ACPSR/AERB were held for in-depth review of specific aspects of the projects.

Table 2.1: Safety Review Committee Meetings of Power Projects

Project Committee	Number of Meetings
ACPSR-LWR	4
ACPSR-PHWR	5
ACPSR-FBR	2
ACPSR-FRFCF	1
PDSC-KGS-3&4 and RAPP-5&6	10
PDSC-TAPP-3&4	21
PDSC-KAPP-3&4	9
PDSC-PFBR	5
PDSC-DFRP	10
PDSC-IFSB	2
PDSC-FRFCF	3
CESC	8
PLDSC-AHWR	8
SEC-700	5

The status of safety review on various projects and important observations and recommendations made during the review process are given in brief in the following paragraphs.

TAPP-3&4

TAPP-4 was operating upto 90 % FP till April 8, 2006 in line with AERB authorization. Subsequently the operation of TAPP-4 was restricted to 50 % FP as bulk neutron power oscillations occurred on a few occasions due to malfunction of Reactor Regulating System (RRS). Operation upto 50 % FP was allowed as no abnormality was observed in the performance of the RRS at any time during the operation of the unit at this power level. 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. Subsequently, TAPP-4 was permitted to raise the power back upto 90 % FP.

TAPP-3 achieved first criticality at 10.44 h on May 21, 2006. Subsequently, low power phase-B physics experiments were carried out and the unit was synchronized to the grid on June 15, 2006. Following satisfactory completion of phase-C commissioning tests at 50 % FP, AERB issued authorization for raising the power upto 85 % FP.

In a joint meeting of ACPSR and SARCOP held in May 2006, it was decided to hand over further safety review of TAPP-3&4 to SARCOP as both the units have gone into operation phase. Accordingly, in September 2006, PDSC submitted a comprehensive safety assessment report to AERB and also presented the status of safety review to Unit Safety Committee (USC) for TAPS-3&4 to facilitate further safety review activities. Thus, the review of the project phase was completed and the safety review activities of the units were taken over by SARCOP and USC.

Joint Meeting of ACPSR-PHWR and SARCOP in Progress at Tarapur
(Shri G.R. Srinivasan, Chairman, ACPSR-PHWR and Shri S.K. Chande, Chairman, SARCOP are seen at the centre.)

Some of the important observations made during the safety review of TAPP-3&4 are given below.

- In view of reactor trips due to halting of Out Processor Nodes (OPNs) and Input Processor Nodes (IPNs) of RRS of TAPP-4, the hardware modifications in RRS and gain increase of Self Powered Neutron Detectors (SPND) were incorporated.
- TAPP-4 had tripped on “High Bulk Neutron Power” on a few occasions due to power oscillations during power operations at 90 % FP and then even at reduced power of 70 % FP. Considering that the operation of reactor upto 50% FP was satisfactory, without any power oscillations, AERB permitted the same. Based on RRS stability analysis carried out by specially constituted task teams of BARC, cycle timings of IPNs and OPNs were reduced. AERB permitted raising of reactor power to 85 % FP and 90 % FP for TAPS-3&4 respectively after incorporation of required changes progressively and ensuring satisfactory performance of RRS. Subsequently, control system gains were reduced appropriately after detailed safety review by TAPS-3&4-USC to further improve the system stability.
- Results of low power phase-B tests of TAPP-3 were satisfactory. The results of reactivity worth measurements during these tests were at variance with the predicted values. These were reviewed and found to have no adverse safety implications. Investigations of the reasons for the deviation are underway.
- Gross Load Rejection (GLR) and Net Load Rejection (NLR) tests were performed at 50 % FP for TAPP-3 after incorporating changes in design of control oil pump for turbine. The results were satisfactory. The tests would be repeated at 85 % FP and would be demonstrated for TAPP-4 also.
- Spent SPNDs with high radiation fields are stored temporarily in spent fuel storage building. NPCIL has been asked to devise a scheme for their safe disposal.
- TAPP-4 full scope training simulator has been made ready. The training simulator was validated by simulating certain events such as gross load rejection from 85 % FP, reactor trip from 85 % FP and subsequent startup and raising power, etc. The associated review was completed.
- Based on requirement of AERB, an active standby diesel driven firewater pump system has been provided and commissioned.
- NPCIL has proposed to delete the earlier provision of step-back, i.e., automatic reduction of reactor power to ~65%FP under certain postulated situations and the proposal is under review.

KGS-3&4 and RAPP-5&6

KGS-3&4 and RAPP-5&6 are “Repeat Designs” of KGS-1&2 and RAPS-3&4 respectively with certain differences in Control & Instrumentation (C&I) systems and plant layout. The design safety review process continued with emphasis on these differences, feedback from the operating plants and observations made during regulatory inspections.

Construction activities for KGS-3 were completed and commissioning activities are in progress. Safety review of various major commissioning activities namely, containment tests, hot conditioning of PHT system, fuel loading, flushing of moderator system with limited quantity of heavy water, filling of PHT system with heavy water, bulk heavy water addition to the moderator, etc., was carried out and clearances were issued in sub-stages, accordingly. After satisfactory resolution of all issues arising from the review and after completion of the prerequisites, authorization for FAC was granted on February 25, 2007 and the unit achieved first criticality at 10:10 hours on February 26, 2007. Subsequently, after review of the results of first criticality, AERB granted authorization for phase-B low power physics tests. AERB granted authorization on March 26, 2007 for synchronization of the unit to the power grid and operation of the reactor power up to 50 % FP after successful completion of phase-B tests and review of the results.

ACPSR-PHWR Members visiting KGS-3 Control Room

From L to R: Shri R.I. Gujarathi, Director, NPSD, Dr. S. M. Lee, Chairman, PDSC-KGS-3&4, Shri S.K. Chande, VC-AERB, Shri S.S. Bajaj, Senior ED (Safety),NPCIl and Shri K. Ramamurthy, Station Director, KGS-3&4 Shri S.K. Chande, VC-AERB, Shri S.S. Bajaj, Senior ED (Safety), NPCIl and Shri K. Ramamurthy, Station Director, KGS-3&4

For KGS-4, civil construction activities and erection of various systems, equipments and components are in progress.

Civil construction activities and erection of various systems, components and equipment remained in progress for RAPP-5&6 units. It is expected that containment proof test, Integrated Leakage Rate Test (ILRT) and PHT system hot conditioning and light water commissioning would be taken up for RAPP-5 in the second quarter of 2007 after completion of required review.

Some of the important observations made during design safety review of these 4 units and commissioning of KGS-3 are given below.

- Containment proof test and ILRT of KGS-3 was carried out during November 2006. Observed leakage rate was 0.24 % of contained air volume per hour at 1.06 kg/cm^2. Interception by Secondary Containment (SC) was measured and was found to be more than 90 % as per the design intent. Containment isolation test was carried out in an integrated manner prior to FAC and results were satisfactory.
- The hot conditioning of KGS-3 was completed successfully and protective uniform magnetite layer of 0.43 microns was achieved. Emergency Core Cooling System (ECCS) test and other light water tests related to PHT system were carried out and system performance was satisfactory.
- The design feature of on-line clutch release test for primary shutdown system has been incorporated in all the 4 units.
- Each of the 4 units has been provided with 3 Diesel Generator (DG) sets of 2400 kW each. After site installation, while testing of DGs of KGS-3 for the largest available load of 400 kW of Primary Pressurizing Pump (PPP) motor, the 6.6 KV DG terminal voltage collapsed and the PPP motor could not be started. This was due to voltage dip in excitation transformer, which is supplying excitation requirements of the pilot exciter of the alternator of DG set. The DG set performance became satisfactory when excitation requirement of DG alternator was fed from Class II buses. NPCIL proposed, as an interim measure, to install a 1 kVA inverter powered from 220 V class I buses of station power supply to cater the excitation requirements of the pilot exciter of each DG alternator and the proposal was accepted after the review. NPCIL has been asked to explore an alternate solution in consultation with manufacturer. In view of the above, a new clause – 'If any of the two power UPS on its battery bank is not available or any of the class-II buses are not available, the reactor shall be brought to cold shut-down state' has been added in the technical specifications for operation.
- Each of these DG sets was equipped with a Class II electrically driven Crank Case Exhaust (CCE) fan. As per the manufacturer, the DG sets can run safely for ~32 seconds only without availability of the CCE fan. Logic has been provided to trip the DG sets with 27 seconds delay in case the CCE fan does not start. Subsequently, the fan power supply was changed over to Class III power supply to reduce the dependence of DG starting on Class II power supplies.
- For 1 of the 6 ion-chamber housings, the distance between calandria and the housing was found to be 28 mm instead of the specified value of 20 mm. The reason of the deviation was reviewed and the deviation on neutron power readings/attenuation factor for the ion-chambers was found acceptable.
- Due emphasis was given for environmental qualifications of safety related structures, equipment and components since the design stage of KGS-3&4. NPCIL has been asked to submit a comprehensive report covering methodology followed, standards used, tests done, analysis carried out, etc., in this regard for review.

- Independent Verification and Validation Committee (IV&VC) reviewed various computer based systems of KGS-3 and a WG audited the reports of IV&VC. NPCIL implemented the recommendations of IV&VC and the WG.

- Pre-Service Inspection (PSI) data for secondary cycle system of KGS-3 has been collected. 14 out of 2676 components were found to have less than 87.5 % of nominal wall thickness at isolated locations. These components would be replaced. Ultrasonic thickness gauging for PHT feeders has been completed. PSI on coolant channels was carried out as per the requirements specified by the expert group on coolant channels.

- Seepage of sub-soil water has been noticed in the stressing gallery of KGS-3. Corrective actions have been taken by site and the CESC would be doing the necessary follow-up. Sub-soil seepage was also noticed through rock-anchors of the raft in the annulus area between Primary Containment (PC) and SC. The corrective actions were carried out to rectify seepages.

- Plant, Site and Off-site Emergency preparedness procedures are under review by AERB.

KK-NPP-1&2

For KK-NPP the review process during this period was mainly focused on third and final sub-stage of regulatory consent for construction, i.e., for EE. Based on satisfactory review of the application for EE and taking into account the commitments from NPCIL for resolution of salient pending issues in a time bound manner, AERB granted clearance for EE for unit-1 on August 30, 2006. NPCIL would seek EE clearance for unit-2 separately.

For unit-1, all the reactor pit equipment and components, viz., core catcher, truss cantilever, dry shield, lower plate, measuring channels, support truss, thrust truss and other embedded parts and support ring for RPV have been erected. The RPV has been installed in the reactor cavity. Nuclear Steam Supply System (NSSS) piping and equipment erection works has been started in the Reactor Building (RB). Civil construction of various buildings and structures of both units remained in progress.

Some of the salient observations/recommendations during safety review are given below.

- Reports on seismic and environmental qualification of safety related control and instrumentation items, the methodology used and the test results, etc., would be made available for review.

- Description and verification of the procedures for computer codes used in strength calculations in mechanical design were reviewed and found acceptable. Similar details for validation of certain other codes would be provided for review.

KK-NPP Unit-1: Reactor Pressure Vessel being taken inside Reactor Building

- Methodology for Verification & Validation (V&V) of computer based systems has been worked out and is under review.

- Ageing effects and life estimation of the High Density Poly Ethylene (HDPE) sheath on the cables of pre-stressing system was carried out by the Indian Rubber Manufacturers Research Association (IRMRA). As per IRMRA report, the estimated life of the sheath is 62 years for service temperature of 33° C and 30 years for service temperature of 40° C. As the ambient temperature at Kudankulam site is generally higher than 33° C, the accelerated drop in life of HDPE due to small rise in temperature is a matter of concern. An action plan is being developed on monitoring and maintaining the HDPE/concrete temperature lower than 33° C.

KK-NPP Unit-1: RPV Positioned Horizontally prior to installation in the Reactor Cavity

- AERB representatives witnessed the mock-up studies for threading and grouting of inverted U-cables of the pre-stressing system for PC structure. The results of the studies were satisfactory.

- It was shown by analysis that enough provisions have been made to guard main control room, SC and safety related pipe trenches against the Low Trajectory Turbine Missile (LTTM). However, proposed location of spent fuel building comes under LTTM. Its layout/design would be finalized by taking into consideration aspects of LTTM.

- Procedure for welding of Stainless Steel (SS) Cladded low alloy steel pipelines of main coolant system as given in Russian Standards, would be followed including for Non-Destructive Examination (NDE) without any deviation. Required shop testing, welders' qualification, etc., would be carried out prior to starting the actual job at site.
- The results of seismic analysis of RB including floor response spectra were reviewed and found satisfactory.
- A simplified seismic analysis of reactor internals by an expert group showed that modelling of reactor internals and RPV support was satisfactory.

PFBR

AERB granted clearance for construction of RV upto +26.715 m elevation and Spent Sub-assembly Storage Bay (SSSB) in May 2006. During the year, safety review focused on reactor physics design, Inclined Fuel Transfer Machine (IFTM), primary & secondary heat transport sodium circuits, reactor assembly components, engineered safety features, reactor auxiliary systems, accident analysis, control and instrumentation systems, etc. for the next regulatory consent sub-stage of construction i.e., EE. Some of the important observations/recommendations made during the review process are given below.

- The neutron detectors, which would be located in a housing below Safety Vessel (SV) are under indigenous development and are to be qualified by appropriate testing.
- Since the Main Vessel (MV) is made up of austenitic SS and radiation damage is not expected to be of concern during the design life of 40 years. However, designers have been asked to explore the possibility of installation of test coupons in MV, as part of surveillance, to facilitate assessment of irradiation damage.
- IFTM will be tested in Large Component Testing Rig Facility at IGCAR before its use in PFBR. The testing programme would be reviewed prior to the testing.
- An expert group was constituted to carry out the safety review of handling and erection procedures for major reactor components such as SV, MV, Roof Slab, Inner Vessel, etc. Based on these reviews, detailed procedures would be worked out and verified.
- As there is no design provision for monitoring of flow through blanket Sub Assemblies (SA), the designers have been asked about the detection of flow blockage in these SAs during reactor operation and also to submit experience/ approach followed in this regard in other countries for review.

Reactor Vault Liner with Biological Shield Cooling Pipes of PFBR

- The designers were asked to submit theoretical analysis and experimental verification of SA vibrations due to internal and external leakage flow. Unlike in initial design, the primary and secondary sodium flows will be kept constant corresponding to 100 % FP level right from the reactor start-up. The implications of this change are under review.
- The designers have been asked to explore the possibility of generating additional signal on the unavailability of Operation Grade Decay Heat Removal System (OGDHRS) (based on Class-IV power failure and/or unavailability of both secondary sodium pumps) to actuate Safety Grade Decay Heat Removal (SGDHR) system.
- IGCAR has started development of training simulator. A document on simulator specifying scope and requirements and the performance boundaries would be submitted to AERB for review. The training simulator will undergo IV&V process as per AERB practice.

Main Vessel Fabrication at Site Assembly Shop of PFBR

- It was noted that minimum height of sodium level above inlet windows on Intermediate Heat Exchanger (IHX) to guard against gas entrainment has been kept as 100 mm at 100 % nominal coolant flow under all conditions. This margin was noted to be less, considering the aspects of accuracy involved in sodium level measurement, alarm setting level and operator/ protection system action, etc. The designers have been asked to re-look this aspect as fall in level below the inlet window may give rise to reactivity transient due to passage of argon cover gas through IHX and subsequently through the core. Also, in the event of sudden fall of a sleeve valve surrounding inlet window of an IHX, possibility of gas entrainment due to increased flow through other 3 IHXs may occur. This aspect is to analyzed by the designers and reported for further review.

- In order to avoid any possible freezing of sodium during initial filling (about 1100 tons) in MV and also from the point of view of restricting the differences in temperature of the reactor core component from thermal stresses during pre-heating/filling, the designers have been asked to carry out temperature mapping of all the critical areas of MV and internals. Concern was also raised for high temperature in concrete filled roof slab and its long term effect on radiation shielding when preheat temperature of about 150±30 ^{0}C is maintained in MV.
- The designers have been asked to eliminate localized edge deformation, if any, at the sliding joint due to large variation in temperature and to confirm that such phenomenon would not affect smooth movement of Fuel Transfer Pot of IFTM.
- Detailed review of the various systems, Argon Cover Gas System, MV and SV cooling systems, Roof Slab cooling systems, etc., is in progress. The designers have been asked to work out the reliability of operation of these systems under various normal operating and transient conditions.
- For equipments/components, which would be installed inside the RV, replacement of elastomer seals (inflatable and back seals) is envisaged once in 10 years. A comprehensive document on ageing management of these equipments and components addressing periodic surveillance, ISI aspects, etc., is asked to be submitted for review.
- CESC reviewed in detail safety aspects related to engineered soil back filling near perimeter wall surrounding 8 buildings (Nuclear Island Connected Buildings, NICB), rigid retaining wall vis-à-vis flexible retaining wall, etc.

KAPP-3&4

The design of 700 MWe PHWR (KAPP-3&4) is evolved from 540 MWe PHWR design (TAPP-3&4). The proposed site for the project is Kakrapar, South Gujarat adjoining the KAPS-1&2. SEC-700 has completed the review of SER. AERB has initiated the design safety review of the project by PDSC. The review of Design Basis Information has been completed and the review of other related aspects as given in Preliminary Safety Analysis Report (PSAR) is in progress.

Some of the important observations/ recommendations made by the SEC and PDSC are given below.

- The SEC review indicated that the exclusion zone of the site is not in full conformity with the AERB Safety Code on Siting. With regard to the distance of Near Surface Disposal Facility (NSDF) for solid waste, from the exclusion zone boundary, review emphasized that the apportioned dose limit of 50 μSv/y for terrestrial route should be met. The report on Site Safety Assessment would be reviewed during detailed design stage.
- An independent study on geological aspects of the site was undertaken by Atomic Minerals Division (AMD) to check the presence or absence of any active fault within 5 km area around the site. The study indicated that there is no positive evidence for existence of any capable fault within 5 km region around the site.
- Based on the review of the reactor physics calculations, NPCIL has been asked to revise the calculations using the 69 neutron energy group cross section set library.
- The adequacy of reactor over power trip set points for reactor operation with flux tilts is to be demonstrated by analysis for different reactor states. The analysis is also to determine the maximum tilt permitted for prolonged operation of the reactor.
- NPCIL has been asked to conduct detailed studies on stability of control system taking into account the small amount of partial boiling at the coolant channel outlets along with related thermal hydraulics and reactor physics aspects.
- Thinning rate of outlet feeders of coolant channels could be more in KAPP-3&4 due to higher flows and partial boiling allowed in the channels vis-à-vis that observed in other operating PHWRs. Considering this, the designers have proposed to use schedule 160 pipes and fittings for feeders to have better margins.

DFRP

IGCAR is setting up DFRP to process spent fuels of FBTR and PFBR. This is a forerunner of the reprocessing facility in FRFCF to be setup at Kalpakkam. It is divided into 2 concrete cell facilities called HEF and PPF. The authorization for construction of HEF was sought from AERB. The documents on the civil design and site were reviewed by CSED and PDSC-DFRP and based on the favourable report by the reviewer, clearance for civil construction of HEF was granted in September 2006.

IFSB

IGCAR has proposed to construct an IFSB for PFBR in FBTR complex for making Fuel Assemblies (FA) for initial 2 core loadings. Subsequent to satisfactory completion of the review of IFSB design and suitability of site, AERB granted clearance for construction for IFSB in August 2006.

Some of the important observations/ recommendations made during the review process are the following.

- The adequacy of shield design to be checked for build-up of certain radionuclides due to decay of in case fuel is stored for extended time periods.
- Analysis of fuel SA drop from a height of 450 mm or more indicated initiation of local plastic deformation of the wrapper of SA. In view of this, it was recommended that appropriate assembling and handling procedures be evolved so as to minimize the probability of SA drop and also to mitigate its consequences.
- Designers were asked to analyze and confirm that sub-criticality, under maximum credible compaction of SAs, would be maintained.
- It was recommended to carry out analysis of the impact of an earthquake equivalent to Safe Shutdown Earthquake (SSE) level on the facility, to confirm the integrity of the fuel storage vaults.

FRFCF

FRFCF is being built at Kalpakkam near the PFBR site, to meet the fuel reload requirement for PFBR. FRFCF comprises of FRP, FFP, RUP and CSP. The facility will also have Waste Management Plant (WMP) and common services and utilities to cater to the needs of the plants. Based on the review of the SER, the site clearance for FRFCF was given in September 2006.

Some of the important observations/ recommendations made during the process of safety review, are given below.

- Civil structures like underground water sump, stormwater drain, Low, Intermediate and High Level liquid waste trenches and DG room (Class III power supply) would be considered as safety related structures/ buildings while reviewing the application for consent of construction.
- The activity levels and quantities of the wastes from all the facilities of FRFCF would be listed as per AERB categorization.
- Finished Floor Level of 12.8 m for safety related structures and 11.8 m for infrastructure buildings would be checked for 100 year return period of maximum postulated flood.

2.1.2 Authorizations/Permissions Issued for Nuclear Projects

TAPP-3

- Authorization for addition of 40 tons of Heavy Water in Moderator System in parallel with initial Fuel Loading Operation and Heavy Water Filling of PHT system.
- Authorization for Bulk addition of Heavy Water to Moderator System.
- Authorization for FAC.
- Authorization to conduct Low Power phase-B Physics Experiments.
- Authorization for Synchronization of the unit with Power Grid and Operation upto 50 % of FP.
- Authorization for Operation upto 85% of FP.

KGS-3

- Authorization for Hot Conditioning of PHT System and Light Water Commissioning.
- Permissions for Draining Light Water from PHT and Moderator Systems.
- Authorization for Initial Fuel Loading in the Core.
- Authorization for Addition of 20 tons of Heavy Water in Moderator System for flushing and Heavy Water Filling in PHT System.
- Authorization for Bulk Addition of Heavy Water to Moderator System.
- Authorization for FAC.
- Authorization to Conduct Low Power phase-B Physics Experiments.
- Authorization for Synchronization of the unit with Power Grid and Operation upto 50 % of FP.

KK-NPP-1&2

- Clearance for EE for KK-NPP-1.

PFBR

- Clearance for Construction of RV upto +26.715 m elevation and construction of SSSB.

DFRP

- Clearance for Civil Construction of HEF.

IFSB

- Clearance for Civil Construction of IFSB.

FRFCF

- Consent for Siting.

2.1.3 AHWR

AHWR has been conceptualized and designed by BARC. The objective of AHWR is to develop fuel cycle technologies involving large-scale utilization of thorium for power production. AHWR is a 300 MWe vertical pressure tube type reactor with light water as coolant and heavy water as moderator. Several passive, advanced and innovative features have been incorporated in the design. A pre-licensing design safety review of AHWR was taken up in 2005 to identify specific areas that need to be resolved before the formal licensing process of the reactor. For this purpose, AERB constituted a design safety committee two years back.

There is no precedence on the review methodology for pre-licensing of such a design. AHWR would perhaps be the first thorium-fuelled NPP in the world with several innovative technologies. There is very limited experience with the thorium technology to-date. In view of this, the review process was a challenging task.

The committee held several meetings for a detailed pre-licensing review of AHWR and prepared a report on its findings and recommendations. As a part of the review, the committee also prepared the following important documents, which will be useful for carrying out licensing review by PDSC at a later stage.

- Objectives, Principles, Goals and Criteria for Safety in Design of AHWR.
- Manual on Safety Analysis and Operability Aspects in Design of Nuclear Reactors.
- Proposed Format and Contents of Safety Analysis Report (SAR) for AHWR.
- Review Questions/Items.
- Report on 'Reactor Physics'.
- Report on 'Thermal Hydraulics'.

The committee prepared a list of issues that could have an impact on licensing of the AHWR design. While a few of them have been resolved, the resolution of the remaining needs further information from the designers. However, acceptance criteria have been established for these issues. The committee has also listed future work and guidelines for the same. A list of items requiring R&D has been arrived at.

2.1.4 Regulatory Inspections of Projects

Regulatory Inspections (RI) of the on-going nuclear projects were carried out as a safety audit measure to ensure compliance with the AERB safety requirements and stipulations. The number of RI carried out for various projects is given in Table 2.2.

Table 2.2: Regulatory Inspections of Nuclear Projects

Site	No. of Inspections
KK-NPP-1&2	1
KGS–3&4	1
PFBR	2
DFRP	2

In addition to these planned inspections, AERB representatives visited TAPP-3&4 and KGS-3 to observe certain important commissioning tests and to assess the preparedness of site for the different phases of commissioning. Inspections of certain project sites were carried out, as necessary, exclusively by experts in civil engineering and industrial safety.

Some of the important observations/ recommendations made by RI teams are given below:

KGS-3&4

- In 1 of the 6 ion chamber boxes installed, the distance between calandria and the chamber was found to be 28 mm instead of the specified value of 20 mm. The reason for this deviation was reviewed and the effect on neutron power was found acceptable.
- In KGS-4, Primary Shutdown System (PSS) guide tube installation was completed. The minimum gap required between calandria tubes and PSS guide tubes, is 10 mm but it was found to be 8.2 mm at 4 locations and 9.2 mm at 6 locations. The origin and implications of the deviations were examined by PDSC and resolved.
- The 5th stage rotor blades of Low Pressure (LP) turbine were received in damaged condition and were subsequently replaced by the manufacturer. After the RI, it was recommended that a detailed report on the job carried out and subsequent checks planned for turbine operation, be submitted to AERB for review.
- As per commissioning procedure for control Uninterrupted Power Supply (UPS), input voltage is to be varied upto under voltage/over voltage, to ensure that alarm appears and rectifier trips and invertors work on battery. As per commissioning report, this test has not been done for all the control UPS. It was recommended that the intended function of UPS should be tested at site.

KK-NPP-1&2

- Review of passport for welding electrodes indicated that tensile test values at high temperature are more than the values at room temperature test. The designers/ suppliers were asked to clarify this.
- It was recommended that KK-NPP should arrange checking of all passports to verify their completeness, basis of acceptance of Non Compliance Reports (NCRs) and implementation of recommended actions, if any.
- Procedure for installation and testing of fuel pool liner system and Quality Assurance (QA) plan for the same job were reviewed. It was recommended that the requirement of protecting the SS liner from contact with CS materials should be incorporated in the procedure and the procedure should also address the repair of welds.
- As per procedure for vacuum testing, soap solution for testing can be prepared by mixing potable water and soap solution. It was recommended that the use of demineralised water should be considered for mixing with soap solution for performing the test.

- The procedure for RPV handling and lifting does not mention the lifting rate of RPV from ground, the rotation and movement speed of crawler crane and the maximum permissible speed of the polar crane movement. Also, it does not specify any requirement of trolley rail leveling on the equipment transport portal. These aspects were asked to be included in the revised procedure.
- As per procedure, the Steam Generator (SG) is to be taken inside the SG cavity in a tilted condition due to space constraints. For this, along with the main sling at the centre, an additional winch of 40 tons capacity is used. However, the maximum load, which will act on the winch, is not indicated. It was recommended that the maximum load expected on the winch while tilting the SG, should be estimated to ensure that it would not exceed the safe working load on the winch.

PFBR

- Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) identified 27 schemes for handling and erection of various reactor components, out of which 5 have been prepared and sent to designer for comments. The selected procedures would be reviewed by AERB.
- The designers proposed to delete the provision of personnel access at the lower elevation of RV. It was recommended that any change in design with regard to deletion of the access opening in the RV liner should be reported to AERB for review.

DFRP

- In fuel cell, there are large number of tanks and pipes in clusters, which extend from base level upto +12 m elevation. It was recommended that proper layout of equipment and piping is essential to facilitate maintenance/decommissioning and asked the site to submit a detailed note on this aspect for review.
- Remedial steps have been taken up at Waste Tank Farm (WTF) for arresting leaks/seepages at WTF area. It was reported that at 12 locations on the floor, grouting has been carried out to correct the seepage of groundwater into the WTF area. It was recommended to check during monsoon period the efficacy and adequacy of the grouting done so far. It was also noted that a pump would be employed to transfer the seepage water to either High Level Waste (HLW) Tank or Delay Tank depending on the levels of activity. This issue is under review.

2.2 NUCLEAR POWER PLANTS AND RESEARCH REACTORS

OPSD of AERB carries out the safety review and monitoring of operating NPPs and research reactors. SARCOP, the apex committee for overseeing safety of operating plants, held 22 meetings during the calendar year 2006.

The USCs met a number of times to review safety related issues of NPPs. The information on number of meetings conducted by various USCs during 2006 is given in Table 2.3.

Table 2.3: Meetings of Safety Committees

Name of the Safety Committee	No. of meetings
SARCOP	22
TAPS-Safety Committee	11
TAPS-3&4 Safety Committee	3
RAPS - MAPS Safety Committee	10
NAPS - KAPS Safety Committee	22
KGS - RAPS - 3 & 4 Safety Committee	8
IGCAR Safety Committee	5
CESCOP	3

All the NPPs and research reactors operated safely. The safety status of individual NPPs and research reactors is briefly described below.

2.2.1 TAPS-1&2 and TAPS-3&4

TAPS-1&2

TAPS-1&2 were operational upto a power level of 160 MWe. TAPS-1 remained shutdown for refueling and In-Service Inspections (ISI) from November 17, 2006 to December 15, 2006.

