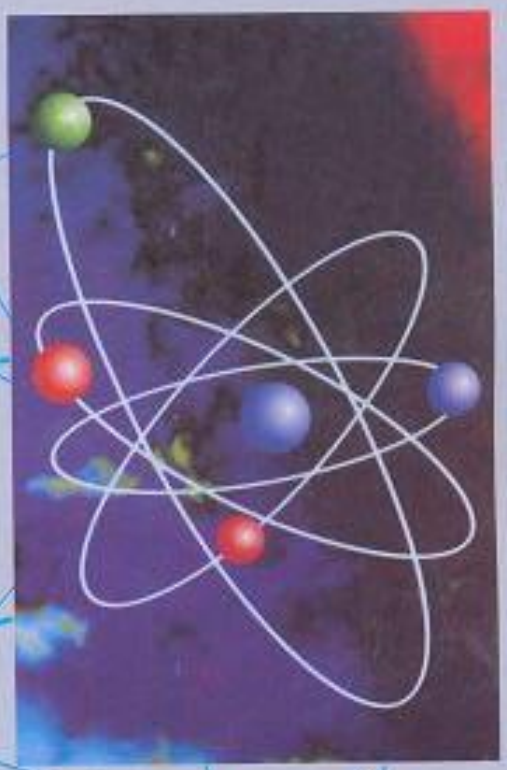
Annual Report
2004-2005



GOVERNMENT OF INDIA

ATOMIC ENERGY
REGULATORY BOARD
MUMBAI

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 ionising radiations and nuclear energy in India does not cause undue risk to health of people and the environment. Currently, the Board consists of a Chairman, four Members and a Secretary. AERB reports to the Atomic Energy Commission.

AERB is supported by Safety Review Committee for Operating Plants (SARCOP), Safety Review Committee for Applications of Radiation (SARCAR), Advisory Committees for Project Safety Review (ACPSRs) and Advisory Committee on Nuclear Safety (ACNS). The ACPSRs recommend to AERB issuance of authorisations at different stages of projects of the Department of Atomic Energy (DAE), after reviewing the submissions made by the plant authorities based on the recommendations of the associated 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 institutes, which use radiation and radioactive sources. AERB also receives advice on development of safety codes and guides and on generic nuclear safety issues from ACNS. 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 institutes, R&D organisations, industries and governmental agencies.

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

AERB has nine Divisions. The Directors/Heads of Divisions constitute the Executive Committee, which meets frequently with Chairman, AERB in the Chair and takes decisions on all important matters related to the functioning of the organisation. AERB enforces the following Rules issued under the Atomic Energy Act 1962:

- Radiation Protection Rules, 1971
- 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

ANNUAL REPORT
2004-2005

GOVERNMENT OF INDIA

ATOMIC ENERGY REGULATORY BOARD

NIYAMAK BHAVAN,
ANUSHAKTI NAGAR