TAPS completed the condition survey, repair and rehabilitation of the main plant buildings at TAPS-1&2. The final report of the work was reviewed and approved by CESCOP. TAPS-1&2 was asked to prepare a procedure for regular monitoring of the main plant buildings. The review of seismic re-evaluation of the units was conducted. The following issues remain pending for resolution, i.e., validation of computer programs used for analysis and design, re-evaluation of foundation structures and issues related to modeling of roof trusses for RB and Turbine Building (TB).

TAPS-3&4

TAPS-3&4, 540 MWe PHWR NPPs, which were commissioned in 2005-2006, were operational up to power level of 85 % FP and 70 % FP respectively.

TAPS-3&4 achieved criticality in March 2005 and May 2006 respectively and safety reviews covering design, construction and commissioning of these units were carried out by NPSD. Based on review of various commissioning tests in these units, AERB permitted the operation of TAPS-4 up to 90 % FP in July 2006. Similarly, permission was granted for the operation of TAPS-3 up to 85 % FP in August 2006. Certain commissioning tests, which form the pre-requisites for operation of these units at 100 % FP are required to be completed.

The PDSC and ACPSR completed the safety reviews of TAPS-3&4 in September 2006. Since then, OPSD, TAPS-3&4 Safety Committee and SARCOP are carrying out the safety review and monitoring of the operation of TAPS-3&4.

Power Oscillations in TAPS-4: Since March 2006, TAPS-4 has been facing a problem of instability in the RRS, resulting in oscillations in reactor power. These oscillations had resulted in tripping of the reactor on overpower on 4 occasions during the year. All these incidents were reviewed in detail in AERB by USC and SARCOP. Based on the preliminary reviews, it was inferred that the reason for the control system instability could be the higher levels of gain in the signal amplifiers of SPNDs of the RRS. Hence, the gain settings of the SPND amplifiers were reduced to eliminate the problem. In spite of this measure, the oscillations did not subside.

Meanwhile, a number of task teams comprising experts from BARC undertook detailed review and analysis of various aspects of RRS design to find out the root cause of power oscillations. The studies carried out by the task teams revealed that the power oscillations observed in TAPS-4 were due to improper combination of control system gain values and the RRS cycle time. Based on the detailed analyses on control system stability and transient response, new values were arrived at for the RRS cycle time and the gains set for different subsystems of RRS. Suitability of the new cycle time and gain values was confirmed with the help of computer based simulations. During these simulations, while the runs with old gain and cycle time settings caused power oscillations, such problems were not experienced with the new gain and cycle time settings.

The analyses carried out by BARC and the suggested values of gains and cycle times were reviewed in detail by SARCOP. Subsequently TAPS incorporated the new values for cycle time and gains in the RRS of TAPS-4. Performance of the reactor with the modified parameters of RRS is being closely monitored.

2.2.2 RAPS-1&2 and RAPS-3&4

RAPS-1 continues to be under shutdown since October 2004. RAPS-2, 3 & 4 operated normally during the year.

RAPS-1

NPCIL submitted a proposal for transfer of fuel bundles having burn-up below 3500 MWd/t from RAPS-1 to RAPS-2. After a detailed review of the safety implications of the proposal, AERB agreed for transfer of fuel bundles from RAPS-1 to RAPS-2.

RAPS-2

Thinning of elbows in the feeder pipes of the PHT system has been observed in several of the Indian PHWRs. The assessment indicates that the rate of thinning in some of the feeders was higher than the initially anticipated rates. Such observations have also been reported from similar reactors abroad. The reason for the thinning appears to be flow assisted erosion-corrosion of the feeder pipe fittings. SARCOP has been closely monitoring the status of health of PHT feeders in the PHWRs.

After the problem was noticed, the scope and coverage of ISI of the feeders has been enhanced significantly in the recent years in all the NPPs. The results of these inspections indicated that the higher than normal thinning is limited only to a small number of feeders. In some cases, it may limit the safe service life of the feeder and the same may need replacement. In view of this concern, NPCIL had undertaken en-masse replacement of PHT feeders in MAPS-1&2 and NAPS-1, during their respective long outages for EMCCR.

In RAPS–2, during its EMCCR outage in 1996-98, elbows in all the 612 feeders were subjected to thickness gauging and residual life assessment. The inspection had shown that the residual life of some of the elbows was less than 10 years. These were repaired by weld overlay in order to extend their service life. ISI of selected feeders was carried out in the unit again in September 2001 and in August 2004. Results of these inspections indicated higher rate of erosion/corrosion in some of the repaired feeders. The issue was reviewed by a group of experts and based on their recommendations, a programme was drawn up for enhanced inspection of feeders during the long shutdowns in 2006 and 2008, with an objective of giving coverage to all the feeders. As per this programme, thickness measurement of elbows belonging to 346 feeders was carried out during the shutdown of RAPS-2, in September – November 2006. A conservative assessment of balance life of the feeders based on the results of this inspection indicated that the balance life of a few feeders is very low in the range of 1 – 2.5 years.

The inspections and reviews indicated that the only viable life management option for feeders in RAPS-2 under the circumstances is replacement of the feeders, as was done in MAPS and NAPS reactors. However considering that the job of en-masse replacement of feeders is a major activity similar to EMCCR, requiring elaborate planning, procurement and reviews, SARCOP acceded to the NPCIL request for continuing operation of RAPS-2, for a limited time up to November 2007, to enable NPCIL to complete all the preparatory activities for taking up feeder replacement. SARCOP had stipulated that during this phase of operation, the coolant channels of the six feeders having residual life below 2.5 years, should be kept in quarantined state. In the quarantined state, the coolant flow trough these channels/feeders is considerably lower than the rated value and thus reducing the rate of erosion-corrosion and consequently extending the life.

2.2.3 MAPS-1&2

Both the units of MAPS operated normally during the year. The review of reports on evaluation of the Ultimate

Load Capacity (ULC) of the Inner Containment Structure (ICS) of the units was carried out. The report was found acceptable with the recommendation that an appropriate ageing management program be devised and structural monitoring measures be implemented to ensure long-term performance of the IC structure, in light of the findings of ULC calculations.

Seismic Re-evaluation of MAPS: The review of seismic re-evaluation was conducted. The major review observations included interaction of D_2O upgrading tower with safety related structure, modeling of dump tank, impact analysis of calandria and seismic qualification of civil engineering structures including containment structure.

2.2.4 NAPS-1&2

NAPS-1 has been under shutdown since November 1, 2005 for EMCCR and other safety up-gradation jobs. NAPS-2 is operating normally.

EMCCR and Safety Upgradations in NAPS-1: NAPS-1 is remaining in shutdown state since November 1, 2005, for EMCCR and safety upgradation activities. During this outage, the old Zircaloy-2 coolant channels with two loose fit garter spring spacers were replaced by coolant channels made of Zirconium-2.5% Niobium alloy with 4 tight-fit garter springs. The new coolant channels will have a much longer life span as compared to the earlier Zircalloy channels, owing to lower hydrogen pick up during operation and reduced possibility of movement of garter springs from their design locations. Thinning of elbows of the feeders in PHT system was noticed earlier also in the NAPS units. Taking advantage of the current long shutdown of NAPS-1, NPCIL has undertaken replacement of the feeders in the PHT system.

A number of other upgradations are also being incorporated in NAPS-1 during the shut down, which will help in enhancing safety and availability of the units. The important upgradations being incorporated are as follows.

- Provision of venting for end shields to obviate degradation of shielding capability during operation.
- Installation of back up dew point sensors in Annulus Gas Monitoring System (AGMS), to improve reliability of pressure tube leak detection system.
- Upgradation of fire detection and alarm system.
- Replacement of existing moderator pumps with canned rotor pumps.
- Replacement of motor-generator sets with solid-state inverters.
- Replacement of existing analog type process controllers with microprocessor based controllers.
- Replacement of existing liquid poison tanks of Secondary Shutdown System (SSS) with modified tanks having spargers.

Presently, the jobs related to replacement of coolant channels have been completed. The activities related to replacement of feeders and implementation of upgradations is in progress. A dedicated review group of AERB is reviewing and following-up of safety aspects related to EMCCR and other jobs in NAPS-1.

2.2.5 KAPS-1&2

Both the units of KAPS operated normally during the year.

2.2.6 KGS-1&2

Both the units of KGS operated normally during the year.

2.2.7 Indira Gandhi Centre for Atomic Research

Fast Breeder Test Reactor (FBTR)

FBTR was operational upto a power level of 16 Mwt.

Seismic re-evaluation of FBTR at IGCAR, Kalpakkam is being carried out jointly by IGCAR and AERB. The document addressing the criteria and methodology for seismic re-evaluation of FBTR was finalized. The document describes the criteria for seismic re-evaluation of FBTR in a manner consistent with current seismic re-evaluation criteria and internationally accepted practices. The document also elaborates various tasks involved in the exercise of seismic re-evaluation of FBTR. A report on derivation of ground motion parameters using probabilistic approach was also prepared.

Kamini

Kamini reactor was operated to carry out various irradiation and neutron radiography experiments.

Authorization for Reprocessing of Irradiated FBTR Fuel Pins: Fast reactor fuel reprocessing, being a complex technology, is being implemented in stages. These include testing of equipment and systems in the engineering laboratories and then integrating them in a hot cell for radioactive runs. FBTR fuel reprocessing is being carried out in the LMC faciltiy, which is a pilot plant set up in Reprocessing Development Laboratory of IGCAR. The objective of LMC is to validate the process and equipments developed so far.

AERB had earlier authorized 6 campaigns of reprocessing of FBTR fuel pins in LMC in stages. Since then, IGCAR has completed these campaigns successfully and requested for authorization for taking up further reprocessing campaigns. After review of the safety aspects and the performance during the previous reprocessing campaigns, AERB had authorized IGCAR to take up reprocessing of fuel pins irradiated up to 100 GWd / t in LMC facility.

2.2.8 Regulatory Inspections

RIs of operating NPPs and research facilities are carried out periodically to,

- check for any radiological and industrial unsafe conditions,
- confirm that the plant operation is as per the approved Technical Specifications and AERB/ SARCOP directives,
- confirm compliance with the maintenance, in service inspection and quality assurance programmes,
- confirm proper maintenance of records/ documentation and
- check that observations/deficiencies brought out in previous regulatory inspection have been rectified.

RIs are conducted following the guidelines specified in AERB Safety Guide, AERB/SG/G-4 on 'Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities'. A manual on Regulatory Inspections covering various procedures, checklists and other requirements has been prepared by AERB and it is under the process of publication. Routine RIs are carried out once in 6 months for NPPs and once in a year for research facilities. In addition, special inspections are carried out during up-gradation and EMCCR work or for any other specific safety requirement.

During the calendar year 2006, a total of 25 inspections were carried out in the operating NPPs and research facilities, of which 21 were routine pre-planned inspections as per the regulatory inspection programme. The remaining 4 were special inspections. These included special inspection to check the preparedness for start up of both the units of TAPS-1&2 after upgradation activities, assess the Calandria Vault (CV) leakage in KAPS-1, assess the incident of feed water line failure in KAPS-2 and check the compliance of regulatory requirements during EMCCR activities of NAPS-1.

The observations during the RIs are categorised into 5 different groups depending upon their significance, as given below. Category wise distribution of observations in different plants is given in Table 2.4. The observations made during the regulatory inspections of nuclear facilities were taken up with the concerned installation and periodically followed up for resolution.

Category: I	Deviations from Technical Specifications and other Regulatory Requirements/ Stipulations.
Category: II	Deficiencies and Degradations in Systems/ Structures/Components of Safety and Safety Related systems.
Category: III	Shortcomings identified in the Design of Safety, Safety related and Safety Support Systems, based on Operating Experience including Generic Deficiencies.
Category: IV	Procedural Inadequacies.
Category: V	Observations on Housekeeping and Departure from Good Practices.

Table 2.4: Categorisation of Deficiencies Observed During Inspections (2006)

Unit	Number of Inspections		Cat.-I	Cat.-II	Cat.-III	Cat.-IV	Cat.-V
	Planned	Special					
TAPS-1&2	2	1	0	2	4	46	1
TAPS-3&4	1	0	0	3	6	58	5
RAPS-1&2	2	0	1	8	10	50	5
RAPS-3&4	2	0	2	0	4	34	1
MAPS-1&2	2	0	0	3	12	52	4
NAPS-1&2	2	1	0	3	4	43	1
KAPS-1&2	2	2	0	5	7	62	2
KGS-1&2	2	0	0	4	13	44	2
RAPPCOF	1	0	0	1	1	7	0
FBTR & KAMINI	1	0	0	4	8	9	8
Steam Generator & Boron Enrichment Test Facility	1	0	0	0	1	4	0
RadiochemistryLaboratory	1	0	0	1	1	13	4
Lead Mini Cell	1	0	0	1	1	11	3
Radio Metallurgy Laboratory	1	0	0	0	0	0	0
Total	21	4	3	35	72	433	36

2.2.9 Licensing of Operating Staff

The number of operating personnel, who were licensed from various power plants during the calendar year 2006, is tabulated in Table 2.5.

Table 2.5: Licensing of Operating Personnel

Plants	No. of Candidates cleared for the Positions					Licensing Committee Meetings
	SCE	ASCE	ASCE (F)	CE	CE(F)	
TAPS-1&2	6	8	-	4	-	3
TAPS-3&4	-	-	-	4	-	1
RAPS-1&2	7	7	1	9	2	3
RAPS-3&4	7	8	-	16	4	4
MAPS-1&2	3	3	-	3	1	1
NAPS-1&2	6	5	2	9	1	2
KAPS-1&2	4	3	3	9	3	2
KGS-1&2	3	4	2	11	3	2
Total	36	38	8	65	14	18

SCE= Shift Charge Engineer; ASCE=Additional Shift Charge Engineer; ASCE (F)= Additional Shift Charge Engineer (Fuel Handling); CE= Control Engineer; CE (F)= Control Engineer (Fuel Handling)

In addition to the above, 1 Junior Shift Engineer (Level-III) and 4 Control Room Assistants/Field Supervisors (Level-IV) were re-licensed for FBTR operations.

2.2.10 Significant Events

It is obligatory for all operating NPPs and research reactors to report significant events promptly to the regulatory body. The reports on these events are submitted in the form of Significant Event Reports (SERs).

The SERs received from the operating NPPs are also rated on the INES. The INES system of the IAEA rates events at seven levels (1 to 7) depending on their safety significance. The accident at Chernobyl NPP in the USSR (now in Ukraine) was rated at level 7 on INES. The incident involved core melt down with the consequences of large-scale off-site radioactivity release having widespread environmental and human health effects. Events rated at level 4 and above are termed as accidents. Events rated at levels 2 and 3 are called incidents. An event at level 1 is an anomaly. Events at level 0 or below are called deviations. The IAEA-INES scale is shown at page no. 79 of the report.

The number of SERs for each year from 2002 to 2006 and their ratings on INES are given in Table 2.6. The classification of SERs for the year 2006 on INES scale is given in Table 2.7. Thirty-nine significant events were reported from the operating NPPs in the year 2006 including fourteen from TAPS-3&4. Five events were rated at level 1 on INES. Rest of the significant events was rated at level 0 on INES. The system wise classification of SERs in NPPs is given in Fig. 2.1.

Fig. 2.1 : System wise classification of SERs in NPPs (Year 2006)

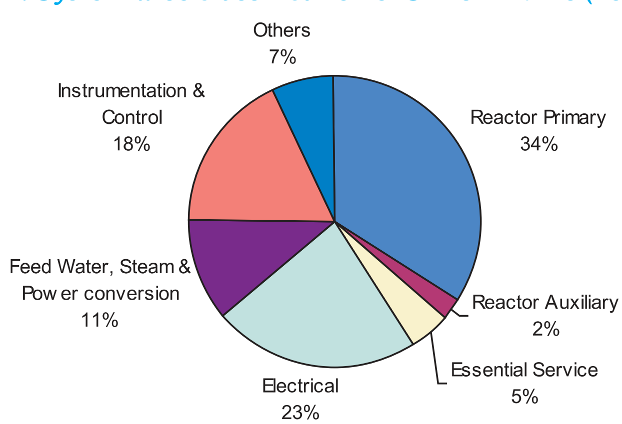


Table 2.6: Classification of SERs in NPPs as rated on INES

INES Levels	2002-2003	April-Dec 2003	2004	2005	2006
Out of Scale	0	0	0	0	0
0	26	21	39	26	34
1	5	10	4	2	5
2	1	0	1	0	0
3	0	0	0	0	0
>3	0	0	0	0	0
Total	32	31	44	28	39

Table 2.7: Classification of SERs in individual NPPs (2006)

Plant Name	Out of Scale	International Nuclear Event Scale					
		0	1	2	3	> 3	Total
TAPS-1&2	-	2	0	0	0	0	2
RAPS-1&2	-	4	1	0	0	0	5
MAPS-1&2	-	6	0	0	0	0	6
NAPS-1&2	-	1	2	0	0	0	3
KAPS-1&2	-	2	2	0	0	0	4
KGS-1&2	-	0	0	0	0	0	0
RAPS-3&4	-	5	0	0	0	0	5
TAPS-3&4	-	14	0	0	0	0	14
Total	-	34	5	0	0	0	39

Two events at NAPS-1 and one event at RAPS-1 were rated at level 1 on INES because of exposure of temporary workers beyond their annual radiation exposure limit of 15 mSv. At NAPS, both the events occurred during EMCCR campaign. Eight workers got radiation exposure ranging from 15.13 mSv to 22.45 mSv in these events. In another event at RAPS, a temporary worker got radiation exposure of 16.48 mSv during the biennial shutdown activities. These exposures are lower than the limit of 30 mSv prescribed by AERB for the occupational exposure.

At KAPS-2, during reactor operation, an auxiliary feed water line (10% flow) to one of the SGs inside SC of RB ruptured. This resulted in loss of water inventory from condensate and feed water system and consequent low water levels in the SG. Reactor was tripped manually. Due to break in normal feed water path to SGs, water level in SGs was made up through the direct path of Auxiliary Boiler Feed Pumps (ABFPs) discharge. PHT system was cooled and depressurized as per the normal procedure. The failure of the pipeline was due to excessive thinning caused by Flow Assisted Corrosion (FAC). Subsequent inspection in both the units of KAPS revealed that FAC was prevalent in the secondary system piping. All the affected pipelines were replaced.

In another event at KAPS-1, 2 of the 3 Instrumented Relief Valves (IRVs) of PHT system opened inadvertently during unit operation. The event resulted in automatic tripping of the reactor on 'PHT System Low Pressure'. The operators closed the IRVs manually. The cause of the event was attributed to earth faults and wrong wiring connections remained unnoticed. There was no external heavy water leak during the event.

Out of the 34 significant event reports of level 0 reported in 2006, an important report was in July 2006, where in one of the 3 protection system channels started reading reactor power as zero during NAPS-2 operation. Reactor was tripped manually. Investigations revealed that corrosion of the guide tube had led to the ingress of CV water into ion chamber housing. Earlier, in the year 1993 also, CV water had entered into same ion chamber housing. Due to this, one ion chamber each of regulation and protective system, were registering low neutron flux. Defect in ion chamber housing could not be rectified due to inaccessibility. However, guide tubes were replaced and aluminum blocks were installed inside ion chamber housing assembly to minimize accumulation of water near to ion chambers and reduce attenuation of neutron signal. After the incident in July 2006, regulatory body asked the utility to explore the possibility of replacement/repair of the defective ion chamber housing. Site is exploring the feasibility of replacement of defective ion chamber housing.

2.3 FUEL CYCLE FACILITIES

Review and monitoring of safety status of fuel cycle facilities and other nuclear facilities is carried out by IPSD of AERB and SARCOP. A three-tier review process is followed for granting consent for major stages for hazardous facilities of nuclear fuel cycle. For less hazardous facilities, a two-tier review process is followed with first review being conducted by the USC of the facility. The nuclear facilities covered with respect to these facilities are given below.

- Nuclear Fuel Complex- Hyderabad & Zirconium Complex -Pazhayakayal.
- Heavy Water Plants-Baroda, Talcher, Thal, Hazira, Manuguru, Tuticorin and Kota.
- Uranium Corporation of India Ltd.-Jaduguda Mill.
- Indian Rare Earths Research Centre-Kollam, Indian Rare Earths Ltd.- Udyogamandal, OSCOM, Chavara and Manavalakurichi.

Highlights on safety status and reviews carried out with respect to these facilities are given below.

2.3.1 Nuclear Fuel Complex (NFC)

All the plants of NFC, Hyderabad operated normally during the year with a satisfactory record of radiation safety. The safety committee of NFC (NFCSC) and SARCOP reviewed proposals from NFC during the year. After ensuring satisfactory compliance to the safety requirements, following proposals were accepted.

- The rehabilitation of old Zirconium Sponge Plant (ZSP) and re-commissioning of the plant equipments. Initially, NFCSC issued clearance for carrying out production trials consisting of 5 batches. After carrying out successful production trials and Hazard and Operability (HAZOP) study, the authorization for the regular operation was granted for 1 year.
- To set up a chlorination plant in the newly rehabilitated ZSP building for processing 150 tons of Zirconium-Niobium (Zr-Nb) accumulated over the years in Zirconium Fuel Fabrication Plant. This chlorinator will be set up exclusively for processing Zr-Nb with a capacity of 600 kg/day. The estimated time period for processing the existing stock is about 2 years.
- Regular operation of New Zirconium Sponge Plant (NZSP) at NFC, Hyderabad. Commissioning and trial run of NZSP were started on June 20, 2004 and all commissioning tests were completed successfully for reduction furnace and vacuum distillation. A detailed HAZOP study was also carried out.
- The commissioning and operation clearance of New Zirconium Oxide Plant (NZOP).
- Extension of the validity period of construction and authorization for Zirconium Oxide and Sponge Project, recently renamed as Zirconium Complex Project Palayakayal (recently renamed as Zirconium Complex Project, Pazhayakayal), Tamilnadu.

2.3.2 Heavy Water Plants (HWPs)

All the HWPs operated safely during the year. HWP (Hazira) faced a flood on 07.08.2006 due to release of a large quantity of water from the Ukai dam and the plant was safely shutdown and normal operations were restored on 27.08.2006.

After ensuring satisfactory compliance to the safety requirements, following important safety issues were discussed in the Heavy Water Plants Safety Committee (HWPSC), Design Safety Review Committee for Diversified Projects (DSRC-DP), Uranium Extraction Project (DSRC-UEP), Advisory Committee for Project Safety Review for Fuel Cycle Facilities (ACPSR-FCF) and SARCOP.

- An incident of heavy ammonia leakage occurred at HWP-Baroda on May 2, 2006 while the plant was under normal operation. The incident took place due to failure of gland packing assembly of 1½" isolation valve on a pump discharge line going to enrichment column. Plant emergency was declared and plant emergency shutdown was taken. One field operator got exposed to ammonia while escaping via the lift and was hospitalized for one day after first aid treatment at dispensary. A committee appointed by HWP-Baroda and AERB investigated the incident. The measures recommended by the committee to eliminate the possibility of such incident in future were discussed subsequently in HWPSC and SARCOP.
- Proposal for grant of clearance for setting up of a technology demonstration Heavy Water Clean Up (HEWAC) facility at HWP, Kota was reviewed in the Safety Committee. This facility is being set up to clean up the heavy water from PHT and moderator circuit of nuclear power stations which would help in reducing the internal dosage of occupational workers of the nuclear power stations. The site review of the proposal led to major modifications in the site related parameters and concrete grades for the structures were upgraded to account for the aggressive environment.
- Based on the review by the DSRC-UEP and ACPSR-FCF of the proposal from HWB for Technology Demonstration Plant (TDP) for recovery of uranium from wet phosphoric acid at RCF, Chembur, AERB granted authorization for siting and construction of TDP.
- The proposal from HWP, Talcher for authorization of construction clearance of "Boron Enrichment Exchange Distillation" project is being reviewed by DSRC-DP.

2.3.3 Uranium Corporation of India Ltd. (UCIL)

UCIL-Turamdih Mill construction activities have been in progress. Development work of Bagjata Mine has started and ventilation circuit is being established. The following authorizations were issued by AERB during the year.

- Authorization for construction of tailings pond and dam with certain stipulations and subject to the submission of analysis report for "worst-case scenario of breach in the tailings dam and the consequences" to AERB and its approval. The report was reviewed in USC and ACPSR-FCF and accepted.
- Authorization of site for Tummalapalle Process Plant (Mill) in Vemula Mandal of Cuddapah district, Andhra Pradesh after review by DSRC-UEP and ACPSR-FCF and their recommendations.
- Technical specifications for radiological safety of Narwapahar Mines and Jaduguda Mill were discussed by USC. It also recommended that the technical specifications for radiological safety of Bhatin Mines should be submitted.

Board Members visiting the Narwapahar Mines, Jaduguda

(From L to R : Shri V.A. Subramani, OSD, Bhavini, Dr. Om Pal Singh, Secretary, AERB, Shri R. Prabhakar, Dir (Tech.), Bhavini, Shri S.K. Sharma, Chairman, AERB, Shri D. Acharya, Dir. (Tech.), UCIL, Dr. K.V. Raghavan, member, Dr. K. Dinshaw, member, Shri S.K. Chande, Vice-Chairman, AERB, Shri Prabhat Kumar, PD, Bhavini, Shri R. Bhattacharya, Head, IPSD, AERB)

2.3.4 Indian Rare Earths Limited (IREL)

Capacity expansion at IREL, Chavara for enhancing the annual production capacity of the Ilmenite, Rutile, Zircon, Illuminite and Monazite concentrates are under progress. The safety committee for IREL plants (IRESC), DSRC-UEP, ACPSR-FCF and SARCOP reviewed the safety and radiological safety status of the following proposals of the IREL plants for clearance and took appropriate decisions.

- The proposal for construction of underground Reinforced Cement Concrete (RCC) trenches for long term storage of thorium oxalate at IREL, OSCOM was reviewed by the safety committee considering thorium oxalate leachability, ground water table and soil characteristics. The committee recommended that IREL should submit revised drawing of RCC trenches showing all the protective barriers having clay, chemical barrier containing bentonite, etc., to the safety committee and SARCOP. Subsequently, SARCOP after deliberations on the proposal asked IREL to check the permeability and dose from the trenches and submit dose calculation method followed in IREL plant, for review.
- The SER for the authorization for siting of 10,000 TPA of Monazite Processing Plant (MoPP), IREL, OSCOM was reviewed and authorization for siting for the same was granted with certain stipulations.
- The proposal for capacity expansion at IREL, Chavara for enhancing the annual production capacity of the various products of the unit is under review in AERB.
- Proposal on THRUST phase-II (retrieval of 21,000 ton thorium concentrate would be carried out from SILO no. 4,5,6), storage of thorium oxalate produced from retrieval process and the proposed layout was discussed in safety committee. The committee recommended to review ventilation aspects and submit the revised report to SARCOP. Subsequently, SARCOP discussed the proposal and asked IREL to submit a detailed report on present thorium oxalate storage status and future plan for storing thorium oxalate.

2.3.5 Licensing for Beach Sand Minerals Industries

Mechanism for licensing under the Atomic Energy (Radiation Protection) Rules 2004 was established. Requirement for amendment of the Mines and Minerals (Development & Regulation) Act, 1957 to introduce licensing procedure of beach sand industries and Atomic Energy (Radiation Protection) Rules, 2004 has been suggested to Ministry of Mines. No objection certificate was issued to DAE for issuing license under Atomic Energy (Working of Mines, Minerals and Handling of Prescribed Substances) Rules, 1984 to Kerala Minerals and Metals Limited (KMML), Chavara for handling prescribed substances.

2.3.6 Regulatory Inspections of Fuel Cycle Facilities (Radiological Aspects)

Regulatory Inspections on radiological safety aspects under the Atomic Energy (Radiation Protection) Rules, 2004 and waste management aspects under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 were carried out at front-end fuel cycle facilities and R&D units namely, NFC, IREL, UCIL Mines and Mills, RRCAT and VECC and major recommendations made were as follows:

- The dose measurements for all workers in Banduhurang mine and Bagjata mine should be carried out.

- Cause for higher activity in the steam condensate of Evaporator–2 containing thorium nitrate solution at IREL, OSCOM should be identified and source of leakage should be arrested.
- Measurement should be done periodically for accounting the thorium content in sodium nitrate ($NaNO_3$) crystals prepared from the $NaNO_3$ solution that is purchased by the private party from IREL, OSCOM.
- Machines/Equipments should be decontaminated and certified by Health Physics Unit before shifting to workshop for maintenance work.
- Clearance should be taken from Health Physics Unit at IREL, Udyogamandal Unit before discharging of the treated liquid effluents to the environment.
- Personal dosimeters should be provided to Turamdih mine workers.
- Appropriate measures should be taken for dry mill tailing disposal site so that background radiation level does not increase.
- Provision of barricade to be made on one side of Chinnavalai beach where tailings enriched with monazite is dumped at IREL, Manavalakurichi.

2.3.7 Regulatory Inspections of Beach Sand Minerals Industries (Radiological Aspects)

Regulatory Inspections on radiological safety aspects under the Atomic Energy (Radiation Protection) Rules, KMML-Kerala and major recommendations made were as follows:

- Monazite content should be measured in the waste generated at each of the plants used for backfilling the mined out sites. In case monazite fraction is much higher than the raw material feed, it should be mixed with raw sand prior to backfilling or monazite enriched waste should be dumped at locations, which are completely under the control of the unit.
- Ambient dosimetry should be practiced for estimation of external and internal dose received by workers.
- Monazite enriched tailings should not be dumped into the sea.
- Sludge deposited in the iron oxide pipeline should be cleaned regularly.
- Issuance of TLD should be reviewed and representative workers of each shift working in monazite/zircon separation circuit are covered.

2.3.8 Licensing of Plant Personnel

Licensing Committee for licensing of operating personnel for Heavy Water Plants met at HWP-Kota, Thal, Baroda, Manuguru and Tuticorin and authorized/re-authorized 79 operation personnel.

2.4 OTHER NUCLEAR FACILITIES

The facilities covered in this section are:

- Variable Energy Cyclotron Centre (VECC), Kolkata
- Raja Rammana Center for Advance Technology (RRCAT), Indore

2.4.1 Variable Energy Cyclotron Centre (VECC)

The existing cyclotron (K-130) was in operation and the equipment erection in the superconducting cyclotron building was in progress. In radioactive ion beam facility, phase wise testing of stable beam operation was in progress. The VECC and RRCAT Safety Committee (VRSC) discussed the following reports/issues pertaining to VECC.

- Medical cyclotron facility at Kolkata is set up for production of isotopes for medical applications, radiopharmaceuticals and for experiments related to materials science and accelerator driven sub-critical systems. The cyclotron system proposed for the project are fixed magnetic field, fixed Radio Frequency (RF), variable final energy, dual Proton Beam Cyclotron with the beam energy up to 30 MeV. The proposal for authorization of construction of the facility was reviewed by VRSC and SARCOP. Based on the recommendations, AERB granted the construction authorization for medical cyclotron facility on March 7, 2007. The siting clearance of the facility by AERB was given in February 2005 subject to the condition that the detailed design of the civil structures is reviewed by Directorate of Construction, Services and Estate Management (DCSEM) before starting up the construction at site.
- VECC submitted a proposal for grant of authorization for commissioning of superconducting cyclotron facility. The facility is K-500 accelerator for light and heavy ions located within the existing plant premises. The superconducting cyclotron is a sector-focused cyclotron with its main magnet super conducting. The highly energetic beams will be used to explore new fields of research in Nuclear Physics and Chemistry, Analytical Chemistry, Condensed Matter Physics and allied applied fields. The proposal was discussed in the VRSC and subsequently in SARCOP. The SARCOP recommended only for the Stage-1 clearance of commissioning, i.e., operation of the 14 GHz Electron Cyclotron Resonance (ECR-II) ion source and availability of beam at the end of analyzing magnet.
- The status of radioactive ion beam facility, VECC, Kolkata was discussed and it was decided that a report on the operational experience of stable beam operation should be submitted to AERB for review.
- Decommissioning proposal of 4 MeV medical LINAC at RRMC, Thakkurpukur, Kolkata was discussed and approved.

2.4.2 Raja Ramanna Center for Advanced Technology (RRCAT)

Indus-1 was operating at 450 MeV beam energy and 100 mA current. Stage-3 of Indus-2 (i.e., injection of the beam into Indus-2 Storage ring at 2 GeV energy and 10 mA current) was commissioned. Electron LINAC Facility was operating at 10 MeV energy level. The 750 Direct Current (DC) accelerator was in operation.

The following proposals were discussed and authorizations were issued to RRCAT.

- The application for installation of Extended X-ray Fine Absorption Structure (EXFAS) beam line of BARC and X-ray Diffraction (XRD) beam line of RRCAT was discussed and recommendations are being reviewed by SARCOP, AERB.
- RRCAT has applied Indus-2, stage-4 clearance for 2.5 GeV energy and 50 mA current. The application has been discussed in VRSC. During the review it was observed that there is no major change in the safety significance by increasing the beam power level to 2.5 GeV. The recommendations of the committee are under the review of SARCOP, AERB.
- RRCAT, Indore applied for authorization for commissioning of stages 3, 4 and 5 of 15 MeV LINAC located in Indus-1 building. This was discussed in VRSC and authorization was granted in August 2006.
- Authorization for trial operation for 750 keV DC accelerator was issued in December 2006.
- VRSC reviewed the application from RRCAT to work in 5th beam line during beam injection in TL-3-Indus-2 and agreed to the proposal with strict adherence to conditions imposed by Health Physics Unit of RRCAT.
- Licence for regular operation of the DC Accelerator using SF_6 gas or $N_2/CO_2/SF_6$ gas mixture at full power was discussed by the safety committee and the committee observed that, RRCAT has not carried out the test run with 750 keV and with SF_6 as insulating gas. Committee recommended that RRCAT should initiate to carry out test run at the design capacity and based on the results of trial, the proposal would be further reviewed by the committee.
- Safety committee reviewed the proposal for permission of operation for a new facility of 12 MeV microtron in IMA building. Subsequently the authorisation for trial operation of 12 MeV microtron at maximum 20 mA current in Industrial and Medical Accelerator (IMA) building of RRCAT was granted by AERB for a period of 1 year with some stipulations.
- The proposal for site clearance for radiation processing facility for agricultural products was discussed in VRSC and based on recommendations the site clearance was granted by AERB for a period of 5 years from March 29, 2007.

CHAPTER 3

SAFETY SURVEILLANCE OF RADIATION FACILITIES

3.1 SAFETY REVIEW OF RADIATION EQUIPMENT AND APPROVAL OF SAFETY PERSONNEL

The radiation facilities in India can be broadly classified as Medical, Industrial and Research facilities. Medical facilities include diagnostic X-ray machines, Telegamma units, LINACs, Brachytherapy units using manual and remote after loading techniques and Nuclear Medicine Centres practicing diagnosis and therapy. Industrial installations include gamma and X-ray radiography equipment, gamma radiation processing plants, ionizing radiation gauging devices (nucleonic gauges) including well-logging devices and manufacturers of consumer products. Research installations include universities and other research institutes handling a variety of sealed and unsealed radiation sources and also X-ray facilities for research purposes.

Number of various radiation installations and radiation devices, which are regulated by AERB as on March 31, 2007, is given in Table 3.1.

Table 3.1: Radiation Installations Regulated by AERB

S.No.	Type of Application	Number of Devices in use	Number of institutions
1	Diagnostic X-ray	~ 50,000	~ 40,000
2	Radiotherapy ● Teletherapy ● Brachytherapy	 Telecobalt 283 Telecesium 4 Accelerators 87 Gamma Knife 4 High Dose Rate 88 Low Dose Rate 31 Manual (Intracavitary) 89 Manual (Interstitial) 34 Opthalmic (^{90}Sr) 20 Opthalmic (^{125}I) 3 Opthalmic (^{106}Ru) 1	231
3	Nuclear Medicine ● RIA Centres ● Diagnostic & low dose therapy ● Diagnostic low & high dose therapy	Not applicable	 450 110 30
4	Research	Not applicable	500
5	Industrial Radiography ● Radiography Camera ● X-ray units ● Accelerators	 1274 218 12	466
6	Gamma Irradiators	12	12
7	Gamma Chambers	128	128
8	Nucleonic Gauges	7600	1435
9	Consumer Products ● Gas Mantle ● Lamp starters ● Smoke Detectors ● Electron Capture Detector (ECD)	Not applicable -	 65 20 95 503

3.1.1 Type Approvals

For the purpose of ensuring that the radiation doses received by workers and members of the public do not exceed the prescribed dose limits and further that such doses are kept As Low As Reasonably Achievable (ALARA), design safety is accorded primary importance and operational control measures are monitored. With this in view, all devices including radiation generating equipment and those incorporating radioactive sources are subjected to a type approval procedure. AERB permits only type-approved devices to be marketed in India. The criteria for type approval are stipulated in the Standards Specifications (SS) documents on a variety of devices, issued by AERB. These SS documents are periodically reviewed and revised, where necessary, in order to meet internationally accepted and current standards. SARCAR examines the design safety features of each device and recommends issuance of type approval. SARCAR held 5 meetings during the year. Based on the recommendations of SARCAR, AERB issued type approval certificates to the manufacturers/suppliers of devices incorporating radioactive materials and radiation generating equipment. Number of the devices type approved during the year is given in Table 3.2.

Table 3.2: Type Approvals Granted
(Radiation Generating Equipment and Equipments Containing Radioactive Material)

Sr. No.	Type of Equipment	Number of Approvals
1	Medical diagnostic X-ray Units	100
2	Radiotherapy Simulators	3
3	Computed Tomography (CT) Units	7
4	Telegamma Therapy Units	10
5	Gamma Knife Units	1
6	Medical Linear Accelerators	16
7	Remote Controlled after-loading Brachytherapy Units	9
8	Gamma Chambers	1
9	Nucleonic Gauging Devices	32
10	Baggage Inspection Systems	-
11	Industrial Radiography Exposure Devices	9
12	Industrial Accelerators	1
13	Industrial X-ray Units	2
14	Blood Irradiators	6
15	Medical Cyclotron	5

3.1.2 Approval of Radiological Safety Officers

During the year 2006-07, approval certificates were issued to 379 RSOs. Details of the approval are given in Table 3.3.

Table 3.3: Approval Certificates Issued to RSOs

Sr. No.	RSO Level	Number Approved
1	RSO Level-III (Medical)	142
2	RSO Level-III (Industrial Radiography)	13
3	RSO Level-III (Gamma Irradiators)	05
4	RSO Level-II (Industrial Radiography)	35
5	RSO Level-II (Nuclear Medicine Diagnosis)	40
6	RSO Level-I (Nucleonic Gauge)	124
7	RSO Level-I (Research Applications)	25

3.1.3 Approval of Packages for Transport of Radioactive Material

As per AERB regulations, Type-A packages, which are permitted to transport radioactive material of activity not exceeding the specified limits, need to be registered with AERB. All Type-B packages are subjected to a stringent approval procedure and are required to fulfill the regulatory standards. Three registration certificates for Type-A packages were issued by AERB during the year. Nine validity certificates of approval of design of Type-B packages were renewed and 1 approval for the design of the Type-B package was issued.

3.2 LICENSING / AUTHORISATION AND REGULATORY INSPECTIONS

3.2.1 Licensing / Authorization

Licenses for operation were issued to 3 medical cyclotrons and 2 high capacity gamma radiation processing plants.

AERB issued 331 regulatory licenses as Certificate of Registration to diagnostic X-ray installations upon confirming that the applicable regulatory requirements are duly satisfied. Details of Licences/NOCs issued by AERB during the year 2006 are given in Table 3.4.

Table-3.4: Licences / NOC Issued

A. Procurement of Sources

Sr. No.	Type of application	Regulatory Licenses/NOCs/Registrations issued	
		Local	Import
1	**Radiotherapy**		
	● Telecobalt	18	9
	● Telecaesium	-	0
	● Accelerators	-	21
	● Gamma Knife	-	2
	Brachytherapy		
	● HDR	-	110
	● LDR	4	-
	● Manual (Intracavity & Interstitial)	8	-
	● Opthalmic Sr-90	-	-
	● Opthalmic I-125	1	-
	● Ophthalmic Ru-106	1	-
2.	**Nuclear Medicine**		
	● RIA facilities	-	158
	● Diagnostic & Therapeutic	93	208
	● Research	76	213
3.	Industrial Gamma Radiography Exposure Devices	628	1
4.	Gamma Irradiators (Category -IV)	7	0
	Gamma Irradiators (Category -I)	8	1
5.	Nucleonic Gauges	82	208
6.	Diagnostic X-ray	331 (Registered)	0
7.	Consumer Products		
	● Gas Mantle	45	-
	● Lamp starters	2	-
	● Electron Capture Devices	-	105
	● Smoke detectors	-	11

B. Authorisations for Export and Disposal of Sources

Export		Disposal of sources			
By BRIT & IRE (Sale)	By user	Authorisations	No. of Sources disposed Off		
16	54	127	At BRIT 256	At WMD, BARC & CWMF Kalpakkam 2815 (ICSD) & 602	Origin supplier aboard 377

3.2.2 Shipments Approved

Consignments, which do not meet all the applicable requirements of the transport regulations due to specific reasons, are permitted to be transported under special arrangements, which include provision of compensatory operational controls. Six such shipments were approved during the year.

3.2.3 Regulatory Inspections

Details related to RIs during the year are given in Table 3.5. In RIs, AERB may find non-compliances with regulatory requirements. The non-compliances with regulatory provisions during inspection are reviewed in the AERB Safety Committee for Investigation of Unusual Occurrences in Radiation Facilities (SCURF). The enforcement actions recommended by SCURF include issuance of warning letters, suspension of radiation practices, withdrawal of certificates of radiation workers and revocation of license issued to operate radiation installations in radiation facilities.

Table-3.5: Regulatory Inspections

Sr. No.	Facilities	No. of Institutes	No. of Inspections
1	Diagnostic X-ray	~ 40,000	80
2	Radiotherapy	231	24
3	Nuclear Medicine ● Diagnostic & low dose therapy ● Diagnostic, Low dose therapy & Ca thyroid treatment centres	140 110 30	40
4	Research	500	5
5	Industrial Radiography	466	74
6	Gamma Irradiators	12	12
7	Nucleonic Gauges	1435	18

3.3 RADIOLOGICAL SAFETY SURVEILLANCE

3.3.1 Radiation Diagnostic and Therapy Facilities

On the basis of pre-commissioning safety evaluation, AERB issued authorizations for the commissioning of 22 Teletherapy units (11 Telecobalt units and 11 Medical LINAC) and 7 remote after-loading Brachytherapy units, and for the decommissioning of 1 Teletherapy unit during the year. Permissions were accorded for re-starting 8 Telecobalt units after source replacement and 13 new radiotherapy centres. Forty nuclear medicine facilities and 5 research institutions, where unsealed radioactive materials are used, were inspected. AERB reviewed annual safety status reports received from the licensees and inspected 208 medical X-ray diagnostic installations. Deviations and violations of regulatory requirements were taken up with the users. In some cases, AERB initiated appropriate regulatory actions such as suspension of license.

3.3.2 High Intensity Gamma Irradiation Facilities

Inspections were carried out at the following 12 operating gamma irradiation facilities:

- Panoramic Batch Irradiation Technology (PANBIT), Thiruvananthapuram, Kerala.
- Radiation Vulcanization of Natural Rubber Latex (RVNRL), Kottayam, Kerala.
- Radiation Sterilization and Hygenisation of Medical Products (RASHMI), Bangalore.
- Shriram Applied Radiation Centre (SARC), Delhi.
- Radiation Processing Facility, BRIT, Vashi, Navi Mumbai.
- Isotope in Medicine (ISOMED), BRIT, Mumbai.
- VIKIRAN, M/s. Organic Green Foods Ltd, Kolkata.
- RAVI, Defence Lab., Jodhpur.
- M/s. Vardaan Agrotech, Sonepet, Haryana.
- M/s A. V. Processor, Ambernath, Thane.
- M/s Universal Medicap Pvt. Ltd., Baroda.
- M/s Microtrol Sterilization Services Pvt. Ltd., Bangalore.

The quarterly safety status reports were received from all the operating gamma radiation-processing facilities. The occupational exposures in gamma irradiation facilities in the last five years did not exceed 2 mSv/y, which is well below the prescribed dose limit of 20 mSv/y. Seven proposals for the loading/ replenishment of Cobalt-60 sources from such facilities were reviewed and clearances were issued. The pre-commissioning testing and inspection was carried out for one gamma irradiation facility.

One gamma radiation processing plant is in the pre-commissioning stage and sites for installation of 7 more such facilities have been approved by AERB.

3.3.3 Industrial Radiography

There are 466 industrial radiography institutions in India. The total number of industrial gamma radiography exposure devices deployed for radiography work is 1274. There are about 218 Industrial X-ray units and 12 Accelerator Facilities. During the year, AERB carried out announced as well as unannounced inspections of 74 industrial radiography sites and installations. The monthly safety status reports received from radiography institutions were reviewed by AERB to ensure availability of safety infrastructure and inventory of radiography devices/sources. Type approval applications for new models of radiography devices were reviewed and approved by AERB.

3.3.4 Nucleonic Gauging

The application of nucleonic gauges for level monitoring, thickness measurement, density measurement and moisture detection, elemental analysis in many industries such as steel, paper, plastic, textile, cement, power, coal and oil exploration recorded a notable increase. AERB inspected nucleonic devices installed in 18 institutions. Six-monthly safety status reports from these installations were reviewed by AERB to ensure availability of safety infrastructure and inventory of nucleonic devices/sources. A database of the nucleonic devices housing radioactive sources used by the various industrial and research institutions in India is being maintained by AERB.

3.3.5 Transport of Radioactive Materials

Twenty-eight permissions for transport of radioactive material were issued, while 37 regulatory inspections of packages were carried out during the year. AERB communicates regularly with other government authorities for the safe transport of radioactive material in and out of the country. The concerned nodal and other agencies are Director General of Civil Aviation (DGCA), New Delhi, Port Trusts, Indian Railways, Airport Authority of India and Customs.

3.3.6 Disposal of Radioactive Materials

The users send decayed radioactive materials from medical, industrial and research institutions for safe disposal to the original supplier or to one of the approved radioactive waste disposal facilities in India. The number of authorizations issued for export to original supplier abroad was 54. The number of authorizations for transfer to domestic supplier and waste management agencies was 127.

Before the authorization for disposal of the material is issued, safety assessments of the disused sources are done by physical inspection, correspondence with the waste generator and the authorized waste management agency. A total of 138 such assessments were done during the year.

3.4 UNUSUAL OCCURRENCES

All unusual occurrences at radiation installations were investigated and appropriate enforcement actions were implemented commensurate with the nature of the occurrence. Details regarding the unusual occurrences during the year are given in Table 3.6.

Table 3.6: Unusual Occurrences (2006)

Application	Number of Institutes	Type of Violations/ Cause of Occurrence
Industrial Radiography	2	• Radiography work at unauthorized sites • Unauthorized source movements • Untrained radiographers operating devices • Radiography work without TLD
Nuclear Medicine	1	• Discharging patients treated with nuclear medicine therapy doses without measuring the radiation emitted by the patient
Nucleonic Gauges	2	• Theft of nucleonic gauges along with source • Sources getting stuck up during Well logging operation
Gamma Radiation Processing Plants	2	• Incident involving misalignment of source pencil • Collision of product carrier with a structural support component

3.4.1 Radioactive Contamination in Steel Products

Radioactive contamination was reported in steel products exported to UK and US. It was noted that all the shipment of contaminated steel products originated from Kolkata. AERB conducted inspection of 20 factories manufacturing engineering products in Kolkata for detection of radioactive contamination in the steel products on the request of Engineering Export Promotion Council, Eastern Region, Kolkata and some of the manufacturing companies. Some radioactive contaminated items were located and safe disposal of the same was arranged. The manufacturing units and exporters of steel products have been advised to use the radiation monitoring equipment for detection of radioactive contamination.

3.4.2 Other Unusual Occurrences

❖ Gamma radiation Processing Plant

➤ An incident resulting in misalignment of source pencil occurred at one of the gamma radiation processing plants due to improper design of source rack. AERB directed the institution to suspend the operations of the facility and submit a report on proposed action plan for rectification of design deficiency responsible for the incident. The facility was allowed to resume operation only after rectification of the deficiency.

➤ An incident occurred at one of the gamma radiation processing facilities involving the collision of product carrier with I-Beam support for source shroud leading to slippage of source hoisting wire ropes. This caused the lowering of the source frame from its fixed position. AERB has directed the facility to suspend operations and submit a report on the proposed action plan for rectification of design discrepancies, which caused the incident.

❖ Industrial Radiography

➤ An Industrial Gamma Radiography Exposure Device (IGRED) model GAMMARID 192/120, Sr. No. 70, weighing about 17 kg, containing about 0.5 TBq activity of Ir-192 source was lost during transport in an auto-rickshaw. The IGRED along with radiography accessories was being carried by a trainee radiographer and his assistant for carrying out radiography work at a place about 5 km away from the device storage facility. En-route, they changed the auto-rickshaw. In the process, they forgot to shift the radiography device from the first auto-rickshaw to the second. The radiography agency intimated the incident to AERB after a week.

Search operations were launched with the help of Police. Radiation detection surveys were carried out at various locations near the incident site. The source could not be recovered inspite of extensive search operations by using high sensitivity radiation survey instruments. The device has adequate shielding with proper locking mechanisms to prevent inadvertent removal of the radioactive source from the device. Since the radiography source is safely housed inside IGRED, it may not cause any significant radiological hazard to the members of the public. Authorization for radiography work of the agency has been withdrawn.

➤ An IGRED model Techops-660, Sr. No. 5785, with 0.29 TBq (~8 Ci) Ir-192 of a radiography agency was stolen on 06-11-2006. The IGRED was kept outside dark room area for use on the same day. However, the radiography work got rescheduled and there was no immediate radiography job to be carried out. As a result, the IGRED was lying unattended outside the dark room area. The workers of radiography agency found the IGRED missing when it was needed for the radiography job.

Extensive radiation detection surveys, with the help of local Police Authorities, were conducted at different areas of the plant. However, the missing IGRED could not be located. No radiation injury has been reported. The device has adequate depleted Uranium shielding with proper locking mechanisms to prevent inadvertent removal of the radioactive source from the device and hence, the event is considered to be insignificant from radiological safety point of view.

The incident took place mainly due to negligence of the certified radiographer of the agency as he left the exposure device unattended. The authorization for radiography work of the agency was withdrawn by AERB and certificates of radiographer and site-in-charge involved in the incident were withdrawn for a period of six months.

❖ Nucleonic Gauges

➤ On 12-10-2006, the oil well logging tool model D4TG – DSNT – SED string with neutron source (19.5 Ci Am-Be 241) got stuck up in the well that belongs to M/s. ONGC, Assam Asset, Nazira. The complete tool with source was fished out successfully on 15-10-2006. There is no damage to source and it was fully secured.

➤ The ECIL make industrial ionizing radiation gauging device (IRGD/nucleonic density gauge), model RDG4124B, containing 9.2 GBq (~250mCi as on date) Cs-137 source was found to be missing on 16-11-2006 from the premises of one of the industrial institution. The overall weight of this Gauge assembly is about 45 kg with lead shielding. The above gauge was being used to measure the density of liquids, suspensions, coal slurries or poured materials in coal washery. However, the coal washery was not in operation since 2003. It was reported that in the year 2005, the electronic parts associated with this gauge were stolen, but the nucleonic gauge assembly was intact.

The missing nucleonic gauge could not be located despite the extensive radiation detection surveys, (with the help of local Police authorities) at different areas of the plant, and all scrap yard situated in the city area. It is presumed that the source might be still inside the nucleonic gauge device. The device has adequate lead shielding with proper locking mechanisms to prevent inadvertent removal of the radioactive source from the device. Since the radioactive source is inside the lead housing of nucleonic gauge, it may not cause any significant radiological hazard to the members of the public. Hence the event is considered to be insignificant from radiological safety point of view.

3.5 OTHER ACTIVITIES

3.5.1 Accreditation of Laboratories

Performance assessment of the low level counting laboratory at Shriram Institute of Industrial Research, New Delhi was carried out and the Accreditation Certificate was issued.

3.5.2 Training Activities

- Training programmes were conducted for X-ray service engineers, nuclear medicine technologists, medical physicist-cum-RSO in radiation therapy facilities, technicians for radiotherapy and radiography facilities and for qualifying persons as RSOs of gamma radiation processing facilities. With this effort, the number of trained manpower for radiological safety function has increased substantially and will contribute to improved radiological safety in radiation facilities.
- A one-day radiation safety awareness programme for Indian Customs was arranged at Jawaharlal Nehru Customs House, Nhava Sheva. The programme was arranged for the personnel involved with the operation of container scanner installed at Jawaharlal Nehru Port Trust.
- Members of AERB served as faculty for courses in the Diploma in Radiological Physics and other courses conducted by BARC.
- Various medical institutes in the country are conducting training programmes for radiography and radiotherapy technicians. AERB, in consultation with experts from BARC and advice from SARCAR, evolved a comprehensive course content for the radiological safety components of these programmes.
- Awareness programmes on safety and security of sources were conducted for authorized users of industrial radiography sources.

CHAPTER 4

INDUSTRIAL SAFETY

4.1 INTRODUCTION

AERB carries out review and monitoring of industrial safety status of all units of DAE, namely, NPPs and projects, nuclear fuel cycle facilities and other nuclear facilities. Licenses are issued/renewed and regulatory inspections on industrial and fire safety aspects are carried out under the Atomic Energy (Factories) Rules, 1996 and enforcement of Factories Acts 1948 in all these facilities.

There have been 7 fatalities during the year (April 2006 - March 2007) due to industrial accidents. These accidents were investigated to arrive at the root cause and remedial measures were suggested to the site to prevent recurrences of such accidents. Table 4.1 gives the brief details of these accidents:

Table 4.1 Fatal Accidents

Sr. No.	Date	Unit	Event	Recommendations made by the Fatal Accident Assessment Committee
1	27.05.06	RAPP-5&6	● Trapped under the muck loaded trolley	● Tractor - Trolley should not be separated out while loading and unloading activities are planned. ● NPCIL should submit the Medical Management Report on accident to AERB within a month.
2	31.07.06	KK-NPP	● Fall from height (While Climbing down the ladder)	● Scaffolding was not properly barricaded. ● The procedure should be prepared for climbing down the ladder fabricated on scaffolding.
3	25.10.06	Kaiga	● Hit by Falling object(Hit by 40mm and 6m long scaffolding pipe.)	● Pipes should be clamped instead of tying temporary with wire rope ● JHA should be done and followed the recommendations.
4	04.11.06	UCIL (Turamdih mill)	● Fall from height (while returning back after finishing the work of putting AC sheet.	● Height passed should be issued. ● Crawling ladder should be used.
5	02.01.07	RAPP 5&6	● Fall from height (While coming down by ladder)	● Systematic & structured training for working at height ● Checklist for ladders, scaffoldings and access paths certified fit for use by engineer-in-charge.
6	14.03.07	BHAVINI	● Fall of person due to hit by falling shutter	● Based on the revised JHA report, an approved written down procedure as well as checklists are to be prepared for strict implementation ● Appropriate and adequate safety training programmes, with actual work demonstration or with films pertaining to DOKA typeshuttering system, should be imparted to the field personnel.
7	20.03.07	BHAVINI	● Fall of ISMB 100 beam, about 2 m long, weighing about 23 kg on the head of person	● Care has to be taken at site to prevent fall of objects from heights causing injury to workmen. All structural members to be rigidly fixed at all levels to prevent their fall. ● For safe movement of material through tower crane from one place to another, signal man should be placed in such a location that he should be able to visualize the whole area and operation clearly

In order to enhance industrial safety at construction sites, AERB decided to conduct "Special monthly inspections" at all Nuclear Power Project sites and other front-end fuel cycle construction sites with respect to industrial safety focusing on work at height. Special monthly inspections were carried out at RAPP- 5&6,KK-NPP, Kaiga-3&4, TAPP-3&4, DFRP, BHAVINI, Turamdih Mills and Zirconium Complex, Pazhayakayal. Job Hazard Analysis (JHA), preparation of safe working procedure and use of field checklist based on the JHA were made mandatory for all hazardous works at project sites.

In view of the fatal accident, which occurred at the RAPP-5&6 site on 2nd January 2007 and major deficiencies with respect to overall safety management of the contractor observed during the investigation carried out by AERB, all the work carried out by the contractor were stopped till the implementation of corrective actions and the recommendations made by AERB.

In view of the fatal accidents that took place at BHAVINI on March 14, 2007 involving a deshuttering job and fall of a contract worker of about 1.5 m (Table 12.1 item 6) Chairman, AERB advised Project Director, BHAVINI to stop all construction activities subject to review by AERB Board. Subsequently, another fatal accident took place on March 20,2007 (Table 12.1 item 7). A high-level investigation team from AERB visited BHAVINI site and reviewed the overall industrial safety aspects and the corrective actions taken by BHAVINI to prevent recurrences of such accidents. Based on the review, restarting of construction activities at BHAVINI site was permitted with some stipulations.

4.2 LICENSES/APPROVALS

The following licenses and approvals were issued during the year.

Licenses Issued / Renewed

The following licences were renewed/issued to various DAE units under the Factories Act, 1948:

- Licence for TAPS-1&2 for a period of 5 years on August 2, 2006.
- Licence for RAPS-1&2 for a period of 5 years on January 09, 2007.
- Licence for MAPS-1&2 for a period of 5 years on January 19, 2007.
- Licence for IREL, Udyogamandal for THRUST Project for a period of 5 years on November 13, 2006.

Approvals Granted

Approvals were granted to competent persons under various sections of the Factories Act, 1948 in the following units.

- Two persons from HWP, Hazira.
- Fifteen persons from IREL, Udyogamandal.
- Two persons from MAPS.
- Three persons from RAPP-5&6.
- Four persons from HWP-Thal.

4.3 REGULATORY INSPECTIONS

RIs on industrial and fire safety aspects under the Atomic Energy (Factories) Rules-1996, radiological safety aspects under the Atomic Energy (Radiation Protection) Rules-2004 and waste management aspects under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules - 1987 were carried out.

During the year, 32 regular inspections and 27 special inspections were carried at construction sites of various projects and operating plants of DAE to ensure minimum safety requirements (with emphasis on safety in work at height). During these inspections, the inspectors ensured immediate rectification of the unsafe conditions observed. JHA preparation of safe working procedure and use of field checklist based on the JHA were made mandatory for all hazardous works at the project sites. Based on the findings of these inspections and AERB directives AERB, NPCIL, HWB, UCIL and BHAVINI have issued notifications empowering the Head (IS&F) of the concerned project site to stop work in case of observing any safety related deficiencies at their project sites and instructed the project directors to ensure proper supervision, use of PPE especially during work at height, implementation of work permit system, JHA for hazardous activities, etc.

Some of the recommendations that emerged from the inspections of different units are given below.

4.3.1 Operating Nuclear Power Plants and Research Reactors

RIs were carried out at TAPS-1&2, NAPS-1&2, RAPS-1& 2 and 3&4, KGS-1&2 and FBTR and KAMINI reactors of IGCAR. The major recommendations arising from the regulatory inspections are as given below.

- Duties and responsibilities of safety supervisor should be laid out in safety manual.
- Audiometry test should be conducted for the identified persons working in the noisy area.
- Fire organization should be as per the requirement of Standard for Fire Protection Systems of Nuclear Facilities (AERB/S/IRSD-1).
- Cranes and hoists should be load tested per specified frequency.
- JHA should be carried out for all hazardous jobs.
- Distinct colour code for acid and alkali pipeline should be followed and also displayed properly.

- The quality of breathing air should be analyzed periodically and record of data should be maintained.
- Artificial resuscitator should be kept in the control room.

4.3.2 Nuclear Power Projects

In order to improve industrial safety at construction sites, AERB decided to conduct special monthly inspections at all NPP sites and other front-end fuel cycle construction sites with respect to industrial safety focusing on work at height. Special monthly inspections were carried out at RAPP-5&6, KK-NPP-1&2, Kaiga-3&4, TAPP-3&4, DFRP and PFBR. Some of the major recommendations made are the following.

- All open sides of a structure from which a worker might fall and floor openings into which a worker might fall should be barricaded or suitably covered.
- All persons working at height should be trained for proper method of ascending and descending on a ladder and general safety features required while using ladders.
- Fall arrester system should be provided while ascending or descending in case a safe means of access is not possible to the working platform.
- Scaffoldings should be checked and certified before use. Suitable scaffolding tags as "Safe for Use" or "Not Safe for Use" should be displayed.
- DOKA (climbing brackets) shuttering components should always be first assembled and then handled for erection as a single unit as per the procedure laid down.

The documents of power projects and operating plants related to industrial and fire safety such as Design Basis Report (DBR) pertaining to fire protection of the nuclear facility and Fire Hazard Analysis and JHA, Construction Safety Manual, etc., were also reviewed.

4.3.3 Front-End Fuel Cycle Facilities

The inspections were carried out for the following plants.

- NFC, Hyderabad.
- HWPs at Baroda, Talcher, Thal, Hazira, Manuguru and Tuticorin.
- UCIL mines at Jaduguda, Turamdih, Bagjata & UCIL mill at Jaduguda.
- Indian Rare Earths Research Centre at Kollam and IREL Plants at Udyogamandal, OSCOM, Chavara and Manavalakurichi.

In each case, a detailed inspection report was sent to the concerned unit. The major recommendations of the inspections are the following:

(a) Nuclear Fuel Complex

- NFC should prepare JHA for all critical works.
- Illumination and sound level measurement survey should be conducted periodically and records should be maintained.
- Existing technical specifications should be finalized and technical specifications should also be prepared for other plants.
- All the plants should follow approved modification procedure.
- Incinerator for active solid waste should be commissioned and disposal of Zircaloy scrap and contaminated lubricating oil should be planned at the earliest.

(b) Heavy Water Plants

- The surveillance frequency specified in the technical specifications for various items should be strictly followed.
- Structured aging management and residual life assessment of critical equipments at HWP-Hazira should be carried out and report should be submitted to AERB.
- The $POCl_3$ monitor at HWP-Talcher being a requirement of Limiting Condition of Operations (LCO) of technical specifications has to be installed at the earliest.
- Minimum safety requirements as per AERB's notification dated November 29, 2004 should be strictly followed for work at height jobs at Boron Enrichment Project site of HWP-Manuguru.
- Audiometric tests should be conducted for the employees identified for working in high noise area at HWP-Manuguru.
- Pending authorization of shift-in-charges and fresh operation personnel of the plant should be expedited.

(c) Uranium Corporation of India Ltd.

- Improvements should be done for safety of working at height in the construction site of Turamdih Mill.
- Required number of safety officer as per AERB's directive should be deployed at the construction site of Turamdih Mill.
- Electrical cable penetrations should be sealed with fire retardant material.
- The safety work permit should specify exact nature of the job.

(d) Indian Rare Earths Plants

- Audiometry test should be carried out for HEMM drivers as per recommendations of ACOH.

- Individual earth resistances for machine/equipment should be measured.
- Accident prevention programme should be implemented at IREL, Udyogamandal.
- Excavation should be done as per the Rule 46 of Atomic Energy (Factories) Rules, 1996 for construction and erection.
- Portable grinder should be inspected periodically.
- Portable fire extinguishers at compressor house of IREL, Udyogamandal should be inspected periodically.
- Hydro testing of air receivers pertaining to Thorium plant should be done at 1.25 times of design pressure or 1.5 times of maximum operating pressure whichever is less as per Atomic Energy (Factories) Rules, 1996.

4.3.4 Other Nuclear Facilities

(a) VECC, Kolkata

- All reportable injuries and man-days lost of the contractor's employee should be recorded and reported in the Tri-annual Safety, Health & Environmental (SHE) Report.
- Authorized persons having valid certificate should only be allowed to work with high voltage power supply system.

(b) ECIL, Hyderabad

- Audiometric test should be carried out for the persons working in the areas of noise level more than 90 dBA engineering measures should be adopted to reduce the noise level in these areas.
- Safety valves of 13 air receivers existing in the plant should be tested independently by the competent person.
- The hoists, Electrically Operated Over-head Traveling (EOT) cranes and chain pulley blocks should be tested once in a year by a competent person.
- Identification of training needs is to be assessed department wise and provide need base training on safety and fire equipment handling.

(c) BRIT, Vashi

- Medical examination of canteen employees should be carried out.
- Fire detection and alarm system should be installed in Diesel storage area.

4.4 PROMOTION OF INDUSTRIAL SAFETY

4.4.1 DAE Safety and Occupational Health Professionals Meet

The 23rd DAE Safety and Occupational Health Professional Meet was held at Kochi during November 1-3, 2006. The meet was organized jointly by AERB and IREL, Udyogamandal. The theme of the meet was "Legal Aspects on Safety, Health and Environment". Dr. Anil Kakodkar, Chairman, AEC and Secretary, DAE inaugurated the meet. About 120 delegates and invited speakers participated in this meet. There were 3 technical sessions, plenary and parallel sessions and one poster session apart from the inaugural and valedictory sessions. The topics included Safety, Environment, Occupational Health, Injury & Occupational Health Statistics, Fatal Accidents, Environment Management Plans and suggestion for amendment in Atomic Energy (Factories) Rules, 1996. Chairman, AERB presented AERB's Green Site Award for the year 2005 to IREL-OSCOM and KAPS.

Inauguration of DAE Safety & Occupational Health Professionals Meet by Dr. Anil Kakodkar, Chairman, AEC and Secretary, DAE

(From L to R : Shri P. K. Ghosh, Ex-Director, IPSD, AERB, Shri L.N. Maharana, Chief General Manager, Rare Earth Division, IREL, Shri S.K. Sharma, Chairman, AERB, Hon'ble Justice Smt. K. K. Usha, Former Chief Justice of Kerala High Court, Shri Anil Kakodkar, Chairman, AEC & Secretary, DAE and Shri S. Sivasubramanian, CMD, IREL)

4.4.2 National Symposium on Industrial and Fire Safety-2006

A National Symposium on Industrial and Fire Safety-2006 was organized by AERB with co-sponsorship by Directorate General Factory Advice Services and Labour Institute (DGFASLI), National Safety Council (NSC) and Directorate of Industrial Safety and Health (DISH) at Mumbai during November 27-28, 2006. Around 240 delegates from various DAE and Non-DAE organizations participated in the symposium. There were 6 invited papers and 40 contributed papers on construction, electrical, process and fire safety and risk assessment. AERB Officers presented 7 papers and 2 of them on "Classification and Prioritization of Risks in Process Industries" and "Present Status and Improvement of Industrial Safety at Construction Sites" were adjudged the first and second best papers respectively. An exhibition was arranged for displaying products and services with respect to industrial and fire safety by vendors. The symposium provided a forum to the regulators and industry to share their experiences and work out measures to prevent the industrial man-days lost/fatalities, fire prevention and mitigation of their consequences.

Inauguration of National Symposium on Industrial and Fire Safety-2006 by Dr. S. Banerjee, Director, BARC
(From L to R : Shri S.K. Chande, Vice-Chairman, AERB, Shri M.N. Gadappa, Director, Directorate of Industrial Safety & Health (DISH), Shri S.Banerjee, Director, BARC, Shri S.K. Saxena, Director General, Directorate General of Factory Advice Service & Labour Institute, Mumbai, Shri S.K. Sharma, Chairman, AERB)

On the concluding day of the symposium, a proposal for setting up of an "Association of Industrial Safety Professionals of India (AISPI)" was accepted. This Association will act as a forum for providing expertise on training, document preparation and safety awareness to all DAE and non-DAE facilities in addition to facilitating information and experience exchange through organization of conferences etc.

4.4.3 Industrial Safety Statistics

The compilation of Industrial Safety Statistics-2006 of DAE (Other than BARC Facilities and Mines) provides the information on data on accidents and analysis of number of injuries and man-days loss caused by various factors. The number of injuries, injury rates and the number of fatalities reported were the lowest in 2006 among the past few years. The reduction in the number of injuries is the result of strengthening measures taken by all concerned. No case of occupational disease was reported for the year 2006 in the DAE units.

There were 43 reportable injuries including 4 fatalities (during the calendar year 2006) and 2 amputations (on fingers), which contributed to 26,106 man-days loss in DAE units in the year 2006 compared to 84 reportable injuries including 9 fatal accidents and 56699 man-days loss in the year 2005 in DAE units. Fig. 4.1 gives the distribution of reportable injuries among DAE units and Fig. 4.2 gives the distribution of man-days loss among DAE units.

The data is compared with units outside DAE. It is observed that industrial safety performance of DAE units is better than other similar industries in the country. Fig. 4.3 gives the comparison of incidence rates in some DAE units and similar industries. Year-wise comparison of injury Frequency Rate (F.R) and Severity Rate (S.R) are given in Figs. 4.4 and 4.5 respectively.

Fig 4.1 Distribution of Reportable injuries in DAE units in 2006

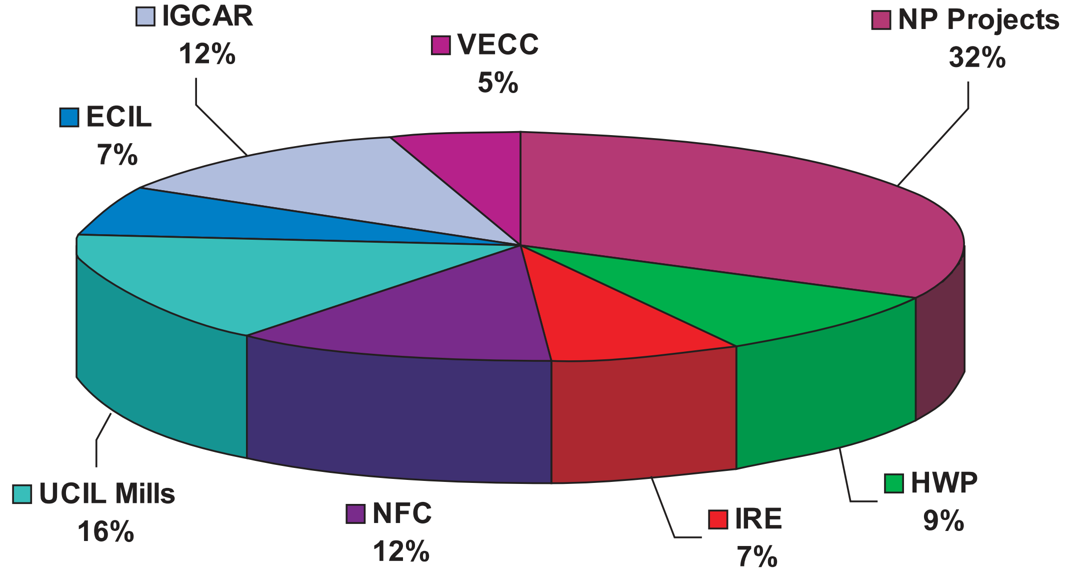


Fig 4.2: Distribution of Man-days Lost in DAE units in 2006

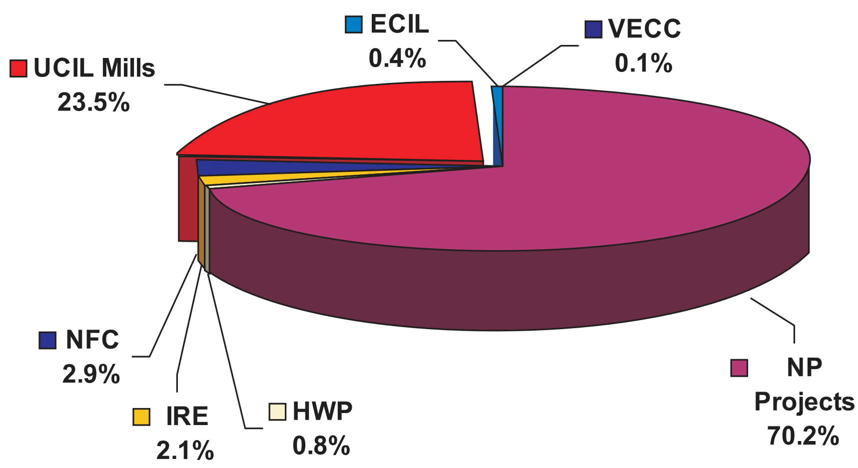
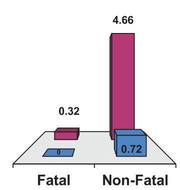
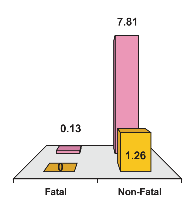


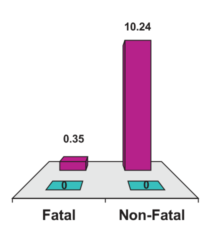
Fig. 4.3: Comparison of Incidence Rates in Some DAE units and similar Industries (National Data)



	Fatal	Non-Fatal
Heavy Water Plants (2006)	0	0.72
Manufacture of Chemical & Chemical products (2001)	0.32	4.66



	Fatal	Non-Fatal
Nuclear Fuel Complex (2006)	0	1.26
Manufacture of Metal Products & Parts except Machinery and Transport Equipment (2001)	0.13	7.81



	Fatal	Non-Fatal
Nuclear Power Plants (2006)	0	0
Electricity, Gas & Steam Generation (2001)	0.35	10.24

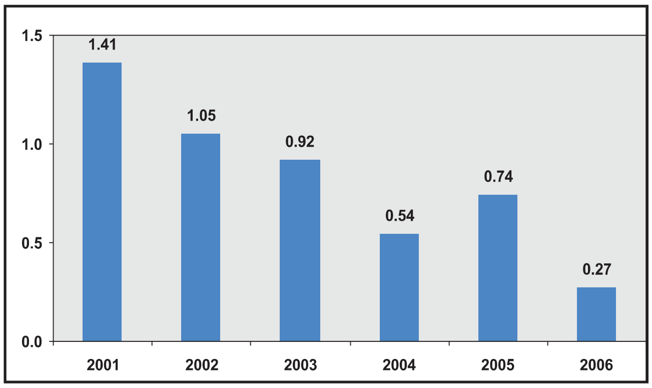


Fig 4.4: Injury Frequency Rates in DAE units during last 6 years

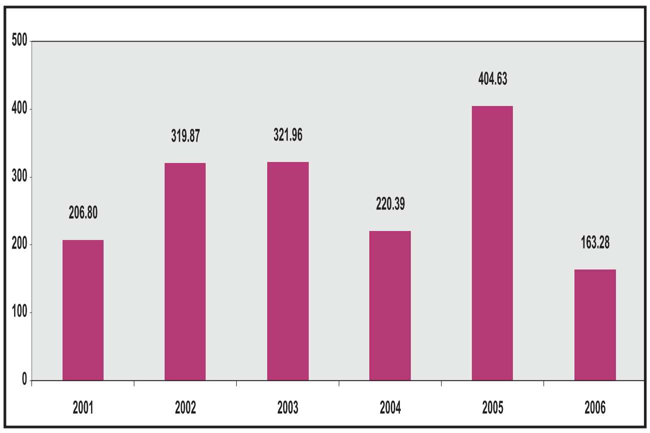


Fig 4.5: Injury Severity Rate in DAE Units during last 6 years

4.4.4 Industrial Safety Awards

The annual Industrial Safety Awards function of AERB for the year 2006 was held on March 6, 2007. The assessment of the plants for the awards is based on a set of parameters that include number of reportable injuries and their severity, longest accident free periods, safety training imparted to personnel and efforts made by plants towards improving safety.

Annual Industrial Safety Awards Function of AERB in Progress

(From L to R : Shri S.K. Sharma, Chairman, AERB, Shri R. Bhattacharya, Head, IPSD, AERB, Shri J. Ganguly, Executive Vice-President L&T Ltd., Chennai, Shri J. Prasad, IPSD, AERB)

Shri J. Ganguly, Executive Vice-President, from M/s Larsen & Toubro Ltd., Chennai presented the Safety Awards for 2006 to NAPS-1&2, HWP-Tuticorin, RAPS-3&4 and Thorium Plant-IREL-OSCOM in the production units group and to BHAVINI in the construction group, for attaining high levels of Industrial Safety. On this occasion, Shri S.K.Sharma, Chairman, AERB released a compilation entitled "Industrial Safety Statistics-2006 of the DAE units".

4.4.5 Fire Safety Awards

Fire Safety Awards for the year 2006 were given on April 16,2007 based on the highest value of Preventive Efforts and Fire Hazard Index (PEFHI) score amongst all DAE units. The PEFHI is calculated as Preventive Efforts minus Fire Hazard Index (FHI). FHI is calculated as summation of product of number of fire incidents and a factor based on classification of fire to give more weightage to fire incidents.

DAE units are categorized based on fire potential as category-I (all operating NPPs, HWP units and NFC) and category-II (IREL units, UCIL units, NPP units under construction, BHAVINI, RRCAT, VECC, BRIT, AMD, IGCAR and ECIL) and accordingly 2 awards were given from each category. Based on these criteria, in category I joint winners were Heavy Water Plant, Manuguru and TAPS-1&2 and in category II, TAPS 3&4 was the winner.

4.4.6 Green Site Award

The Green Site Award for the year 2005 was based on the highest value of Greenery (G) of the site. Greenery (G) of the site is the product of existing greenery area (E) and efforts made for green site (T). In the calculation of efforts made for green site (T), weighing factor for terrain conditions of the site and effective site area is taken into consideration. The DAE units are categorized into two categories based on the total area of the plant including housing colony site (X) namely, category 'A' ($X <= 350$ hectares) and category 'B' ($X > 350$ hectares). Based on these criteria, in category 'A', IREL-OSCOM was the winner and in category 'B', KAPS-1&2 was the winner.

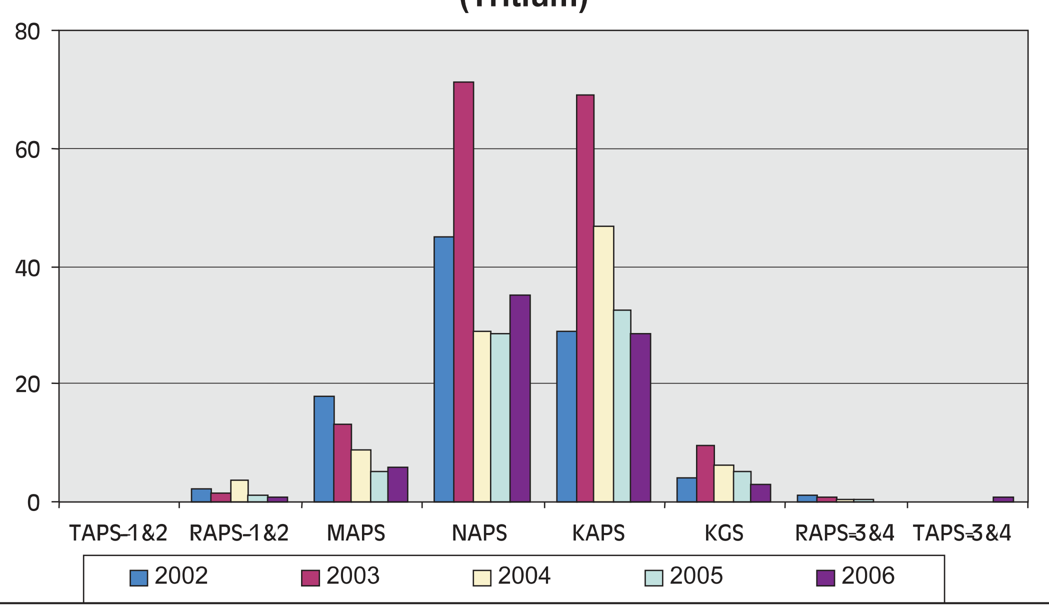
CHAPTER 5

ENVIRONMENTAL SAFETY AND OCCUPATIONAL HEALTH AND SAFETY

5.1 ENVIRONMENTAL SAFETY

The Environmental Survey Laboratories (ESL) of the Health, Safety and Environment Group, BARC carry out environmental surveillance at all the operating NPPs at sites. The liquid and gaseous waste discharged to the environment during the year 2006 from the operating units was only a small fraction of the prescribed technical specification limits. Figs. 5.1a - 5.1e show the liquid and gaseous discharges from the plants for the years 2002, 2003, 2004, 2005 and 2006 as per cent of permissible limits as per technical specifications. Figs. 5.2a and 5.2b show the committed dose to the members of the public due to the release of radioactive effluents from the plants. Radiation dose to members of the public near the operating plants is estimated based on measurements of radionuclide concentration in items of diet, i.e., vegetables, cereals, milk, meat, fish, etc and through intake of air and water. It is seen that in all the sites the effective dose to public is far less than the annual dose limit of 1 mSv prescribed by AERB.

Fig. 5.1a : Liquid Waste Discharges From NPPs (Tritium)

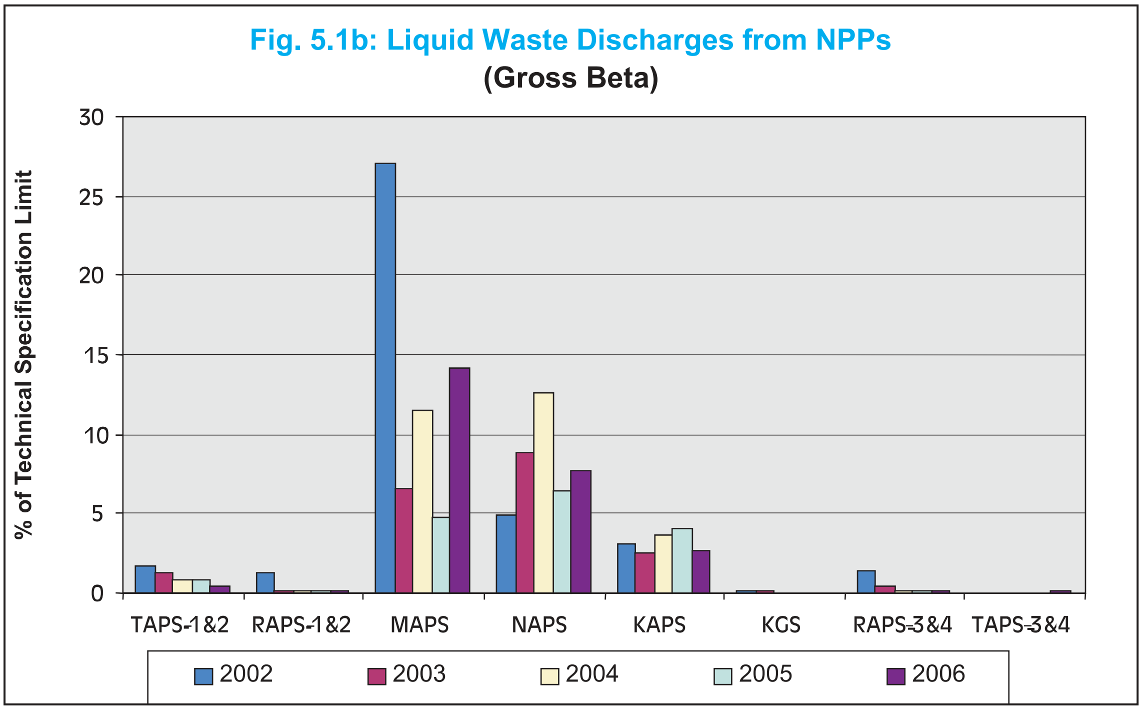


Note:

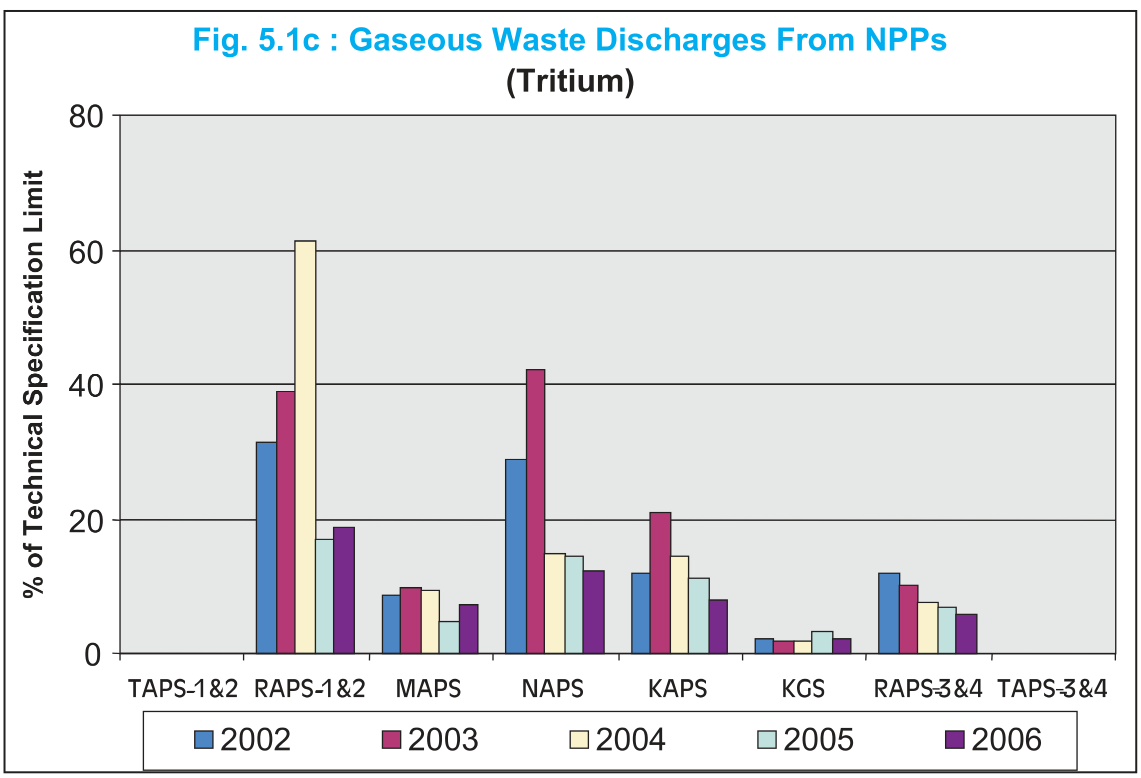
1) TAPS is a Boiling Water Reactor. Hence, there is no generation / dishcharge of Tritium.

2) The data of MAPS pertains to transfer of liquid waste to Centralised Waste Management Facility, Kalpakkam for processing & discharge to the environment.

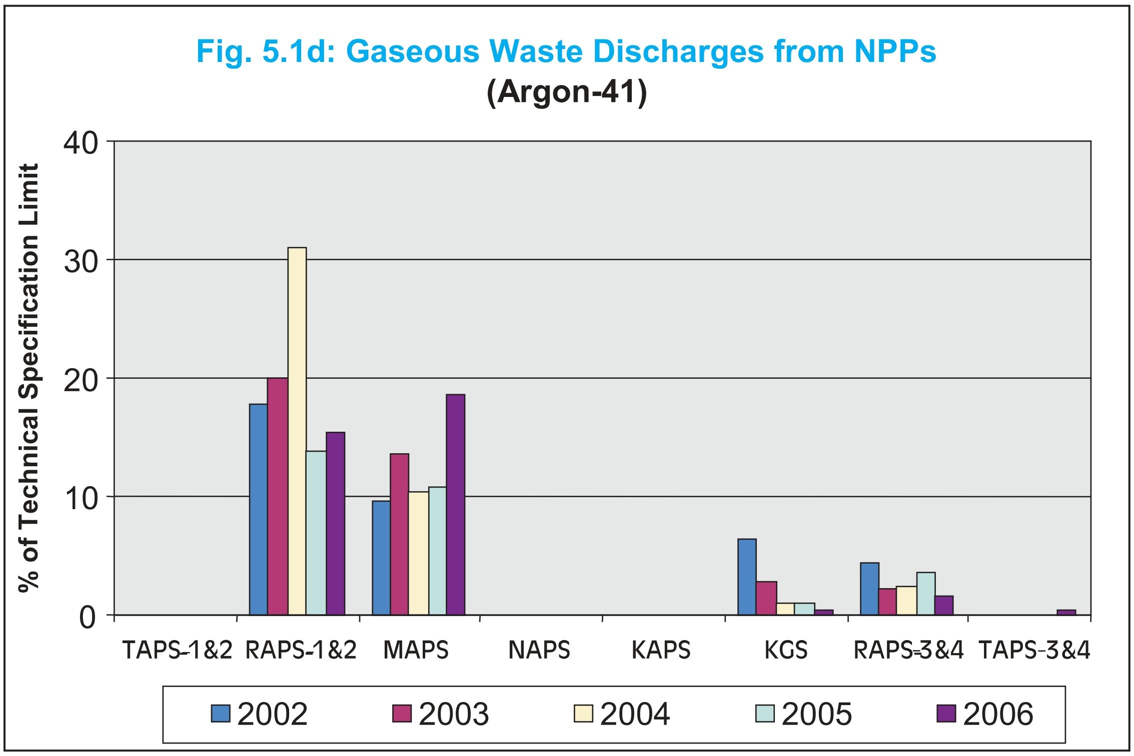
3) The releases from NAPS and KAPS were high in 2003 due to steam generator tube leaks.



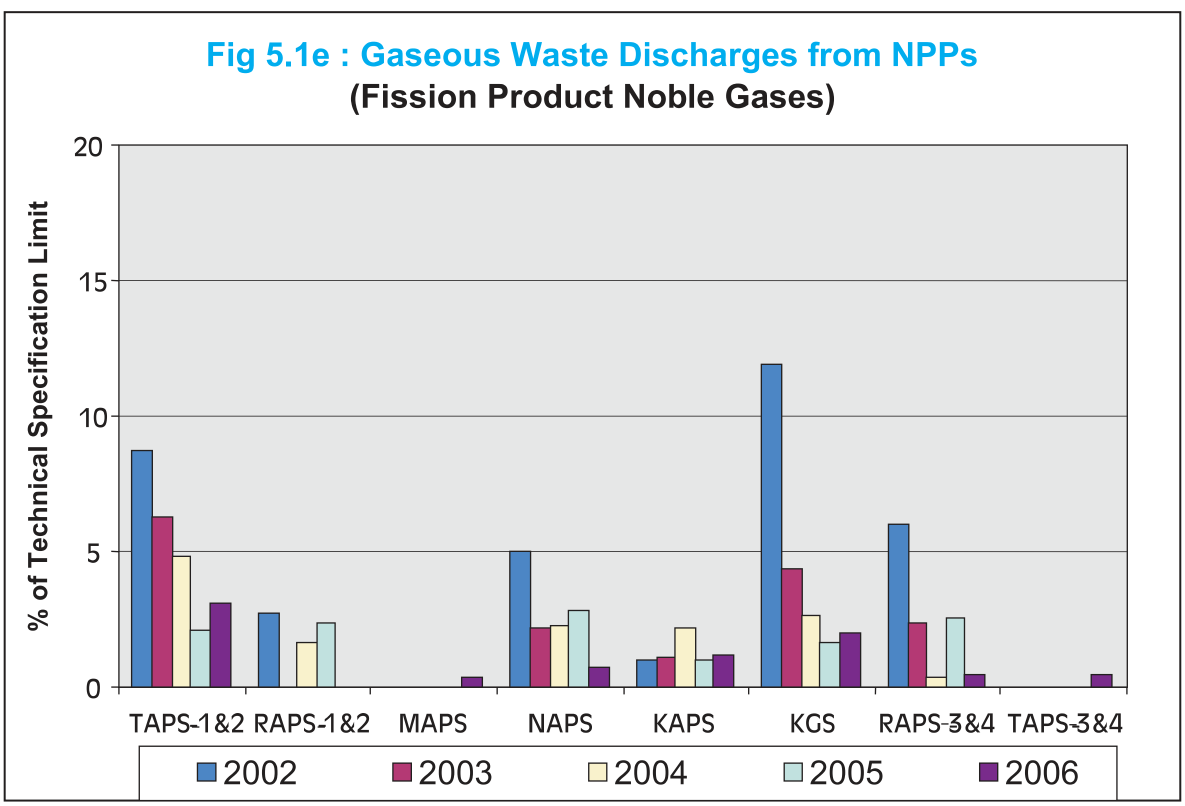
Note: Liquid waste discharges from MAPS was high in 2002 due to Dilute Chemical Decontamination campaign in PHT System of unit-2.



Note: Tritium release from RAPS-1&2 was high in 2004 due to external heavy water leaks.



Note: Limits for release of Argon-41 are not specified in technical specification of NAPS and KAPS.



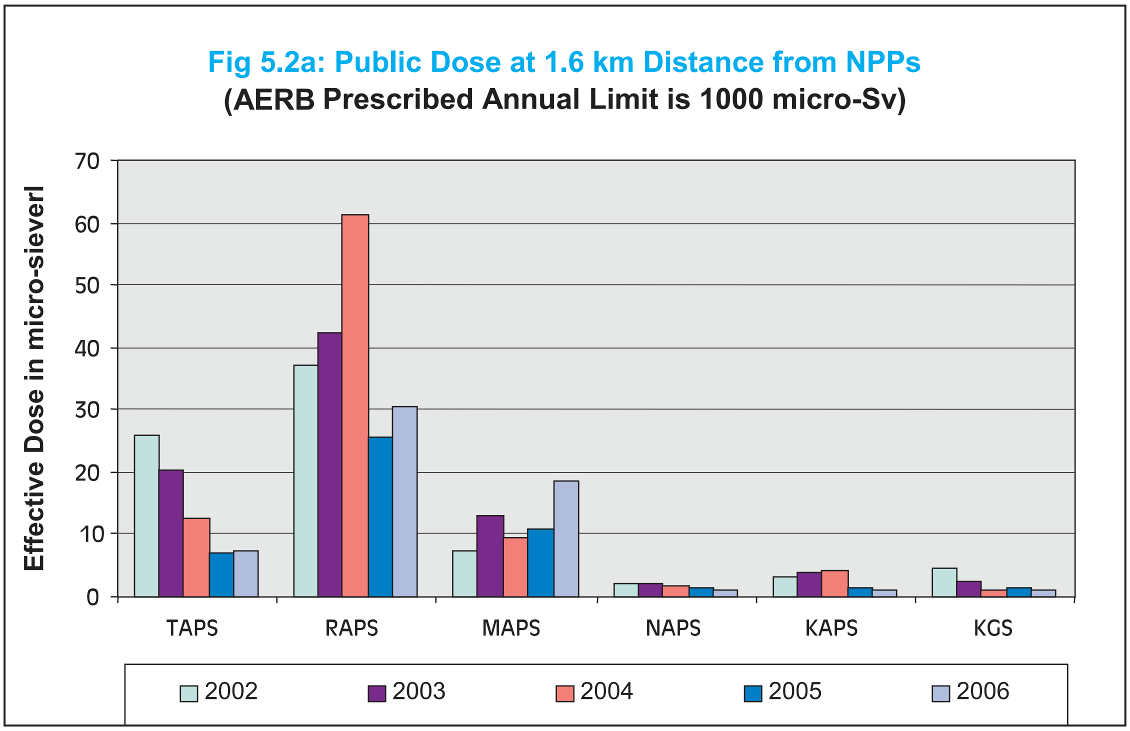


Fig 5.2a: Public Dose at 1.6 km Distance from NPPs
(AERB Prescribed Annual Limit is 1000 micro-Sv)
Effective Dose in micro-sieverl
70
60
50
40
30
20
10
0
TAPS
RAPS
MAPS
NAPS
KAPS
KGS
2002
2003
2004
2005
2006

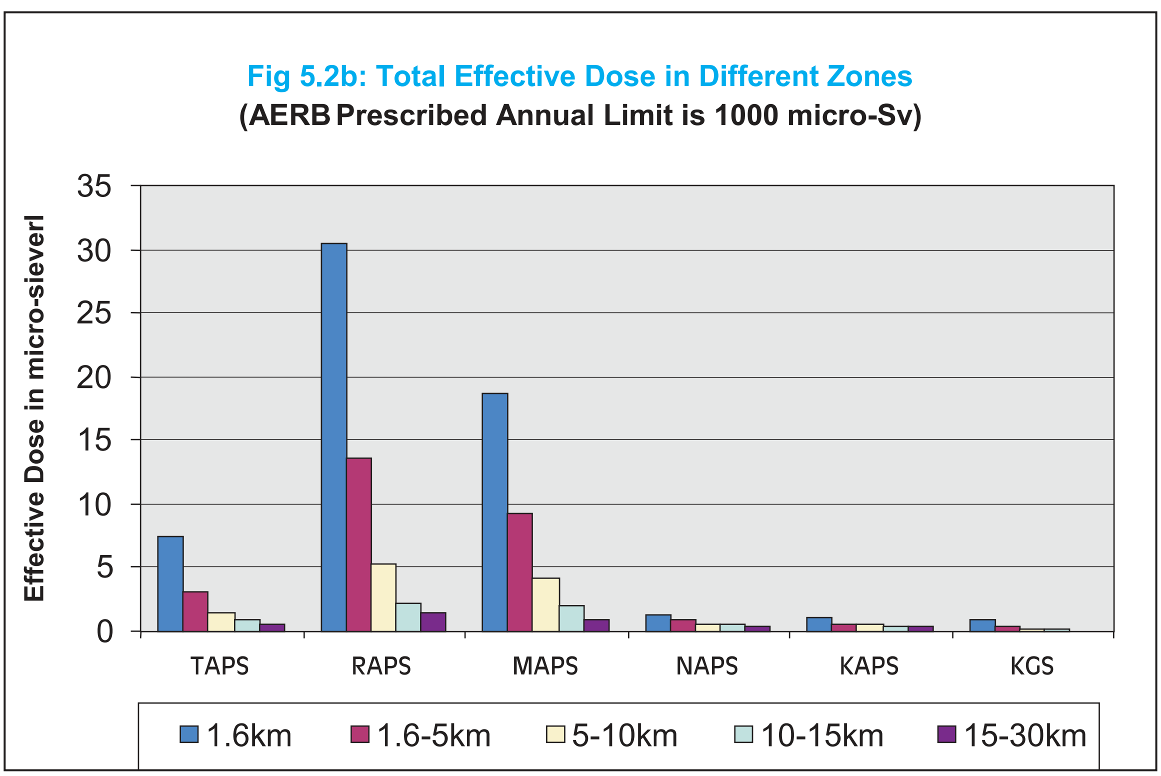


Fig 5.2b: Total Effective Dose in Different Zones
(AERB Prescribed Annual Limit is 1000 micro-Sv)
Effective Dose in micro-sieverl
35
30
25
20
15
10
5
0
TAPS
RAPS
MAPS
NAPS
KAPS
KGS
1.6km
1.6-5km
5-10km
10-15km
15-30km

5.2 OCCUPATIONAL EXPOSURES

No worker in the Front end fuel cycle facilities of DAE [IREL (Udyogamandal, Chavara, Manavalakurichi, OSCOM); UCIL (Jaudguda, Bhatin, Narwapahar, Turamdih); NFC-Hyderabad) received radiation dose greater than the annual dose limit of 30 mSv during the year 2006. Number of workers of these facilities who received radiation doses between 20 mSv and 30 mSv during the period 2002-2006 is given in Table 5.1

Table 5.1: Number of Workers in Industrial Plants of DAE who Received Radiation Exposure between 20 mSv (Investigation Level) and 30 mSv (Annual Limit)

Year	2002	2003	2004	2005	2006
IRE-Udyogamandal	0	4	0	1	0
IRE-Manavalakurichi	0	0	0	0	0
NFC	0	1	0	0	0
All other Industrial Plants	0	0	0	0	0

The number of workers who received radiation doses between 20 mSv and 30 mSv during the years 2002 – 2006 in NPPs is given Table 5.2a. Details of radiation doses received by workers in medical, industrial and research institutions are given in Table 5.2b.

Table 5.2 a: Number of Workers in NPPs Exposed to > 20 mSv (Investigation Level) and > 30 mSv (Annual Limit)

Year	2002		2003		2004		2005		2006	
	20-30 mSv	>30 mSv	20-30 mSv	>30 mSv	20-30 mSv	>30 mSv	20-30 mSv	>30 mSv	20-30 mSv	>30 mSv
TAPS-1&2	2	0	0	0	0	0	0	0	0	0
RAPS-1&2	0	0	0	0	0	0	0	0	0	0
MAPS-1&2	2	1	0	0	0	0	1	0	0	0
NAPS-1&2	10	1	1	0	0	0	0	0	4	0
KAPS-1&2	1	0	3	0	1	0	0	0	0	0
KGS-1&2	0	0	0	0	0	0	0	0	0	0
RAPS-3&4	0	0	0	0	0	0	0	0	0	0
TAPS- 3&4	-	-	-	-	-	-	0	0	0	0

Table 5.2 b: Radiation Doses Received by Workers in Medical, Industrial and Research Institutions (2006)

Category of Radiation Worker	Number of Monitored persons	Average Dose for Persons (mSv)	Average Dose for Persons (mSv)	Number of Workers Receiving Annual Individual Dose Excluding Zero Dose, D (mSv)					
				0 < D ≤20	20 < D ≤ 30	30 < D ≤ 35	35< D ≤ 40	40 < D ≤50	D > 50
Diagnostic X-rays	17637	0.44	1.35	5633	11	3	4	4	15
Radiation Therapy	4677	0.21	0.65	1529	-	-	-	-	-
Nuclear Medicine	660	0.50	1.02	324	-	-	-	-	-
Industrial Radiography & Radiation Processing	3540	0.58	2.26	897	8	2	1	-	3
Research	2691	0.07	0.55	346	-	-	-	-	-

5.3 OCCUPATIONAL HEALTH AND SAFETY

5.3.1 Advisory Committee on Occupational Health

Two meetings of Advisory Committee on Occupational Health (ACOH) were held during the year. The committee reviewed the "Yearly Status on Occupational Health-2005" reports submitted by the DAE units and made observations that there was no occupational disease reported in the year 2005 except few cases of hearing loss. Subsequently, a sub-committee was constituted to investigate the cases of Noise Induced Hearing Losses (NIHL) at RAPS, KAPS and UCIL to recommend the measures required to prevent NIHL.

CHAPTER 6

EMERGENCY PREPAREDNESS

NPPs are provided with adequate safety features to guard against the possibility of any accident. Further, the safety features such as a containment building around each NPP helps in mitigating the consequences, should an event occur. In the extremely rare event of a nuclear accident, it might become necessary to take certain mitigating measures in the public domain. This requires a high degree of preparedness. Site-specific emergency preparedness plans are therefore drawn up and maintained at all stations for plant emergencies, site emergencies and off-site emergencies. To test these plans, periodic emergency exercises are carried out involving the station authorities, district administration, and the members of public. Plant Emergency Exercises (PEE) are carried out once in a quarter, Site Emergency Exercise (SEE) once in a year and Off-Site Emergency Exercise (OSEE) once in 2 years.

During the year 2006, emergency exercises were carried out as given in Table 6.1. The response of the plant personnel, officials and public involved in the exercise and general level of the awareness amongst the public were satisfactory.

The plant and site emergency preparedness and response plan for KGS - 3&4 and revised off-site emergency preparedness and response plan for Rawatbhata DAE Center were reviewed in detail.

Table 6.1: Number of Emergency Exercises (2006)

PLANT	PEE	SEE	OSEE
TAPS-1&2	4	1	-
RAPS-1&2	4	1	-
MAPS-1&2	4	1	-
NAPS-1&2	4	1	-
KAPS-1&2	4	1	1
KGS-1&2	4	1	-
RAPS-3&4	4	1	1
TAPS-3&4	4	1	-

Periodic SEE and OSEE were carried out at hydrogen sulphide based HWPs at Manuguru and Kota. SEEs are carried out once in 6 months and OSEEs once in 2 years.

Periodic emergency exercises are carried out at ammonia based HWPs at Baroda, Thal, Hazira, Tuticorin and Talcher. PEEs are carried out once in a quarter and fire drills once in 2 months.

CHAPTER 7

DEVELOPMENT OF SAFETY DOCUMENTS

AERB develops safety documents, which include Safety Codes (SC), Safety Guides (SG), Safety Manuals (SM) and Technical Documents (TD) for nuclear and radiation facilities and related activities. The progress on various safety documents during the year is given below. A total of 120 documents have been published so far.

7.1 NEW SAFETY DOCUMENTS PUBLISHED DURING THE YEAR

1. Consenting Process for Nuclear Power Plants and Research Reactors (AERB/NPP & RR/SG/G-1).
2. Consenting Process for Nuclear Fuel Cycle Facilities and Related Industrial Facilities (AERB/NF/SG/G-2).
3. Regulatory Inspection and Enforcement in Nuclear Power Plants and Research Reactors (AERB NPP&RR/SM/G-1).
4. Operational Experience Feedback on Nuclear Power Plants (AERB/NPP/SG/O-13).
5. Reliability Database for Probabilistic Safety Assessment of Nuclear Power Plants (AERB NPP TD/O-1).
6. Non-Conformance Control, Corrective and Preventive Actions for Nuclear Power Plants (AERB NPP/SG/QA-8).
7. Document Control and Record Management for Quality Assurance in Nuclear Power Plants (AERB NPP/SG/QA-9).
8. Near Surface Disposal of Solid Radioactive Waste (AERB/SG/RW-4).
9. Safety in Thorium Mining and Milling (AERB/SG IS-6).

7.2 SAFETY CODES UNDER REVISION

1. Code of Practice on Design for Safety in Pressurized Heavy Water Based Nuclear Power Plants (AERB/NPP/SC/D) published in 1989.
2. Code of Practice on Quality Assurance for Safety in Nuclear Power Plants (AERB/NPP/SC/QA) published in 1988.
3. Code of Practice on Safety in Nuclear Power Plant Operation (AERB/NPP/SC/O) published in 1989.
4. Industrial Gamma Radiography Exposure Devices and Source Changers (AERB/SS-1/Rev.1) published in 1992.
5. Land-based Stationary Gamma Irradiators (AERB SS-6/Rev.1) published in 1993.

7.3 SAFETY DOCUMENTS TRANSLATED AND PUBLISHED IN HINDI

1. नाभिकीय ऊर्जा संयंत्र–कार्मिकों, जनता के स्वास्थ्य एवं पर्यावरण संरक्षा के नियमन के लिए मापदण्ड (एईआरबी/एसजी/जी–8; 2001)
   Criteria for Regulation of Health and Safety of Nuclear Power Plant Personnel, the Public and the Environment (AERB/SG/G-8; 2001).
2. दाबित भारी पानी रिएक्टर वाले नाभिकीय ऊर्जा संयंत्रों में अग्नि संरक्षण (एईआरबी एसजी/डी–4; 1999).
   Fire Protection in Pressurized Heavy Water Reactor Based Nuclear Power Plants (AERB/SG/D-4; 1999).
3. दाबित भारी पानी रिएक्टर के लिए ईंधन हस्तन तथा भंडारण प्रणाली की डिजाइन (एईआरबी/एसजी/डी–24; 2002)
   Design of Fuel Handling and Storage Systems for Pressurized Heavy Water Reactors (AERB/SG/D-24; 2002).
4. नाभिकीय ऊर्जा संयंत्रों की संरक्षा के लिए महत्त्वपूर्ण सिविल इंजीनियरी संरचनाओं का अनुरक्षण (एईआरबी/एसएम/सीएसई–1; 2002)
   Maintenance of Civil Engineering Structures Important to Safety of Nuclear Power Plants (AERB/SM/CSE-1; 2002).

7.4 SAFETY DOCUMENTS UNDER DEVELOPMENT

1. Atmospheric Dispersion and modeling (AERB/NF/SG/S-1).
2. Extreme Values of Meteorological parameters (AERB SG/S-3).
3. Containment System Design (AERB/NPP/SG/D-21).
4. Computer Based Systems of Pressurized Heavy Water Reactors (AERB/SG/D-25).
5. Probabilistic Safety Assessment for Nuclear Power Plants and Research Reactors (AERB/NPP&RR/SM/O-1).
6. Design of Nuclear Power Plant Containment Structure (AERB/SS/CSE-3).
7. Code of Practice on Radwaste Management (AERB NRF/SC/RW).
8. Predisposal Management of Low and Intermediate Level Waste (AERB/SG/RW-2).
9. Predisposal Management of High Level Radioactive Waste (AERB/SG/RW-3).
10. Management of Radioactive Waste from Mining and Milling of Uranium and Thorium (AERB/NF/SG/RW-5).
11. Management of Spent Radioactive Sources and Radioactive Waste from Medical and Industrial Facilities (AERB/RF/SG/RW-6).
12. Decommissioning of Nuclear Fuel Cycle Facilities other than Reactors (AERB/SG/RW-7).
13. Radiological Safety in Uranium Mining and Milling (AERB/SG/IS-7).
14. Regulatory Inspection and Enforcement In Nuclear Fuel Cycle And Related Industrial Facilities (Other than Nuclear Power Plants and Research Reactors) (AERB NF/SM/G-2).

CHAPTER 8
SAFETY STUDIES

8.1 SAFETY ANALYSIS

8.1.1 Station Black Out (SBO) Analysis of PWR-KK

The SBO analysis of KK-NPP was carried out as a part of collaboration between AERB and Light Water Reactor Division (LWRD) of BARC, using the computer code SCDAP/RELAP5/MOD3.2, with and without taking the credit of Passive Heat Removal System (PHRS).

SBO with PHRS: SBO analysis for about 18 hours was carried out with PHRS available. In case of SBO, Class IV fails and Class III power supply fails to backup. Consequently all Reactor Coolant Pumps (RCP), the main and auxiliary feed water pumps trip. The pressure control system in the pressurizer does not work because supply to the heaters and spray system is off. Turbo-generator stop valve closes and the reactor trips at 1.9 s on tripping of all RCPs. However, the decay heat produced in the reactor is removed through PHRS. PHRS is designed for prolonged residual heat removal from the reactor core during SBO and Beyond Design Basis Accidents (BDBAs). The system is based on heat removal from the secondary side of SGs to atmosphere and works on the principle of natural circulation. One train of PHRS is devoted to each loop of the primary coolant system. PHRS starts at 30 s following SBO and achieves full capacity of heat removal in 90 s. Following RCP coast down, natural circulation sets in primary coolant system. The safety parameters such as maximum clad temperature, fuel temperatures, primary coolant pressure are predicted and observed to be well within the safety limits. The various safety parameter transients obtained were compared with corresponding transient curves obtained using the computer code, DINAMIKA. It was observed that all the trends observed in the predictions using the code DINAMIKA are observed in the present analysis. The magnitudes differ. DINAMIKA predicts conservative values for fuel clad temperatures by about 20 to 30°C. The depressurization of the system is faster as predicted by the code DINAMIKA. This may be due to differences in thermal hold up considered in pipe walls and other structures.

SBO without PHRS: An analysis for SBO was carried out along with failure of PHRS to understand how fast the core melt down may start and how further progression of the event takes place. Additional failure in form of failure of steam dump valve to atmosphere (BRU-A) was considered. This is an extremely low probable event and lies in the region of residual risk. Only mode of heat removal is through steam discharge from Pulse Safety Devices (PSD) in the pressurizer and SG. SG-PSD first operates at 6.1 s when SG pressure reaches 8.2 MPa and continues to operate on and off till about 10,000 s. Pressurizer-PSD first operates at 3086 s and continues to operate on and off till about 13630 s. Temperature reaches melting point of fuel around 10000 s. Further analysis is in progress to estimate the time at which core slumps and the vessel fails.

8.1.2 Hydrogen Distribution Analysis

NPCIL analysed the hydrogen distribution in the containment using PACSR computer code for loss of coolant accident combined with loss of emergency core cooling for various PHWRs. AERB carried out the hydrogen distribution analysis for TAPP-3&4 using a containment thermal hydraulic code, for independent verification of 1 case. The analysis was divided into 2 parts and in each part 2 cases were analysed. In part-1, the coolant discharge rates were taken from the NPC report and 2 separate cases were analysed. The objective of this analysis was to compare the results of PACSR code with the AERB results for assessment of system modeling. The first case was with the existing containment features and the second one was with the fan system proposed by NPCIL for hydrogen mitigation management. This is an engineered safety feature in the containment to bring down the hydrogen concentration inside fuelling machine vault to safe level. The fans are located in pump room and facilitate airflow from pump room to fuelling machine vault for mixing/dilution of hydrogen. In the proposed system, fans are started automatically based on containment isolation signal. In part-2, actual coolant discharge rates for a large break in inlet header for TAPP-3&4 were considered and NPCIL results were not available for comparison. The salient results of the analysis are given below.

Part-1 of the Analysis: For case 1, the trends predicted in both the analyses (AERB code and PACSR) are similar. The magnitudes for hydrogen mass and concentration (volume percent) predicted by AERB are lower and steam concentrations predicted by AERB are higher compared to predictions of PACSR code. Predictions by PACSR in respect of flammability mixtures are on conservative side. For case 2, the hydrogen concentrations follow the similar trends and the peak hydrogen concentration predicted by PACSR is about 11.5 % in the break compartment as compared to about 10 % predicted by AERB code. The steam concentrations are differing quite significantly in both the analyses. However, the predictions by PACSR are conservative with regard to flammability mixture concentrations (hydrogen concentration and steam concentration).

Part-2 of the Analysis: The mass of hydrogen generated is predicted to be about 33 kg and the concentration rose to about 32 % in the break compartment. The maximum steam concentration is about 30 % in the break compartment. This mixture may enter into the detonation region with further reduction of steam concentration due to condensation on containment walls. The case was also analysed taking the credit of forced circulation using a fan. The peak hydrogen concentration predicted is about 11.5 %. The mixture concentrations have entered into the deflagration region and did not go to detonation zone. However one has to study the effect by simulating the coolers.

8.1.3 Standard Problem Exercise (SPE)

Two joint standard problem exercises were proposed in the AERB-USNRC discussion meet. The first standard problem exercise is based on experiments (ISP-42) carried out at PANDA facility in Switzerland while the second problem is based on the severe accident initiated by a small break LOCA at TMI-2 in 1979. Analysis on both the exercises was started in collaboration with BARC and NPCIL. The input data for both the exercises was supplied by USNRC.

(i) Phase A of the PANDA Natural Circulation Facility Analysis (ISP-42)

The SPE PANDA facility is based on natural circulation in containment and has six phases (A to F). Analysis of phase-A of International standard problem exercise (ISP-42) on PANDA natural circulation facility was carried out. The phase A of the experiment/analysis includes the simulation of phenomena of steam injection into drywell, its mixing and condensation in drywell, startup of passive containment cooling system and its effect on drywell pressure. The results were compared with the experimental observations. The analysis was carried out upto 6000 s. The trends of the various thermal hydraulic parameters (temperatures, pressures, flow rates, etc.) are in good agreement with the experimental results. However, this analysis needs further improvements with respect to simulation of pressure drops and heat losses to the environment.

(ii) Severe Accident Analysis of TMI-2

In the second standard problem exercise on the accident at TMI-2, the PHT system was simulated on the best estimate thermal hydraulic code, RELAP5/SCDAP. TMI-2 is a 2772 MWth PWR with 2 loops with once through SGs and a pressurizer. Initial steady operating results were obtained and compared with the operating data. The data compares well within the desired accuracy. The accident progression analysis is in progress.

8.1.4 Severe Accident Analysis of PHWRs

In-vessel severe accident progression in PHWRs is significantly different from that in LWRs. Currently there is no computer code available for estimating this. A computer model using computer code, ANSYS is being developed for this. The thermal behaviour of reactor channels is obtained from thermal hydraulic code and mechanical disassembly of the reactor channels is being simulated on ANSYS as a beam element with uniform loading. The mechanical interaction between 2 successive channels is accounted by using built in contact and target element combination. High temperature creep effect is also accounted by incorporating a suitable material model. A set of graphs are being developed which could independently be used for assessing core disassembly progression.

8.1.5 Stagnation Channel Break Analysis of PHWR

For a particular narrow range of breaks in an inlet feeder, there would be flow stagnation in the corresponding coolant channel leading to fuel damage due to high temperatures. The analysis was carried out, using thermal hydraulic code RELAP5/MOD 3.2, for 220 MWe PHWR, to find out the range of break sizes resulting in flow stagnation. Break sizes ranging from 1% to 100% were considered. The range of break-sizes for which there is sustained very low flow condition in the affected channel was estimated. The results of analysis indicate that the flow stagnation occurs for break having flow area of 42.5% to 44.5% of feeder and for these break sizes the clad temperature exceeds 1477.6 K. Based on these results, the conditional probability that a feeder break is a stagnation channel break will be estimated.

8.1.6 Uncertainty Evaluation in Best Estimate Accident Analysis of NPP

One AERB officer was deputed to University of Pisa, Italy during the period to work on uncertainty evaluation in best estimate accident analysis of NPP using 'Code with the capability of Internal Assessment of Uncertainty (CIAU)' under the guidance of Prof. Francesco D'Auria. The following evaluations were carried out.

i) Analysis to Qualify the Nodalization (K_v scaled calculation): This was carried out to qualify the nodalization of generic VVER-1000 NPP using 4.1% cold leg small break LOCA in PSB VVER Integral Test Facility (ITF), which is required to carry out uncertainty evaluations using CIAU for reference small break and large break Loss of Coolant Accident (LOCA).

ii) Uncertainty Evaluation: Reference transient calculations were performed for small break and large break LOCA for generic VVER-1000, using thermal hydraulic code RELAP5/MOD 3.3 and uncertainty evaluations were done for clad temperature, primary mass inventory and primary pressure using CIAU.

iii) Post Test Analysis of Test Conducted in Integral Test Facility: CIAU is based on database obtained from qualified post test analysis results of qualified ITF. CIAU database stores accuracy of six driving quantities (upper plenum pressure, primary mass inventory, SG pressure, clad temperature, core power and SG level) resulting from both code output and experimental values. These accuracies of code calculation for ITF tests are extrapolated for uncertainty evaluation of best estimate accident analysis of NPPs with due consideration for statistical data analysis, scaling, geometry distortions etc. To qualify the nodalisation of the test facility both 'Steady State Level' and 'On Transient Level' qualifications were demonstrated as per Uncertainty Methodology based on Accuracy Extrapolation (UMAE). Post test analysis for the tests mentioned below are carried out to enlarge the data base of CIAU using RELAP5/MOD 3.3 and applying all the steps of UMAE.

a) Total loss of feed-water with failure of HPIS pumps and operator actions on primary and secondary circuit depressurization' carried out in PSB-VVER ITF.

b) '4.1% cold leg SB LOCA' carried out in PSB-VVER ITF.

c) Test 9.1B (ISP-27) '2 inch cold leg break without HPIS and with delayed ultimate procedure initiation' carried out in BETHSY ITF.

d) Test 6.2TC '2 inch cold leg break with taking only credit of high pressure accumulator of ECCS' carried out in BETHSY ITF.

e) Test A2-81 (ISP-18) '1% cold leg break with taking only credit of HPIS of ECCS' carried out in LOBI-MOD2 ITF.

f) Test BL06 '1% cold leg break without HPIS of ECCS in carried out LOBI-MOD2 ITF.

g) Test BL12 '1% cold leg break with taking only credit of high-pressure accumulator of ECCS' in LOBI-MOD2 ITF.

8.1.7 Fire Analysis of Lub Oil Storage Room, TAPP-3&4

A case study was carried out to familiarize with the computer code 'Fire Dynamic Simulator (FDS) version 4.0' from National Institute of Standards and Technology, USA. The analysis was carried out for the cases of fire in the lub oil leak area of TAPP-3&4.

Two cases were considered, case 1 was for the scenario when fire doors were open and case 2 was for the scenario when fire doors were closed.

In case 1, the temperature near the bottom cable tray reached 315 °C in 110 s and temperature at the top cable tray reached 350 °C in 120 s. The temperature further increased to 400 °C in next 60 s. It was observed that, the temperature reached ignition temperature of PVC insulation in 180 s.

In case 2 it was observed that the temperature near the bottom cable tray reached 350 °C in 100 s. After 200 s, the heat release rate continuously decreased and at 601 s fire gets self-extinguished, as sufficient amount of oxygen was not available for burning. It was also observed that the smoke density was higher in case 2 than that in case 1.

8.1.8 Review of KK Level-1 PSA

The preliminary review of KK level-1 PSA was completed in the PSA committee. The event trees of various initiating events, fault trees of various systems and the input data used in the analysis were reviewed.

A case study for large break in hydro accumulator pipeline was carried out using the RISK SPECTRUM V1.2 as part of the review of KK Level-1 PSA report. The initiating event 'Large LOCA with equivalent diameters from 135 mm to 279 mm' was chosen and analyzed with RISK SPECTRUM software for sample verification of PSA Level-1 of KK. Fourteen systems including safety and support systems were modeled for this purpose. Event tree was drawn for the above-mentioned event. The frequencies of accident sequences, which are significant contributors to Core Damage Frequency (CDF), are compared with those of KK level-1 PSA report. Discrepancies observed would be discussed in detail in the PSA committee for resolution.

8.1.9 Case Study on PSA for Food Irradiation Facility, Vashi

A case study on the PSA for Food Irradiation Facility, Vashi was carried out. In the study 2 initiating events were identified and event sequences were developed for the safe and unsafe conditions. Fault trees were developed for the various possibilities of system failure. Generic values were used for the component failure probability. Screening values were used for the basic Human Error Probability (HEP). The calculated risk is 4.764 E-07/y.

8.1.10 Safety Status of Indian Containment Structures

A study on the safety status of containment structures of Indian PHWR based containment structures was undertaken by AERB. Study covered various aspects of engineering, pre-commissioning test, operation and in-service test, leak tightness, degradation of Indian containment structures. All these aspects were examined with respect to international practice; especially the French practice as French containment structural systems are similar to that of Indian PHWR based NPP. The study brought out that the Indian practice of containment structure testing falls short of international practice; leak tightness of Indian containment structures is much higher than that of French containment structures, even more than 20 times in some cases; certain shortcomings of Indian practice of design of containment structures, which is based on French code RCC-G; and inadequacies in the construction. This study brought out relevance of different provisions of AERB safety standard on design of nuclear power plant containment structure, AERB/SS/CSE-3 with respect to the safety status of Indian containments structures.

8.1.11 Comparison of draft AERB Safety Standard AERB/SS/CSE-3 on "Design of Nuclear Power Plant Containment Structure" with Canadian design Standard CSA N287.3 on "Design Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants"

A study on comparison of design provisions of Canadian design Standard CSA N287.3 on 'Design Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants' and draft AERB design Standard AERB/SS/CSE-3 (draft) on 'Design of Nuclear Power Plant Containment Structure' was carried out. This exercise was carried out to establish equivalent partial safety factor to various loads in draft AERB/SS/CSE-3 in line with CSA N 287.3. The reason for selection of Canadian Code was that this is the only international design code of containment structure for PHWRS.

A computer code, using 'C' language, was developed for limit state method of design for serviceability and strength of prestressed dome/wall elements as per draft AERB/SS/CSE-3. The program takes basic geometry, loads and material properties, prestressing and non-prestressing reinforcement as input. It undertakes stress check for uncracked /cracked section for all load combinations and compares it with various requirements of draft AERB/SS/CSE-3 for current and non-current sections for normal/abnormal design condition. If stress limits specifying limit state of serviceability are not-satisfied, program revises non-prestressing steel to check if increase in non-prestressing steel helps to satisfy limit state of serviceability. If section still fails to satisfy serviceability requirement, message indicating revision in thickness and/or prestressing requirement is displayed appropriately in out-put files. The above code was further augmented to perform limit state of serviceability design as per CSA N287.3 for service/abnormal category of loads.

Another computer code, using C-language was developed for limit state of strength design of prestressed dome/wall elements as per Canadian design Standard CSA N287.3. The program takes basic geometry, loads, material properties, prestressing and non-prestressing steel as an input for all elements submitted to it for design. It performs limit state of strength design for both service and abnormal/environmental category of load combinations. The output of the program gives reinforcement steel requirement and governing load combination for designed elements. The program also gives detailed output in the form of design forces, section properties, neutral axis position, strain and stress in concrete, non-prestressing and pre-stressing steel, force capacity and moment capacity.

The computer programs mentioned above were validated for different design situations such as wall/dome element, hoop/meridional direction, compression/tension predominant loading, normal/abnormal design condition etc. The validation was done for limit state of strength and serviceability for both draft AERB/SS/CSE-3 and CSA N287.3 design Standards.

A report on 'Inter comparison of Canadian and draft AERB design standards for nuclear containment structure', AERB report No: AERB/C&SED/6512601/R0 was also prepared. The outcome of this study would help in finalising partial safety factors for loads to be adopted in AERB/SS/CSE-3.

8.1.12 Long Term Prestressing Loss For Containment Fragility Analysis At Severe Accident Condition

As part of the preparation of AERB Safety Standard "Design of Nuclear Power Plant Containment Structure", AERB/SS/CSE-3, a study on prestressing loss using various National and International standards was carried out. This study was felt necessary on account of the increase in prestressing loss and leakage rate reported by French NPPs during full pressure in–service containment testing compared to the leakage rate obtained during pre-commissioning test. The observed increase in leakage rate is attributed to the higher loss in prestressing force along with the stress flow around the opening. To examine these aspects, provisions of prestressing losses specified in American Society for Mechanical Engineers (ASME): Section III Div. 2, RCC-G, Draft AERB standard, Indian Standard Code and Code published by Indian Road Congress were compared. The prestressing loss of both 2 types, instantaneous and time dependent were considered. Time dependent losses due to shrinkage, creep of concrete and relaxation of prestressing steel were taken into account. The computed values were examined with respect to actual performance data of French containment structures. The prestressing loss calculated using AERB/SS/CSE-3 compared best with the performance data.

8.1.13 Reliability Study of Prestressed Concrete Containment Structure

A reliability study was conducted by AERB to examine the level of safety of containment structure designed by draft AERB/SS/CSE-3. Two example problems; (1) singly reinforced concrete beam for both flexure and shear modes of failure, and (2) prestressed concrete containment structure for global failure mode of hoop tension were examined.

The formulation for the reliability study was based on first order second-moment method (FOSM) of level-2 reliability analysis. Concrete strength, ultimate strength of prestressing cable and pressure load were considered as basic variables of reliability analysis of containment structure. For concrete beam, the basic variables were concrete strength, yield strength of reinforcement, dead load and live load. To understand the impact of uncertainty associated with the basic variables, a parametric study was carried out. A computer programme was also developed for this study.

It was observed from the results of reliability analysis of singly reinforced concrete beam that the draft AERB/SS/CSE-3 ensures similar safety level as that of Indian National code IS 456 as minimum. As regard to prestressed concrete containment structure, the conditional probability of failure is generally more than 10^{-4} for g_{pt} = 1.4 and remains below 10^{-4} for g_{pt} =1.6. The study concluded that g_{pt} = 1.6 is the prudent value of partial safety factor to pressure load for design of prestressed concrete containment structure of NPP.

8.1.14 Probabilistic Seismic Hazard Analysis (PSHA) of Kalpakkam site.

Seismic risk is considered to be a major contributor in the total risk of an NPP due to external events because of the pervasive nature of earthquakes. The definition of seismic hazard constitutes an important and initiating part of a Seismic Probabilistic Safety Analysis (SPSA). The AERB guide, "Seismic studies and Design Basis Ground Motion for Nuclear Power Plant Sites", (AERB/SG/S-11) is due for revision in the near future. The guidelines for conducting Probabilistic Seismic Hazard Analysis (PSHA) for NPP sites is one of the main aspects that have to be included in the guide. In order to understand the intricacies in conducting PSHA for a region like peninsular India and for identifying approaches for resolving the possible problems to be encountered, the probabilistic seismic hazard analysis of an existing NPP site was carried out. Kalpakkam has been taken as the sample site for this work. The uniform hazard spectra developed from this study will also be useful for the seismic qualification work of FBTR.

The computer programme 'EQRISK', was used for carrying out the analysis. The computer programme was augmented by adding certain modifications were carried out in the source code of the software to incorporate provisions for generation of uniform hazard spectra corresponding to different attenuation relationships, inclusion of added dispersion in data, variability in distance measures, etc. EQRISK is under free software license considerable time was spent in understanding the source code and validating the modifications carried out.

The methodology for PSHA was developed in consultation with experts. Parametric studies of PSHA was conducted to understand the effects of dispersion of data, apportioning of seismic activity, cutoff values of sigma, minimum and maximum magnitudes of earthquakes to be considered for the analysis, etc, on the seismic hazard. Separate software was also developed to combine the results based on logic tree approach. From the analysis, it was noted that the Uniform Hazard Spectra (UHS) corresponding to a SSE level of exceedence results in higher Peak Ground Accelerator (PGA) than that derived using deterministic approach. But at higher spectral periods, the trend was reversed. UHS developed by this study has been proposed to be used during the seismic evaluation of FBTR.

8.1.15 Studies related to Tsunami

Major nuclear installations including NPPs are located along the indian coast. Determination of the probable maximum tsunami is necessary in order to work out the design basis of the nuclear facilities sited on the Indian coast. A study programme of tsunami hazard assessment for Indian code has been undertaken. The outcome of this study is expected to provide useful information for safety provisions of AERB Safety Guide AERB/SG/S-11 and AERB/SG/6-A and B. The study programme consists of the following:

- Issues related to near tsunami, propagation and inundation, especially with respect to indian coast are to be studied separately considering seismic hazard, global and local bathymetry around Indian region. The study is required for establishing relevant criteria for probable maximum tsunami (near field).

- Japan Society of Civil Engineers (JSCE) has organized recent findings and progress of technology in the form of standard assessment method for evaluation of the tsunami model for the safety assessment of nuclear power plants in Japan. An effort was made to understand critical aspects of this assessment method by JSCE and use this for tsunami hazard assessment in Indian coast.

- Numerical modeling of tsunami generation using rupture propagation during earthquake. Sensitivity studies of critical parameters affecting sea-floor deformation will be carried out.

- Tsunami propagation study for Indian Ocean region is being undertaken using 'SWAN' computer code. SWAN is a fortran computer program for solving nonlinear shallow water equations. SWAN computations can be made on a regular and a curvi-linear grid in a cartesian or spherical co-ordinate system. The initial phase of the work included collecting information on earthquake source parameters for historical tsunamigenic earthquakes and collecting world bathymetry (1min, 3 min) from publicly available resources on internet. Trial runs for tsunami propagation for Dec'2004 Sumatra earthquake were carried out for indian ocean region with 1 min bathymetry data. Mariograms (graph showing wave amplitude vs time variation) were obtained at various stations along east coast of India. Time of arrival of first wave at these stations was verified with published literature. Further simulation studies for different earthquake sources are planned for verification, before taking up tsunami hazard analysis work for NPP sites along indian coast.

8.2 SAFETY REVIEW OF NUCLEAR POWER PLANTS/PROJECTS

8.2.1 Review of PFBR Design Requirements

Specialist Group PDSC-PFBR/ SG-8 compared PFBR safety criteria, 1990 with IAEA standard on safety of NPP design (NS-R-1), 2000. Two of the main differences in the 2 set of criteria are due to (a) Non-integration of probabilistic safety assessment in the deterministic design, (b) Details of defence in depth levels. Subsequently the compliance of PFBR design with NS-R-1 criteria was evaluated. It was observed that almost all the clauses of the IAEA criteria can be complied with, prior to the plant criticality and designers have agreed to this.

8.2.2 AHWR

A document on “Safety Criteria, Objectives, Principles and Requirements for Safety in the Design of AHWR” was prepared. The document is divided into 3 sections: the first section contains the requirements that are applicable to all types of reactors (Technology-independent criteria); the second section contains the requirements applicable to AHWR; and the third section is applicable to reactors, which are of first of a kind. Risk informed safety goals, more independence in different levels of defence in depth, effective inclusion of severe accident considerations in design, concept of lines of protection and effective mitigation of severe plant conditions are some of the highlights of this document.

CHAPTER 9

SAFETY RESEARCH INSTITUTE

Research activities in the following areas are being pursued at AERB's Safety Research Institute (SRI), Kalpakkam.

- Nuclear Safety Studies.
- Reactor Physics Studies.
- Radiological Safety Studies.
- Environmental Safety Studies.

9.1 NUCLEAR SAFETY STUDIES

9.1.1 Seismic Re-evaluation of FBTR

For seismic re-evaluation of FBTR, a criteria document was developed consistent with the internationally accepted practices. This document also describes the methodology to be adopted for carrying out seismic re-evaluation and the different tasks involved in the exercise and interfaces with the different activities. Work was also undertaken to identify the frontline systems and support systems that perform safety functions in case of a seismic event. This will involve identification of (a) the safe shutdown path, (b) systems for maintaining the plant in the safe shutdown condition and decay heat removal and (c) systems to maintain containment integrity. To meet this objective, a list of 19 Initiating Events (IEs) for the functions found to be most important for seismic induced core melt was identified. The frontline and support systems that perform safety functions for each of the initiating event were also identified and the corresponding fault trees were developed based on the system functions. A total of about 90 fault trees for 19 event trees of IEs were developed as part of this activity. Further work is in progress.

9.1.2 Functional Reliability Analysis of Safety Grade Decay Heat Removal System (SGDHRS) of PFBR

As part of the PFBR level-1 PSA activity, evaluation of functional reliability analysis of SGDHRS has been carried out. A list of critical parameters with reference to initiating event groups that will have significant impact on the mission success was prepared. Sensitivity analysis was carried out for some of the parameters and these parameters were ranked according to their importance. Each of the selected parameters was assigned suitable probability distribution and ranges of variation and a functional reliability analysis of SGDHRS was carried out. Uncertainty in the parameters was assessed using 1D plant dynamics computer code, DHDYN. From a set of 50 runs of the computer code, a multi response surface for 3 important responses was constructed. A large number of Monte Carlo simulations were conducted using the response surface model to estimate the functional failure probability of SGDHRS. The probability of functional failure of SGDHRS (on natural convection) is found to be dependent on the number and duration of sodium loop availability during the initial few hours of mission of operation of SGDHRS.

The SGDHRS fails a) due to component failures in the system OR b) due to failure of forced convection AND functional failure. That is,

$$\lambda_{SGDHR\text{-}TOT} = \Sigma_i f_i * (P_{Comp,i} + P_{FUN\text{-}F,i} * P_{FC}) ,$$

where f_i is number of demands per year of type i for DHR, $P_{Comp,i}$ is the probability of failure of SGDHR due to component failures for initiating event i, and $P_{FUN\text{-}F,i}$ is the functional failure probability for initiating event of type i, P_{FC} is the failure probability of forced convection. The integrated failure frequency of SGDHRS with both functional and component failures is found to be 2.1E-7/y.

9.1.3 Development of Database on Fast Reactor Components

The development of database on failure rates for fast reactor components was continued. So far failure data have been collected for about 3000 components and stored in the database. The data is stored and retrieved from a relational database system. The application can be used to obtain a suitable failure rate for a given component specification, viz., category, group. The module to combine the operating experience with the stored data and estimation of the posterior failure data using Bayesian technique has been completed. While the security of the database is ensured, user interface is made available to retrieve component reliability information over the IGCAR intranet.

9.2 REACTOR PHYSICS STUDIES

9.2.1 PWR Physics Analysis

In continuation of the work initiated last year on the development of expertise in PWR physics analysis and fuel management strategy (taken up in collaboration with Reactor Physics Design Division (RPDD) /BARC and NPCIL), the computer code system, EXCEL & TRIHEX-FA along with 172-energy groups IAEAGX/ ENDFB6GX cross section libraries in WIMS-D format, developed at Light Water Reactor Physics Section (LWRPS), RPDD, BARC, have been acquired and commissioned at SRI. Few groups lattice database has been generated using EXCEL code for all types of fuel assemblies of KKNPP. Core physics analysis for the proposed 8 fuel cycles of KK-NPP was carried out with TRIHEX-FA code using the aforementioned lattice database. The results of the analysis include critical soluble boron concentration, 3D distribution of power, burn-up, fuel/coolant temperature, coolant density, reactivity coefficients and kinetics parameters of core average delayed neutron fraction 'β', prompt neutron mean life time 'ℓ' and the material inventory. A report on the above analysis has been prepared and circulated for expert comments.

In addition, 42 theoretical benchmark problems available in the literature related to VVER core physics, were analysed. These benchmarks have regular one region core configuration with different lattice pitch, fuel enrichments and boron concentrations in moderator/coolant. In all, there are about 300 benchmark problems, which were experimentally studied in ZR-6, clean critical zero power fuel assembly facility at Budapest in Hungary. A FORTRAN-90 program has been written to solve zero dimensional 5 group diffusion equation and to get 5 group flux values by using the homogenized 5 group cross sections which are available in EXCEL output. k-infinity, k-effective, migration area and epithermal to thermal fluxes were calculated by using these 5 group fluxes. All results are in good agreement with experimental results.

9.2.2 External Neutron Source Calculations for PFBR Start Up

The work on for estimation of the shutdown neutron count rates of external neutron source subassemblies using Monte Carlo method was continued. The aim of the work is to employ Monte Carlo Method to cross check the results obtained using deterministic calculations. The problem was modeled with MCNP and neutron count rates at the detector location with three external neutron sources of Sb-Be type (35 cm length) were calculated. The results of the study have been recorded as a design note. The calculations were revised by incorporating the atomic number densities of iron, nickel and chromium not as a single isotope, but by mixing the isotopes of each of these materials as naturally present. The revised computation showed that the neutron count rates have been reduced by about a factor of 2 as compared to the earlier estimates.

9.2.3 Criticality Safety of Stacked PFBR Fuel Sub assemblies

Criticality safety analysis was undertaken to arrive at the safe number of fresh PFBR fuel SAs that could be closely stacked and stored. A safety value of 0.9 is assumed for k-eff in the computational analysis using MCNP code. From the results, it is inferred that about 6 PFBR fuel sub-assemblies can be stacked even in water flooded condition.

9.2.4 Doppler Coefficient Benchmark Computations

Continuous-energy Monte Carlo code, MCNP along with its cross section data library in ACE format based on ENDF/B-V &VI was used to analyse a new LANL circulated computational benchmark on Doppler coefficient for different types of UO_2. Doppler coefficient has been computed by calculating the Eigen values of some selected idealized PWR fuel pin cell configurations with 7 different fuel enrichments of UO_2. Even though the benchmark contained configurations for different kinds of mixed oxide fuel configurations, the same could not be analyzed for evaluating the doppler coefficient due to lack of nuclear data for some of the isotopes. The pin cell configuration is modeled in 3-D geometry by assuming an infinite dimension instead of reflecting boundary conditions in the axial direction and reflective boundary conditions are assumed on all other four sides of the pin cell. Doppler coefficients for all the UO_2 cases are estimated using two different cross-section sets: Case-I based on ENDF/B-VI and case II based on ENDF/B-V. In Case-I, fuel temperature changes from 600° K Hot Zero Power (HZP) to 900° K Hot Full Power (HFP) but in case-II due to lack of data in the MCNP data library, fuel temperature change assumed is from 587° K HZP to 881° K HFP. The maximum decrease in reactivity (doppler defect) in going from HZP to HFP is found to be 1233 pcm for case-I and 1374 pcm for case-II. These maximum reactivity changes are observed for natural enrichment of UO_2.

9.2.5 SCALE (Standard Computer Analyses for Licensing Evaluation) computer code added to SRI Code Depository

The SCALE computer code version 5 was procured from ORNL, USA and added to SRI computer code depository. The code has been commissioned and is being used for the KK-NPP core physics and fuel burn-up computations.

9.3 RADIOLOGICAL SAFETY STUDIES

9.3.1 Photo Neutron Flux and Dose Rate Estimations for ThO_2 Bundle Immersed in D_2O

Photo neutron flux dose rate calculations for Thoria (ThO_2) bundle consisting of nineteen pins with Zircaloy clad were done using MCNP code. This was undertaken in collaboration with RPDD, BARC to quantify the photo neutron flux as well as dose rate for the situation when the bundle gets completely immersed in a cylindrical heavy water pool of radius 165 cm and height 200 cm. The assignment has application in AHWR neutron flux calculations.

The photon emitted by Tl^{208} isotope formed in the decay chain of Th^{232} is cause for the production of photo-neutrons in heavy water. The source term of Tl^{208} isotope formed in the Thoria bundle under study (year of manufacture 1984) has been estimated using ORIGEN-S code and is found to be 1.57×10^7 photons/sec. Total gamma dose rate on the surface has been found to be 580 μGy/h.

9.3.2 Graphical User Interface for TRIHEX-FA Computation

Graphical User Interface (GUI) is developed to display the LWR physics analysis results from TRIHEX-FA calculations. Provision to compare the core follow-up simulation results of KK-NPP against the Russian supplied results is made available through the interface (Fig.9.1).

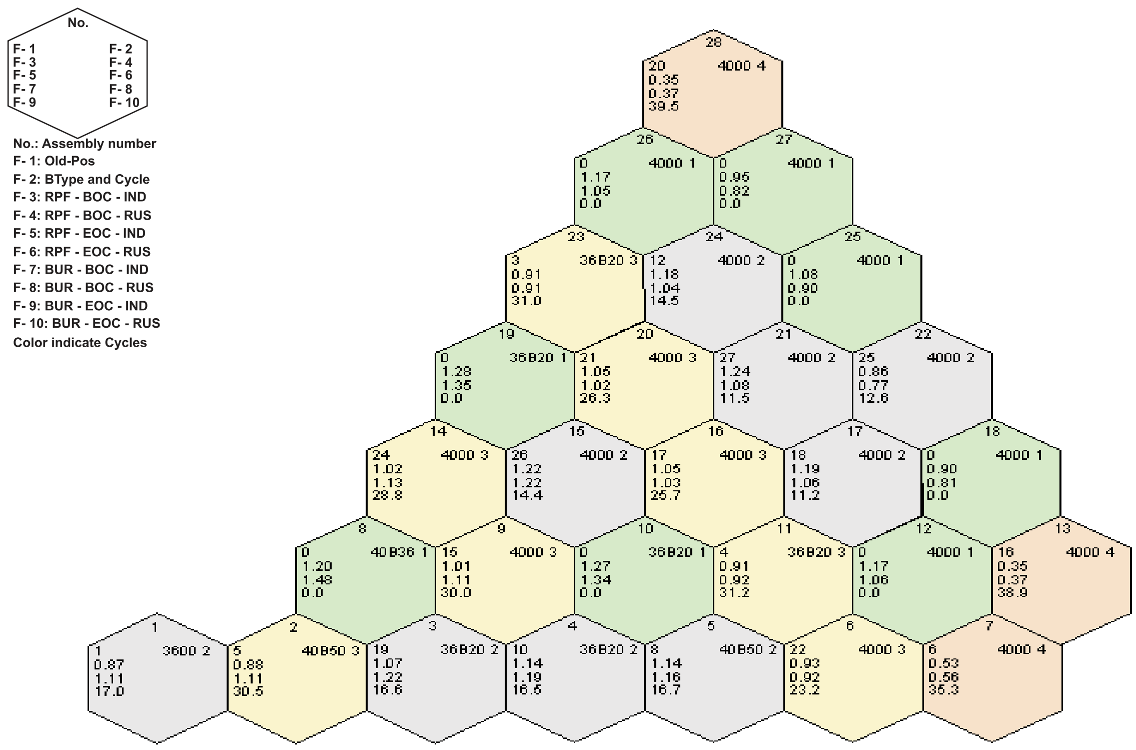


Fig. 9.1: A Sample Comparison of Core Follow-up Simulation of KK NPP for Cycle-8 obtained using GUI-TRIHEX-FA

9.4 ENVIRONMENTAL SAFETY STUDIES

9.4.1 RS-GIS Studies

9.4.1.1 Mapping of Surface Water Bodies around Kalpakkam Area

To arrive at accurate information on area under surface water bodies in the study area about 30 km radial zone from MAPS, it is proposed to carry out a detailed mapping using Survey of India (SOI) toposheets and satellite images (SOI toposheets published in 1972, satellite data of 2001 (IRS 1D LISS 3 + PAN merged) and satellite data of 2006 (IRS P6 LISS 3).

During the year 2005, the entire state of Tamil Nadu received good rainfall from the northeast monsoon and the Kanchipuram district received 1471 mm rainfall. Hence, it was decided to ascertain the status of the surface water bodies in comparison with the data provided in SOI toposheets (1972). Accordingly, the satellite data of 2006 (IRS P6 LISS 3) was used to delineate the aerial extent of the surface water bodies and compared with SOI toposheets-1972 (Fig. 9.2), and assess any impact on the extent of surface water bodies due to various man-made activities.

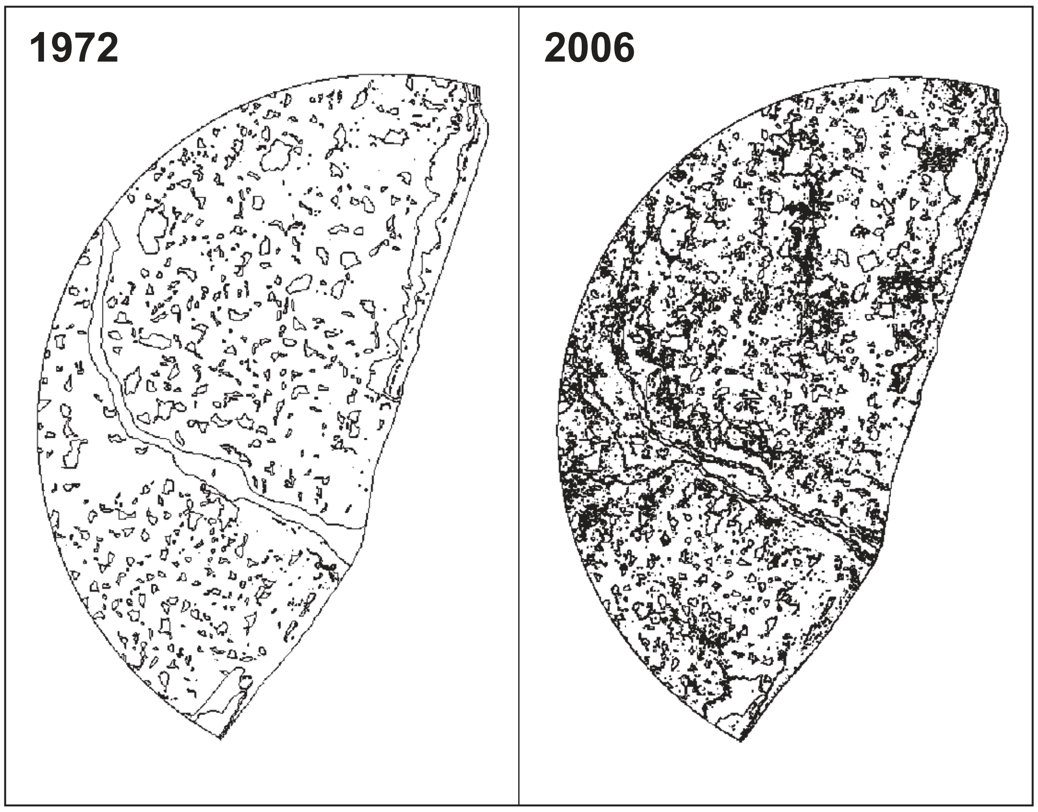


Fig. 9.2: Aerial Extents of Water Bodies in the year 1972 and 2006

Changes in the land use/ land cover of the surface water bodies were also studied for the above period. The likely causes have been identified using satellite data. By comparing the data on surface waiter bodies during 1972 and 2006 the changes were identified and shown for a typical example in Fig. 9.3.

Fig. 9.3: Changes in the Water Bodies due to Developmental Activities

From the above study it was observed that during the year 2006 the area of surface water bodies (239.32 sq.km) derived from IRS P6 L3 satellite, 2006 compared well with the area of the water bodies (233.37 sq.km) shown in the Survey of India topo sheets, 1972. The agreement is well within the limits and marginal increase could be due to submerging of low-lying areas.

Changes in land use/land cover in the aerial extent of water bodies have been evaluated and the likely causes have also been identified. In all about 15.12% of area of water bodies was lost due to human activities during this period. The specific impacts on water bodies are provided below:

- Due to additional natural vegetation cover 3.09 sq.km (1.33%)
- Due to developmental activities 0.68 sq.km (0.29%)
- Due to additional farming 2.95 sq.km (1.26%)
- Due to aquaculture farms 28.56 sq.km (12.24%)

From the above study it was deduced that there is no major change in the area under water bodies due to the commissioning of the MAPS or other developmental activities in the area since 1972.

9.4.1.2 Development of Decision Making Tools in GIS Environment for Emergency Response System for NPPs

A work on decision-making tools for emergency response system for NPPs was taken up. Under this, a user-friendly query was built on plume dispersion pattern using AML (Arc Macro Language) program in GIS platform.

GUI based user interface tool for emergency response system was created to display the probable path of plume direction with other socio-economic details such as population, data on live stock, data on water bodies with the background of satellite imageries.

A typical plume pop-up window is shown in Fig. 9.4. Further work is in progress.

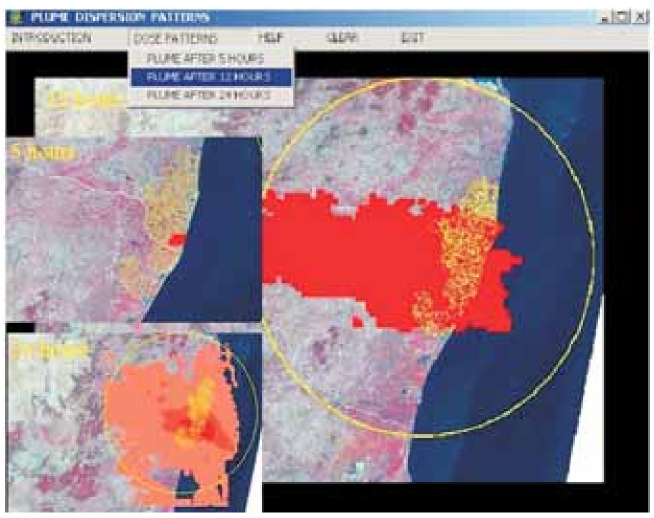


Fig. 9.4: Typical Plume Pattern

9.4.2 Hydro Geological Investigations at Kalpakkam

The water table fluctuations for the entire year was measured in 15 observation borewells in the entire study area. The groundwater samples were collected for analysis for major ions. Rainfall is the only source of recharge, which is noted from immediate response of water table with respect to season.

9.4.2.1 Geophysical Survey

The resistivity survey is a geophysical technique to interpret the lithological boundaries (aquifer characterisation) from the resistivity variations with respect to depth. The suvey was carried out in 5 different stations. The resistivity survey indicates that the area is characterised by three distinct litho units at profile station 1 (Fig. 9.5) viz. sandy layer with clay pockets (4 m thickness) overlying weathered and fractured rock of thickness 11 m. This weathered and fractured layer is underlined by massive charnockite beyond 15 m.

Fig. 9.5: Subsurface Characterization Based on Resistivity Survey (not to scale)

9.4.2.2 Ground Water Chemistry

The pH, temperature, Electrical Conductance (EC), salinity and total dissolved solids (TDS) were measured insitu using portable borewell logger (Multi probe system, YSI 556 MPS). The collected samples were analyzed in the laboratory for Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^{2-} (titration); Na^+ (Flame photometry); Cl^-, NO_3^- and SO_4^{2-} (Spectrophotometry and Ion-Chromatography). The groundwater chemistry data is presented in Table 9.1 below. The chemical analysis of the water samples has indicated that the most dominant ions include Magnesium (Mg^{2+}), Sodium (Na^+), Chloride (Cl^-), Sulfate (SO_4^{2-}) and Nitrate (NO_3^-).

The Piper trilinear diagram, plotted to classify the groundwater revealed that the ground water of Kalpakkam site is of Na - $Cl+SO_4^{2-}$ type and Na - $CO_3^{2-}+HCO_3^{2}$ type. Bore well samples BW3, BW4, BW5, BW9 and PBW9 are categorized under Carbonate-Bicarbonate type. The BW6, BW7& BW8 which lie closer to Buckingham canal and the PBW1, PBW2, PBW3 & PBW4 lying closer to Bay of Bengal fall under Chloride type. The presence of higher concentration of Magnesium than Calcium in the areas of high chloride levels present in the close vicinity of Buckingham canal and Bay of Bengal suggests the saline water incursion (Fig. 9.6).

Table 9.1: Ground Water Characterization

Parameter	pH	TDS	EC ms/cm	Ca^{2+} ppm	Mg^{2+} ppm	Na^+ ppm	CO_3^{2-} ppm	HCO_3^{2-} ppm	Cl^- ppm	NO_3^- ppm	SO_4^{2-} ppm
Minimum	7.1	116	200	0.99	0.5	20	0.5	25	20	0.4	0.5
Maximum	8.7	11850	20533	35	99	5844	33	606	5720	286	1854
Mean	7.7	2012	3489	14	13	1026	11	259	751	113	219
Std. Dev.	0.3	3060	5322	11.03	24	1604	14	197	1479	72	475

Fig. 9.6: Piper Trilinear Plot

9.4.2.3 Ground Water Corrosiveness

For the better understanding of ground water corrosive nature of Kalpakkam region, the corrosivity indices like Langeliar Saturation Index (SI), Aggressivity Index (AI) and Larson Ratio (LnR) were employed. According to the above corrosive indices, the groundwaters of southern part of the study area are of highly corrosive in nature (Fig.9.7). Presence of higher concentrations of Chloride (Cl^-) and Sulphate (SO_4^{2-}) makes the groundwater more corrosive. The saline water incursion along the seacoast and Buckingham canal could be source of supply of these ions into the groundwater system. The study shows that proper precautionary steps have to be taken during sub-surface civil constructions particularly in the southern part of the study area.

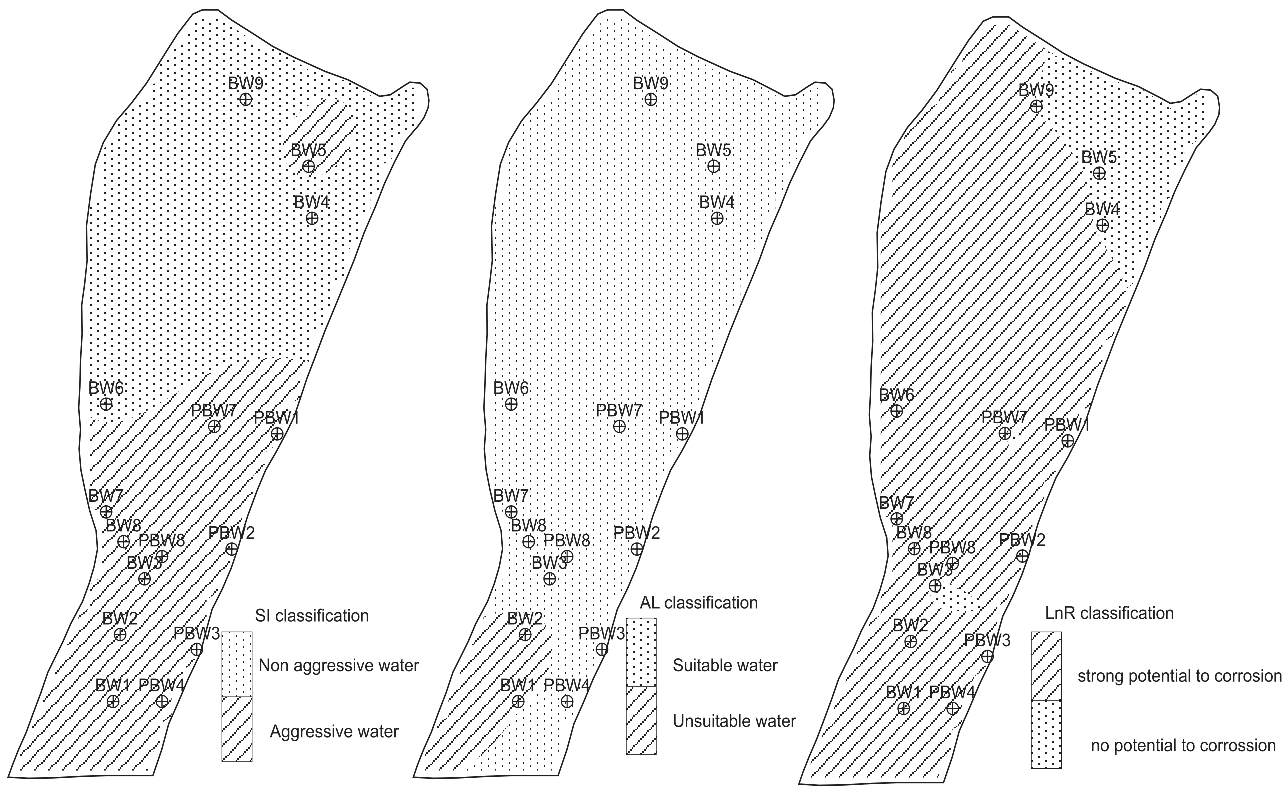


Fig. 9.7: Ground Water Classification Based on Corrosive Indices

9.4.3 Environmental Impact of Power Plant Chlorination on Entrained Plankton

The prime objective of the present study is to understand the effect of chlorinated effluents on entrained plankton near the discharge zone of a coastal power plant, MAPS. Field samples have been collected from Intake point, Pump House, Condenser Cooling Water Pump (CCWP) outlet and Process Sea Water Pump (PSWP) outlet and Mixing Point for a period of 20 months and analyzed for total residual oxidants, phytoplankton biomass and chlorination byproducts. Further laboratory studies have been carried out with 4 marine diatoms namely, Amphora coffeaformis, Amphiprora palludosa, Cocconies scutellum and Chaetoceros wighami to understand the effect of various concentration of chlorine on the cell count, chlorophyll levels and primary productivity of the diatoms.

In continuation of the previous studies, experiments were done using confocal laser scanning microscope and image analysis to find the effect of chlorine in the fluorescence intensity of chlorophyll, the experiment has been completed for only one diatom so far. To understand the decay of chlorine with temperature and time, an experiment was designed and the results are presented below. Further experiments were done to study the role of chlorine in the formation of trihalomethane.

9.4.3.1 Chlorine in Trihalomethane Formation

Seawater was dosed with different concentrations of chlorine (1-10 mg/L). The samples were extracted using n-Hexane and analyzed using for trihalomethane (THM) formation. Samples were analyzed for every half–an–hour up to 120 h based on the chlorine doses given. The dominant THM compound formed was Bromoform. The other compound that was formed was Dibromochloromethane. As the chlorine concentration increased, the other 2 compounds namely Monobromodichloromethane and Chloroform were also identified. The decay of THM was also studied. It was observed that Bromoform was persistent and depended on the chlorine dose.

9.4.3.2 Assessment of Chlorine Toxicity to Marine Diatom using Confocal Laser Scanning Microscopy (CLSM)

The effect of chlorination on Amphiprora palludosa was studied. It was subjected to three different doses of chlorine. CLSM was used for collecting cell chlorophyll fluorescence using standard image capturing techniques and the mean fluorescence intensity (MFI) was measured using image analysis software (NIH image). The MFI decreased to 61 % and 57 % in comparison to control for 2 and 3 mgL^{-1} respectively after 1 h exposure to chlorine (Fig. 9.8a, 9.8b & 9.8c). MFI analysis for images collected in cells incubated for 18 h after chlorination did not show any recovery.

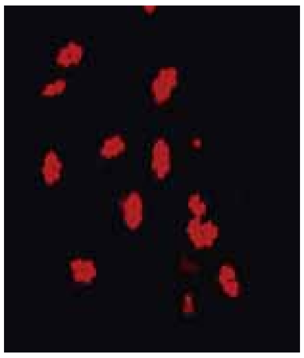


Fig 9.8a

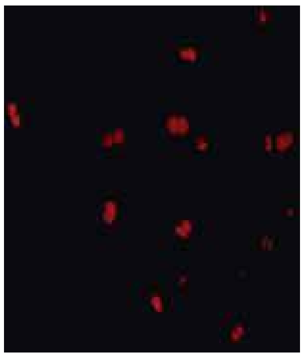


Fig 9.8b

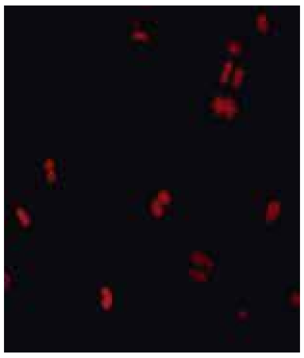


Fig 9.8c

Fig 9.8 Mean Fluorescence Intensity for 3 Different Doses of Chlorine on Amphiprora Palludosa

CHAPTER 10

PUBLIC INFORMATION

10.1 PRESS RELEASES

AERB periodically issues press releases in English and Hindi to keep the public informed about important regulatory activities. Press releases were issued on the following topics during the year.

- AERB obtained the ISO 9001:2000 Certification from the BIS and the certificate was handed over to Shri S. K. Sharma, Chairman, AERB by Shri A.S. Basu, Deputy Director General, BIS on November 15, 2006.

- A 7-member delegation of the USNRC led by USNRC Commissioner Peter B. Lyons visited the Indian AERB during March 27 to April 4, 2006 under the on-going nuclear safety co-operation programme between the two regulatory bodies. Extensive discussions were held on topics of the severe accident analysis and management, digital control and instrumentation and on planning future work on some standard problem exercises.

- A 9-member delegation of AERB led by Shri S.K. Chande, Vice Chairman, AERB visited the USNRC, Washington, DC during January 8-16, 2007 under the on-going Nuclear Safety Cooperation Program between the two bodies. Extensive discussions were held on the topics of digital system reliability, new control room designs and proactive material degradation programmes.

- AERB accorded clearance on 25 February 2007 for first criticality of KGS-3 located in Karwar district of Karnataka. KGS-1&2 are already in operation at this site for the last 6 years. KGS-4 is in advanced stage of construction. Each of these units is of 220 MWe capacity.

- AERB presents industrial safety awards to the DAE units every year whose performance in industrial safety area is of a high order. The industrial safety awards presentation function of AERB for 2006 was held on March 6, 2007. Shri J. Ganguly, Executive Vice President from M/s Larsen & Toubro Ltd., Chennai, presented the safety awards for 2006 to BHAVINI, Kalpakkam in construction group, NAPS, Narora, RAPS-3&4, Rawatbhatata, HWP, Tuticorin and IREL-Thorium Plant, Chatrapur in production units group.

- The 8th meeting of the INSAG was hosted by AERB during 12th to 16th March 2007 in Mumbai. The INSAG is a group of experts with high professional competence in the field of nuclear safety, working in regulatory organizations, research and academic institutions and the nuclear industry. INSAG provides recommendations and opinions on current and emerging nuclear safety issues to the IAEA, the nuclear community and the public. The members of INSAG are from Canada, China, Finland, France, Germany, Hungary, India, Japan, Republic of Korea, Russian Federation, South Africa, Spain, United Kingdom and United States of America.

10.2 AERB NEWS LETTER

AERB News Letter covers AERB press releases, important national and international news, safety reviews of plants / projects and permissions issued to nuclear and radiation facilities, activities related to training, workshops, colloquia, seminars, symposiums, etc., The News Letter regularly carries experts' views regarding safety of nuclear and radiation facilities. AERB News Letters Vol. 19 No.1- 3 was published in Hindi and English during the year 2006. A home page covering new appointments, retirements, AERB staff club activities, obituaries, etc., has also been included in the News Letter.

10.3 ANNUAL REPORT

Annual Report of AERB brings out the details of works carried out in various divisions of AERB during every financial year. The report is widely circulated to all the units and PSUs under the DAE, Nuclear Regulatory Agencies of other countries, IAEA, premier educational and research institutions in India, RSOs of various hospitals and nuclear installations, news papers and news agencies in India, ex-members and Chairmen of AERB, Ex-Directors and Ex-Heads of the divisions of AERB. The report is published in English as well as in Hindi.

10.4 INTERACTION WITH MEDIA

Queries raised by press are replied on phone as well as during press meets by the senior officers of AERB. During the year, number of queries on topics like AERB collaboration with USNRC and other regulatory bodies, KGS-3 fuel loading and criticality, industrial safety awards, loss of radiation sources and radiation processing of food items came from press and were replied. Such information is often published in the daily newspapers. During this year, a press meet was organized on the occasion of INSAG meeting in Mumbai and the members of INSAG responded to various questions from the media representatives.

10.5 RIGHT TO INFORMATION ACT-2005

Required measures were taken on implementation of 'Right to Information (RTI)' Act in AERB and the required information has been put on AERB website. Seven queries were received from various applicants under RTI Act and they were replied appropriately in time. The link is being established with Central Information Commission (CIC) site so that on-line information is available to CIC about the implementation of RTI act in AERB. Public Information Officer (PIO) and Assistant Public Information Officer (APIO) attended the workshop on RTI organized by ISTM, New Delhi. To bring awareness about RTI among the AERB personnel, an AERB colloquium was organized on "Right to Information Act-2005" by APIO, AERB bringing out the objectives, concept and methodology of the implementation.

10.6 AERB WEBSITE

AERB as part of its policy of public information has been putting information relevant to public and utilities on its website. The information related to radiation installations for use of radiation in medicine, industry and research for societal benefits and beach sand mining units has been put in website. The information includes the applicable acts, codes and rules, regulatory forms related to issuance of licenses, authorizations, registration and consent and other information related to AERB.

CHAPTER 11

INTERNATIONAL COOPERATION

11.1 AERB – USNRC NUCLEAR SAFETY COOPERATION PROGRAM

The nuclear safety co-operation between AERB and USNRC was resumed in February 2003. A total of 7 meetings took place between the two regulatory bodies during the years 2003 to 2006; the meetings are being held alternatively in India and USA every year. The objective of these meetings continues to be furthering the dialogue on nuclear safety between Indian and US Governments.

The 8th discussion meeting under the Program was held at the USNRC Headquarters, in Rockville, Maryland from January 8 – 16, 2007. The Indian delegation, consisting of members from AERB, BARC and NPCIL and one member from Indian Embassy in Washington, D.C. was led by Shri S.K. Chande, Vice Chairman, AERB. A total of 41 delegates, led by Mr. James Edward Lyons, Director Division of Site and Environmental Reviews, office of New Reactors participated from USNRC. The two AERB engineers deputed in USNRC also attended the meeting. The topics covered in the meeting were: Digital Systems Reliability and New Control Room Designs, Experience in Construction of New Nuclear Power Plants, Flow Accelerated Corrosion and Erosion-Corrosion in Primary and Secondary Systems and Proactive Materials Degradation Study Programs. The Status of work done on Standard Problem Exercise on Containment Performance Under Severe Accident Conditions, Severe Accident Analysis Exercise utilizing TMI-2 data and Thermal Hydraulics Exercise utilizing data from the PANDA Test Facility was discussed.

NRC and AERB participants agreed that the ongoing cooperation is helping in improving understanding of issues relating to safety of NPPs in both the countries. It was agreed that the following topics are for ongoing areas of cooperation.

- New Reactor Designs (LWRs) (e.g., technical basis for certification for a design, models/ reviews/technology-independent safety criteria, experimental work for developing enabling technologies for advanced reactor designs and reliability evaluation of passive safety systems).
- PRA Methods and Applications (including seismic evaluations)/ Severe Accident Analysis & Management (for both operating reactors and new designs).
- Proactive Materials Degradation Programs (including concrete aging and temperature effects).
- Digital Systems (both hardware/software) Reliability and Qualification (including control room designs and operator support systems).
- Experience in License Extension and up-rating of Old Plants and Development of Operating Procedures for Management of Severe Accidents.
- Operating Experience Feedback in India and the U.S.

Safety criteria for High Temperature Reactors (HTRs) and Strategies for Knowledge Preservation may be considered at a later date. The work on the standard problems will continue.

It was decided that next AERB-USNRC Meeting will be held in Mumbai in last quarter of 2007 and involve a three day seminar covering the topics of interest including Advanced Reactors and Digital Instrumentation and Control Systems, and a 2 day workshop covering the 3 standard problem exercises now underway.

After the meeting, AERB delegation visited the Pilgrim Nuclear Power Station in Plymouth, Massachusetts and held technical discussions and toured research facilities at Massachusetts Institute of Technology, Boston.

As part of this cooperation programs, USNRC is hosting 2 young AERB engineers at its head office in Washington D.C. for a period of 1 year starting from July 2006.

11.2 OTHER COOPERATIVE ACTIVITIES

AERB also has nuclear safety cooperative programme with ASN; the French Regulatory Body. Under this co-operation, a French delegation of 5 members headed by Mr. Andre Claude Lacoste, Director General, ASN visited AERB on October 25, 2005. Presentations were made and discussions were held on topics like Flooding Events, Safety and Leak Tests of Pre-stressed Concrete Containments, and Safety and Transport of Radioactive Materials. A Seminar under Nuclear Safety Cooperation between AERB and ASN is planned during May 8-10, 2007 covering the topics of licensing process of new projects, EPR design assessment, severe accident management and instrumentation and control system.

AERB also has co-operative activities with the Regulatory Body of the Russian Federation. A workshop on information exchange on nuclear safety was held between Rostekhnadzor, the Russian Regulatory Body and AERB, during February 2005 in Mumbai. During this workshop, nuclear safety topics related to VVER-1000 reactors were discussed (Two VVER units of 1000 MWe each are presently under construction at Kudankulam in Tamil Nadu with Russian assistance). India has also joined the WWER Senior Regulators Forum in which operating and other experiences of countries operating/constructing Pressurized Water Reactors are discussed annually.

In addition to the bilateral co-operation activities AERB also participates in several activities of the IAEA. These include IRS, INES based reporting of events, Commission on Safety Standards (CSS), INSAG and the work related to development of Safety Standards, Coordinated Research Programmes (CRP), Conduct of Training Workshops and Technical Meetings, etc. AERB also participates in the IAEA annual meetings of Senior Regulators of countries Operating CANDU type Nuclear Reactors.

11.3 IAEA COORDINATED RESEARCH PROGRAM

AERB has completed the IAEA sponsored CRP on 'Safety Significance of Near Field Earthquakes'. The CRP was based on a number of shake table tests conducted on the scaled down model of a concrete wall as part of CAMUS experiments between 1996 and 1998 in the CEA facilities in Saclay, France. The main aim of the CRP was to understand the applicability of the recent engineering practices developed for evaluating the seismic vulnerability of the non-nuclear facilities in the seismic safety assessment of nuclear facilities with respect to the effects of near field earthquakes. About 20 institutions from different countries were actively involved in the exercise. Apart from linear analysis, CRP required the participants to perform displacement-based methods as well as non-linear time history analyses of the test specimens.

Based on the study, it was concluded that the seismic response of structures predicted by deflection based method agrees reasonably well with experimental values for both far field and near field input motions. The matching is good in case of overall performance of the structure like top displacement. On the other hand, agreement is poor in case of localized behavior like strain. The method can be adopted with reasonable confidence in seismic qualification as well as reevaluation of structures, systems and components of NPP.

11.4 INSAG MEETING HOSTED BY AERB IN MUMBAI

The 8th meeting of the INSAG of IAEA was hosted by AERB during 12th to 16th March 2007 in Mumbai. The INSAG is a group of experts with high professional competence in the field of nuclear safety, working in regulatory organisations, research and academic institutions and the nuclear industry. INSAG provides recommendations and opinions on current and emerging nuclear safety issues to the IAEA, the nuclear community and the public. The members of the current INSAG are from Canada, China, Finland, France, Germany, Hungary, India, Japan, Republic of Korea, Russian Federation, South Africa, Spain, United Kingdom, United States of America and the OECD/NEA.

Presently Shri S.K. Sharma, Chairman, AERB is the member of INSAG from India. Before him, Dr. Anil Kakodkar, Chairman, AEC was the member of INSAG from India.

Apart from the intensive meetings on 3 days, the INSAG delegates visited TAPS and BARC. In BARC, INSAG Chairman, Dr. Richard Meserve, Dr. Taniguchi, Deputy Director General, Dept. of Nuclear Safety and Security IAEA and Dr. Carlos Alejaldre, Deputy Director General of ITER delivered technical talks under a special Trombay Colloquium on 'The Nuclear Renaissance', 'Global Partnership for Nuclear Safety and Security' and 'International Thermonuclear Experiment Reactor (ITER)' respectively. A Press Meet was also organized at BARC on 15th March 2007.

Inauguration of INSAG Meeting in Progress

(Sitting from L to R in the centre : Dr. Richard Meserve , Chairman, INSAG, Dr. Anil Kakodkar, Chairman, AEC & Secretary, DAE, Shri S.K. Sharma, Chairman, AERB and Dr. Taniguchi, IAEA)

An INSAG seminar on "International Developments in Nuclear Power Technology" was organized. The following presentations were made by seven INSAG members:

1. "OECD/NEA: The Way Forward" by Mr. Luis Echavarri, Director General, OECD/NEA.
2. "Experiences from Licensing and Construction of EPR Type Nuclear Power Plant in Finland" by Mr. J. Laaksonen, Director General, Radiation & Nuclear Safety Authority, Finland.
3. "PAKS Fuel Damage Incident" by Mr. J. Ronaky, Director General, Hungarian Atomic Energy Authority, Hungary.
4. "APR – 1400 and SMART for Near Term Deployment in Korea" by Mr. C.S. Kang, Professor, Department of Nuclear Engineering, Seoul National University, Republic of Korea.
5. "Licensing of the Pebble Bed Modular Reactor (PBMR) in South Africa" & "Safety Goals in Nuclear Power Plants" by Mr. Tim Hill, Manager, Koeberg Programme, Nuclear Regulatory Authority, South Africa.
6. "Experience and Further Development of the WWER Technology" by Mr. V.G. Asmolov, Deputy Director General Russia.
7. "The Advanced CANDU Reactor" by Dr. David F. Torgerson, Senior Vice President and Chief Technology Officer, AECL,Canada.

The INSAG meeting provided good opportunity to indian nuclear scientists and engineers to interact with this group of international experts.

CHAPTER 12

HUMAN RESOURCE DEVELOPMENT

12.1 MANPOWER AUGMENTATION

AERB manpower is being augmented at various levels and through various channels taking into consideration the expanding nuclear power programme and increasing use of radiation for the societal benefits. This is being done through fresh recruitments, transfer of experienced personnel from operating plants and R&D institutes like BARC and IGCAR and induction of postgraduates through AERB Graduate Fellowship scheme (AGFS) in IIT Bombay and IIT Madras. During the year, the following manpower was inducted in AERB.

- Two students sponsored in AGFS for M. Tech in 2004 joined AERB in August 2006.
- Four officers, 2 each from training school of BARC and NPCIL, joined AERB in September 2006.
- Five officers joined AERB through inter-unit transfer; one from BRIT and four from BARC.
- Nine staff members joined through direct recruitment.
- One student in each in IIT-Madras and IIT-Bombay were sponsored for M. Tech. in 2006. These students will join AERB in August 2008. Two students in each of these IITs are planned to be selected for the academic year 2007-2008.
- Seven engineers with required experience and educational qualifications have been selected at senior levels from the Indian industry. They are likely to join AERB in April-May 2007.
- As on 31st March 2007, the total personnel in AERB are 189 comprising 147 scientific and technical and 42 supportive staff.

12.2 MANPOWER TRAINING AND QUALIFICATION IMPROVEMENT

12.2.1 Continued Education Programme (CEP)

Eight technical personnel from AERB attended the CEP conducted by Human Resource Development Division (HRDD) of BARC and cleared the examinations in the following topics.

- Seismic Design of Nuclear Reactors and Facilities.
- Preparedness and Response to Nuclear Emergencies.
- Structural Integrity Assessment Methods.
- Programming Languages.

12.2.2 Orientation Course for DAE Graduate Fellowship Scheme (DGFS) Fellows

Five AERB engineers are undergoing training in TAPP-3&4. Two engineers, selected under AGFS, underwent training in Orientation Course for DGFS Fellows (OCDF) in HRDD of BARC.

12.2.3 Nuclear Training Centres (NTC) of NPCIL

Six engineers are undergoing 'On Job Training' (OJT) in NTC at Tarapur and 1 engineer is undergoing training at Kalpakkam.

12.2.4 Qualification Improvement

AERB Staff is encouraged to acquire higher educational qualification while in service. One officer from ITSD continued Ph.D. programme with University of Mumbai; one officer from ITSD enrolled for M.Sc Degree in Computer Sciences with University of Mumbai. Two M. Tech Students have enrolled for Ph.D. Programme in IIT Bombay and IIT Madras.

12.3 REFRESHER COURSES

Refresher Courses were organized on VVER reactors covering the topics: VVER Design, RB Layout, Special Safety Systems, Redundancy Principle, Comparison of VVER-1000 and PHWR, VVER Core, Fuel System Design, etc.

Refresher Courses were also organized involving a series of lectures on various aspects of 'Fast Breeder Reactor Technology and Engineering of PFBR'.

In-house faculty from AERB, faculty from NPCIL and IGCAR delivered the lectures. The staff from AERB, NPCIL and BARC attended the courses.

12.4 DEPUTATION ABROAD

- One officer worked for 1 year in University of Pisa on 'Uncertainty Analysis of Thermal Hydraulic Safety Studies'.
- Two officers are deputed to USNRC, Washington D.C. for one year with effect from July 2006 and are working on Nuclear Reactor Regulation, Probabilistic Risk Assessment Licensing and Nuclear Regulatory Research in Probability Risk Assessment (PRA) Support Branch.
- One officer is working on 'Simulation of Radionuclides Migration through Bentonite-Sand Backfill in a Geometrical Centrifuge' in Japan under the fellowship of Japan Society for Promotion of Science.
- Many AERB officers went on deputation abroad for short periods to attend IAEA meetings, seminars and conferences.

12.5 AERB COLLOQUIA

Following colloquia were organized.

- 'Surveillance Requirements and Safety Issues for RPV of VVERs' by Dr. Milan Brumovsky from Czech Republic. The talk addressed several salient aspects on material behaviour and testing, corrosion properties, structural integrity, material and component ageing including radiation damage, ageing management, plant life management, component lifetime evaluation etc.
- An Awareness Pogram on 'ISO: 9001-2000' in connection with ISO: 9001-2000 certification for AERB by Shri Ram Prasad, IPSD, AERB. In this talk, important aspects like the concepts of Quality Management System, its applicability to AERB, documentation and implementation requirements of ISO, etc were addressed.
- 'Technology Independent Safety Criteria for Indian NPPs based on New Designs' by Dr. S.K. Gupta, Director, SADD, AERB. The requirements for new design reactors like enhanced defence-in-depth, emphasis on inherent safety characteristics, R&D support, etc. were addressed.
- 'Right to Information Act-2005' by Shri A. Ramakrishna, ITSD, AERB. The talk covered various aspects like background of Right to Information Act-2005, concept, objectives, processing of the applications under RTI, appeals under RTI and the implementation etc.

12.6 KNOWLEDGE MANAGEMENT

Storage and Retrieval

In AERB, a 'Knowledge Portal' has been opened at the internal website of AERB, as part of knowledge preservation and easy retrieval. Training/teaching material, proceedings of conferences and seminars, papers presented/ published by AERB personnel and management information system are being posted on the portal. National and international Codes/Guides/Manuals are also being posted on the portal.

12.7 TRAINING PROGRAMME ON 'AERB CODES AND GUIDES'

AERB conducted training programme on 'AERB Codes and Guides' at Nuclear Training Centre, RAPS, Kota for the senior technical staff from operation and maintenance from RAPS-1 to 6 units. Following topics were covered under the Training Programme.

- AERB Safety Codes / Guides / Manuals.
- Core Management and Fuel Handling in PHWRS and BWRS (SG/O-10A&B).
- Life Management and Renewal of Authorisation (SG/ O-14&O-12).
- Radiation Protection During Operation of NPPS (SG/ O-5).
- Operational Safety Experience Feedback (SG/O-13).
- Regulatory Inspection of NPPs (SG / G-4 and SM-1).
- Core Reactivity Control in PHWRs (SG/D-7).
- Preparedness of Operating Organisation for Handling Emergencies at NPPS (SG/O-6).
- AERB Operation Safety Code (SC/O).

CHAPTER 13

SAFETY PROMOTIONAL ACTIVITIES

13.1 SAFETY RESEARCH PROGRAMME

One of the objectives of the AERB is to promote safety research and related activities relevant to safety and regulatory work. For this, a Committee for Safety Research Programmes (CSRP) has been constituted to frame rules, regulations and guidelines and to evaluate, recommend and monitor the research projects. The committee also recommends financial assistance to universities, research organizations and professional associations for holding symposia and conferences of interest to AERB after scrutinizing the applications. The CSRP met 3 times during the year.

During the year, the committee deliberated on 11 new project proposals and recommended grant-in-aid for 6 new projects as given in Table 13.1. It also approved the renewal of 6 ongoing projects as given in Table 13.2. In addition, financial support was provided to 27 seminars, symposia and conferences.

Table 13.1: New Research Projects Approved

Sr. No.	Project Title	Principal Investigator	Institution
1.	Temperature Prediction of the Thermowell in the Core Temperature Monitoring System of FBTR	Dr. A. Mukhopadhyay	Jadavpur University, Kolkata.
2.	Evaluation of Patient Specific Doses for Optimised X-ray Diagnostic Imaging Systems in a Rural Setup	Dr. M.R. Raju	International Cancer Centre, Bhimavaram, AP
3.	Investigations on Instabilities and Nonlinear Dynamics of AHWR	Dr. Manmohan Pandey	IIT-Guwahati
4.	Impact of Power Plant Entrainment on Zooplankton: Assessment of Thermal & Chemical Stress Effects on Copepods	Dr. K. Altaff	The New College, Chennai
5.	Development of a 3-D Space-Time Kinetics Model for the Analysis of Light Water Reactors	Prof. J.B. Doshi	IIT-Bombay, Mumbai
6.	Transfer Coefficient of Radiostrontium (^{90}Sr) in Food Crops	Dr. A. Raja Rajan	Tamil Nadu Agricultural University Coimbatore

Table 13.2: Research Projects Renewed

Sr. No.	Project Title	Principal Investigator	Institution
1.	Developing Tissue Equivalent TLD Materials for Personnel Monitoring	Dr S.K. Omanwar	Amravati University, Amravati
2.	Durability of High Performance Concrete in Indian Conditions	Prof S. Saraswati	Jadavpur University, Kolkata
3.	Prediction of Oceanic Dispersion of Radionuclides released from MAPS into Coastal Waters of Kalpakkam	Dr. Usha Natesan	Anna University, Chennai
4.	Development of Novel Polymeric Nuclear Track Detectors	Dr. V.S. Nadkarni	Goa University, Goa
5.	Simulation of Spontaneous Growth and Arrest in Rate-dependent Structural Steels used in Nuclear Containment Vessels and Steam Pipelines	Dr. D.V. Kubair	IISc., Bangalore
6.	Investigation on the Role of Computerised Radiography with Photostimulable Phosphor Plates for Portal Imaging and QA in Radiation Therapy	Dr. B. Paul Ravindran	CMCH, Vellore

13.2 WORKSHOPS/SEMINARS PROGRAMME

13.2.1 Workshop on Containment Structures of Indian Nuclear Power Plants

AERB organized a workshop on "Containment Structures of Indian Nuclear Power Plants" on 18th August 2006 in AERB with the objective of discussing various aspects of containment structures of indian NPPs. Around 108 delegates from NPCIL, BARC, Consultants and AERB participated in the workshop.

The presentations covered the aspects like design and construction, regulatory requirements, operating experience, safety status of containment structures and containment vis-à-vis exclusion zone. At the end, a panel discussion was held to deliberate the issues that arose from the presentations.

13.2.2 Workshops on Safety and Security of Industrial Radiography Sources

A total of 4 workshops were organized on 'Safety and Security of Industrial Radiography Sources; two in AERB, Mumbai and two in SRI-Kalpakkam. The basic objectives of these workshops were to,

- provide an opportunity to industrial radiography institutes to interact with AERB,
- stress upon the regulatory requirements for safe handling of radiography sources during use, transport, storage and disposal/decommissioning,
- provide forum for interaction among the industrial personnel on the subject matter, and
- obtain feedback in the implementation process of regulatory provisions for ensuring safety and security of radiography sources/devices.

13.2.3 Workshop for Nuclear Medicine RSOs

Two one-day appraisal programmes were conducted in April 2006 for RSOs of nuclear medicine departments. The program was intended to provide better understanding of regulation in nuclear medicine centres and in turn to improve safety in radiation installations. The workshop addressed radiological safety issues in running medical cyclotrons facilities and handling Positron Emission Tomography (PET) isotopes. It also addressed the violations observed during RIs.

13.2.4 AERB-ANMPI Seminar on Radiation Safety and Regulations in Nuclear Medicine

A one-day seminar was organized by AERB in Mumbai on Radiation Safety and Regulaions in Nuclear Medicine. The purpose of this seminar was to provide current status of regulatory and radiation safety aspects of nuclear medicine practices. The seminar focused on aspects like requirement of qualified manpower, training and certification, facilities required in diagnostic and therapeutic centres, criteria for discharge of patients administered with radioiodine etc., release of corpses with high residual activity and requirement for production and use of PET radioisotopes. The managers of nuclear medicine centres, physicians, senior technologists and RSOs participated in the seminar. The seminar was organized in cooperation with the Association of Nuclear Medicine Physicians of India (ANMPI) .

13.2.5 Discussion Meet on Applications of PSA in Nuclear Power Plants – Status and Future Directions

A two-day discussion meet on 'Applications of PSA in Nuclear Power Plants' was organized by SRI-AERB and Institution of Engineers at Kalpakkam during August 10-11, 2006. There were 17 invited talks. The aim of the meet was to share the experience gained in PSA and the progress made in different utilities. A panel discussion was conducted at the end of the meet to summarize the deliberations and provide directions for the future.

13.2.6 Workshop on Regulatory Requirements for Accelerator Safety

One-day workshop on 'Regulatory Requirements for Accelerator Safety' was held on May 19, 2006 at AERB Auditorium. The objective of the workshop was to familiarize the users of accelerators with industrial and radiological safety aspects and to apprise them of the various regulatory requirements as envisaged in the AERB document titled 'Safety Guidelines on Accelerators'. The lectures delivered by experienced faculties from AERB, BARC, RRCAT and VECC covered topics like fundamentals of accelerator safety, radiation safety philosophy, problems in high energy accelerators, operational safety aspects of DAE and non-DAE accelerators, shielding and emerging techniques, access control and zoning aspects, non radiological safety aspects. At the end of the Technical Sessions there was 'Open Forum and Discussions'.

13.3 REVIEW OF SAFETY DOCUMENTS OF BUREAU OF INDIAN STANDARDS (BIS)

AERB officials participated in review of the following BIS codes/draft codes:

1. IS 14489: 1998 Code of Practice on Occupational Safety and Health Audit
2. IS 14489 (1998): Code of Practice on Occupational Safety and Health.
3. IS 875 (Part 2) (1987): Code of Practice for Design Loads (other than earthquake) for Buildings and Structures Part 2: Imposed Loads (2nd revision) [Amendment].
4. IS 875 (Part 5) (1987): Code of Practice for Design Loads (other than earthquake) for Buildings and Structures Part-5: Special Loads and Load Combinations (2nd Revision) [Amendment].
5. Draft IS 1893 (Part 1): Criteria for Earthquake Resistant Design of Structures: Part 1 : General Provisions and Buildings.
6. Draft IS 1893 (Part 2): Criteria for Earthquake Resistant Design of Structures: Part 2: Liquid Retaining Tanks.
7. IS 1893 (Part 3): Criteria for Earthquake Resistant Design of Structures: Bridges and Retaining Walls.
8. Revision of IS 1393: Guidelines on Seismic Evaluation, Repair and Strengthening of Masonry buildings.
9. Revision of IS 3370 (Part 2): Indian Standard Code of Practice for Concrete structures for Storage of Liquids.
10. IS 269:1989: Ordinary Portland Cement 33 grade– Specification (4th revision).
11. IS 8112-1989: 43 Grade Ordinary Portland Cement–Specification (1st revision).
12. IS 3812 (Part 1): 2003 : Pulverised Fuel Ash Specification : Part 1 : For Use as Pozzolana in Cement, Cement Mortar and Concrete.
13. IS 388:2003: Silica Fume Specification.

They also reviewed other standards on various PPE specifications and Code of safety of various dangerous chemicals and respiratory protective devices (Chemical Oxygen Type).

13.4 REVIEW OF DRAFT IAEA SAFETY DOCUMENTS

AERB is the nodal agency to coordinate the review of draft IAEA documents by indian experts. During the year, following Documents of IAEA were received for review. The comments obtained from various experts were consolidated and communicated to IAEA.

- Operational Limits and Conditions and Operating Procedures for Research Reactors (DS261).
- The Operating Organisation and the Recruitment, Training and Qualification of Personnel for Research Reactors (DS325).
- Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors (DS340).

- Compliance Assurance for the Safe Transport of Radioactive Material, IAEA Safety Standard Series No. TS-G-1.4.
- Core Management and Fuel Handling for Research Reactors (DS350).
- Predisposal Management of Radioactive Waste (DS353).
- Disposal of Radioactive Waste (DS354).
- Safety of Uranium Fuel Fabrication Facilities (DS317).
- Safety of MOX Fuel Fabrication Facilities (DS318).
- Safety of Conversion and Enrichment Facilities (DS344).
- Handbook on Combating Illicit Trafficking in Nuclear and other Radioactive Material.
- Security of Radioactive Material during Transport.

CHAPTER 14

OFFICIAL LANGUAGE IMPLEMENTATION

During the year, the Official Language Implementation Committee (OLIC), AERB continued its efforts to ensure effective implementation of the official language policy and enhance the use of Hindi in AERB. The progress of implementation was reviewed by the Executive Committee on a regular basis.

During the year, 4 Hindi workshops were organized in Mumbai jointly with DPS, DCSEM and HWB to train employees to make notings and write letters in Hindi. Eight AERB employees attended these workshops. A scientific talk in Hindi on "Chernobyl Durghatna: Ek Vishleshan" by Shri S. A. Sukheswala, AERB was also organized.

During this year, 4 safety documents were published and 9 safety documents were translated into Hindi. With this AERB has published 28 safety documents in Hindi.

Hindi training classes were conducted through Hindi Teaching Scheme of Ministry of Home Affairs, Government of India and 13 staff members attended these for appearing in Pragya/Praveen examinations. Hindi stenography training classes commenced in February 2007 and 9 stenographers of AERB are undergoing the training.

To increase the use of Hindi, 11 competitions such as story and essay writing, slogan writing, writing notes and drafts, Hindi typing, shabd gyan, quiz, scientific and technical translation, elocution, crossword puzzle, debate, etc., were organized during the year. Prizes were distributed to the winners of previous year's competitions in November 2006.

All the documents that come under the Official Language Act 1963 section 3(3) are issued bilingually. In Administration Section, service books are maintained in Hindi only. The incentive schemes for promoting use of Hindi in official work have been implemented.

Annual Report and Newsletters are being published in both Hindi and English and distributed to DAE units, academic institutes, press media, hospitals and industrial units using radiation for societal benefits. Press releases are also issued in Hindi and English.

Hindi Day and Hindi Week celebrations were organized by the Joint Official Language Co-ordination Committee of DAE units of Mumbai (AERB, DPS, DCSEM, HWP) in September 2006.

AERB Hindi Day Celebrations in Progress

(From L to R : Shri S. P. Agarwal, Chairman, OLIC, Shri S. K. Sharma, Chairman, AERB and Shri C.K. Vijayan, AO-II, AERB)

CHAPTER 15

GENERAL

15.1 IMPLEMENTATION OF ISO 9001:2000 QUALITY MANAGEMENT SYSTEM IN AERB

Recognizing the importance of quality for effectiveness in its regulatory systems, AERB decided to get its core activities audited for compliance with ISO 9001:2000 QMS requirements. Three major processes of AERB were chosen for certification.

- Consenting Process of Nuclear and Radiation Facilities.
- Regulatory Inspection of Nuclear and Radiation Facilities.
- Development of Safety Codes, Guides and Standards.

One officer was deputed for "Lead Assessor Course for ISO 9001:2000" organized by National Centre for Quality Management, Mumbai in March 2005, to get familiarized with the requirements of ISO 9001:2000. A committee was appointed in May 2005 to study the feasibility of implementing ISO 9001:2000 in AERB. In August 2005, the committee after detailed assessment recommended that it is feasible and advisable to implement the ISO 9001:2000 in AERB. The BIS was selected as training and certifying body for the purpose. In December 2005, 25 officers from various divisions of AERB successfully completed the training program on Internal Quality Audit-cum-Documentation. Quality Manual (QM), the Level-I document of QMS was prepared and the application for grant of QMS certification was submitted to BIS in March 2006. Adequacy audit of QM was carried out by BIS in April 2006. QM and Level-II documents were finalized by May 1, 2006. Quality Policy of AERB promulgated on June 1, 2006 and this date was taken as the date of implementation of ISO 9001:2000 in AERB. Awareness program for AERB staff was carried out on July 28, 2006. First and second internal audits were conducted in June 2006 and August 2006 respectively and all the Non-Conformance Reports were resolved. Preliminary Audit by BIS was conducted on September 29, 2006. Certification Audit by BIS was conducted on October 30-31, 2006 and ISO 9001:2000 certification was awarded to AERB on 15th November 2006; the anniversary date of formation of AERB in 1983. AERB is the first technical regulatory body in the country to be awarded the ISO 9001:2000 certification.

15.2 AERB EXPANSION PROJECT

Construction of Niyamak Bhavan-B (AERB Annex building) adjacent to the existing Niyamak Bhavan-A as part of 10th plan "AERB expansion project" is nearing completion. The new building is externally a replica of Niyamak Bhavan-A. In addition to meeting rooms and office space for accommodating additional staff of AERB, the Niyamak Bhavan-B also has a well-equipped lecture hall and a well appointed conference room. One of the sessions of the INSAG meeting hosted by AERB in Mumbai in March 2007 was held in this conference room.

In the 11th five year plan, AERB is augmenting infrastructure and manpower to meet the needs of envisaged increase in regulatory activities commensurate with the expansion of nuclear energy programme of DAE and increasing use of radiations in medical, industrial and research applications in India. It also seeks to strengthen work and to create AERBs southern and eastern Regional Centres towards expeditious implementation of its regulatory functions.

APPENDIX

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ANNEXURE

LIST OF ABBREVIATIONS

ACI&FS : Advisory Committee on Industrial & Fire Safety
ACRS : Advisory Committee on Radiological Safety
ACNS : Advisory Committee on Nuclear Safety
ACOH : Advisory Committee on Occupational Health
ACPSR : Advisory Committee for Project Safety Review
ACPSR-FCF : Advisory Committee for Project Safety Review for Fuel Cycle Facilities
AERB : Atomic Energy Regulatory Board
AGFS : AERB Graduate Fellowship Scheme
AGS : Annulus Gas System
AHWR : Advanced Heavy Water Reactor
ALARA : As Low As Reasonably Achievable
AMD : Atomic Minerals Division
ASME : American Society of Mechanical Engineers
ANMPI : Association of Nuclear Medicine Physicians
BARC : Bhabha Atomic Research Centre
BDBA : Beyond Design Basis Accident
BHAVINI : Bhartiya Nabhkiya Vidyut Nigam
BIS : Bureau of Indian Standards
BRIT : Board of Radiation and Isotope Technology
CCE : Crank Case Exhaust
C&I : Control & Instrumentation
CCWP : Condenser Cooling Water Pump
CDF : Core Damage Frequency
CEP : Continued Education Program
CESC : Civil Engineering Safety Committee
CESCOP : Civil Engineering Safety Committee for Operating Plants
CSP : Core Sub-assembly Plant
CSRP : Committee for Safety Research Programmes
CT : Computed Tomography
CV : Calandria Vault
CWMF : Central Waste Management Facility
DAE : Department of Atomic Energy
DBR : Design Basis Report
DDG : Deputy Director General
DFRP : Demonstration Fast Reactor Fuel Reprocessing Plant
DG : Diesel Generator
ECCS : Emergency Core Cooling System
ECIL : Electronics Corporation of India Ltd
EE : Equipment Erection
EMCCR : En-Masse Coolant Channel Replacement
EPR : European Pressurized Water Reactor
ESL : Environmental Survey Laboratory
FA : Fuel Assembly
FAC : First Approach to Criticality
FBTR : Fast Breeder Test Reactor
FFP : Fuel Fabrication Plant
FP : Full Power
FRP : Fuel Reprocessing Plant
F.R. : Frequency Rate
FRFCF : Fast Reactor Fuel Cycle Facility
GIS : Geographic Information System
GLR : Gross Load Rejection
GUI : Graphical User Interface
HDPE : High Density Poly Ethylene
HEF : Head End Facility
HEP : Human Error Probability
HRDD : Human Resource Development Division
HWB : Heavy Water Board
HWP : Heavy Water Plant
IAEA : International Atomic Energy Agency
ICS : Inner Containment Structure
IFSB : Interim Fuel sub-assembly Storage Building
IFTM : Inclined Fuel Transfer Machine
IGCAR : Indira Gandhi Centre for Atomic Research

IGRPP : Industrial Gamma Radiation Processing Plant
IHX : Intermediate Heat Exchanger
ILRT : Integrated Leakage Rate Test
INES : International Nuclear Event Scale
IPN : Input Processor Node
IREL : Indian Rare Earths Limited
IRMRA : Indian Rubber Manufacturers Research Association
IRS : Incident Reporting System
IRV : Instrumental Relief Valve
ISI : In-Service Inspection
ISO : International Organisation for Standardization
ITER : International Thermonuclear Experiment Reactor
ITF : Integral Test Facility
IV &V : Independent Verification & Validation
IV & VC : Independent Verification and Validation Committee
JHA : Job Hazard Analysis
LINAC : Linear Accelerator
KAPP : Kakrapar Atomic Power Project
KAPS : Kakrapar Atomic Power Station
KGS : Kaiga Generating Station
KK-NPP : Kudankulam Nuclear Power Project
LCO : Limiting Condition for Operation
LMC : Lead Mini Cell
LOCA : Loss of Coolant Accident
LTTM : Low Trajectory Turbine Missile
LWR : Light Water Reactor
MAPS : Madras Atomic Power Station
MCNP : Monte Carlo N-Particle
MoU : Memorandum of Understanding
MV : Main Vessel
NAPS : Narora Atomic Power Station
NDE : Non-Destructive Examination
NFC : Nuclear Fuel Complex
NLR : Net Load Rejection
NOC : No-Objection Certificate
NPCIL : Nuclear Power Corporation of India Ltd.
NPP : Nuclear Power Plant
NSSS : Nuclear Steam Supply System
NTC : Nuclear Training Centre
NZOSP : New Zirconium Oxide and Sponge Plant
OECD : Organisation for Economic Cooperation & Development
OGDHRS : Operational Grade Decay Heat Removal System
OLIC : Official Language Implementation Committee
ONGC : Oil and Natural Gas Commission
OPN : Output Processor Node
OSCOM : Orissa Sand Complex
OSEE : Off-site Emergency Exercises
PC : Primary Containment
PDSC : Project Design Safety Committee
PEE : Plant Emergency Exercises
PEFHI : Preventive Efforts and Fire Hazard Index
PFBR : Prototype Fast Breeder Reactor
PHRS : Passive Heat Removal System
PHT : Primary Heat Transport
PHWR : Pressurized Heavy Water Reactor
PLDSC : Pre-Licensing Design Safety Committee
PPF : Process Plant Facility
PPP : Primary Pressurising Plant
PSAR : Preliminary Safety Analysis Report
PSA : Probabilistic Safety Analysis
PSD : Pulse Safety Device
PSI : Pre-Service Inspection
PSHA : Probabilistic Seismic Hazard Analysis
PSS : Primary Shutdown System
PSWP : Process Sea Water Pump
PWR : Pressurized Water Reactor
QA : Quality Assurance
QMS : Quality Manual System
RAPP : Rajasthan Atomic Power Project
RAPS : Rajasthan Atomic Power Station
RB : Reactor Building
RCP : Reactor Coolant Pump
R&D : Research and Development
RI : Regulatory Inspection
RPV : Reactor Pressure Vessel
RRCAT : Raja Ramanna Centre for Advanced Technology

RRS	:	Reactor Regulating System
RS	:	Remote Sensing
RSO	:	Radiological Safety Officer
RTI	:	Right to Information
RUP	:	Reprocessed Uranium Oxide Plant
RV	:	Reactor Vault
SA	:	Sub Assembly
SARCAR	:	Safety Review Committee for Applications of Radiation
SARCOP	:	Safety Review Committee for Operating Plants
SBO	:	Station Black Out
SC	:	Safety Code
SC	:	Safety Committee
SC	:	Secondary Containment
SCALE	:	Standard Computer Analyses for Licensing Evaluation
SEC	:	Site Evaluation Committee
SER	:	Site Evaluation Report
SG	:	Safety Guide
SM	:	Safety Manual
SS	:	Standards Specifications
SSE	:	Safe Shutdown Earthquake
SCURF	:	Standing Committee for Investigation of Unusual Occurrences in Radiation Facilities
SEE	:	Site Emergency Exercise
SER	:	Significant Event Report
SFSB	:	Spent Fuel Storage Bay
SG	:	Steam Generator
SG	:	Specialists Group
SGDHRS	:	Safety Grade Decay Heat Removal System
SMART	:	System Integrated Modular Advanced Reactor
SPE	:	Standard Problem Exercise
SPND	:	Self Powered Neutron Detector
SRI	:	Safety Research Institute
SS	:	Stainless Steel
SSE	:	Safe Shutdown Earthquake
S.R	:	Severity Rate
SSS	:	Secondary Shut down System
SSSB	:	Spent Subassembly Storage Bay
SV	:	Safety Vessel
TAPS	:	Tarapur Atomic Power Station
TAPP	:	Tarapur Atomic Power Project
TDP	:	Technology Demonstration Plant
TF	:	Task Force
TMI	:	Three Mile Island
Type B (U)	:	Type B (Unilateral)
USC	:	Unit Safety Committee
UCIL	:	Uranium Corporation of India Limited
USNRC	:	United States Nuclear Regulatory Commission
VECC	:	Variable Energy Cyclotron Centre
V & V	:	Verification and Validation
VVER	:	Water Water Energy Reactor
WG	:	Working Group
WMP	:	Waste Management Plant
ZCP	:	Zirconium Complex Project
ZSP	:	Zirconium Sponge Plant

INTERNATIONAL NUCLEAR EVENT SCALE (INES)

Level/ Descriptor	Nature of the Events	Examples
7 MAJOR ACCIDENT	• Major release: Widespread health and environmental effects	Chernobyl NPP, USSR (now in Ukraine), 1986
6 SERIOUS ACCIDENT	• Significant release: Likely to require full implementation of planned counter measures	Kyshtym Reprocessing Plant, USSR (now in Russia), 1957
5 ACCIDENT WITH OFF-SITE RISK	• Limited release: Likely to require partial implementation of planned counter measures • Severe damage to reactor core/ radiological barriers	Windscale Pile, UK, 1957 Three Mile Island, NPP, USA, 1979
4 ACCIDENT WITHOUT SIGNIFICANT OFF-SITE RISK	• Minor release: public exposure of the order of prescribed limits • Significant damage to reactor core/radiological barriers/ fatal exposure of a worker	Windscale Reprocessing Plant, UK, 1973 Saint-Laurent NPP, France, 1980 Buenos Aires Critical Assembly, Argentina, 1983
3 SERIOUS INCIDENT	• Very small release: public exposure at a fraction of prescribed limits • Severe spread of contamination/ acute health effects to a worker • Near accident, no safety layers remaining	Vandellos NPP, Spain, 1989
2 INCIDENT	• Significant spread of contamination/ over exposure of a worker • Incidents with significant failures in safety provisions	
1 ANOMALY	• Anomaly beyond the authorized operating regime	
0 DEVIATIONS BELOW SCALE	No safety significance	

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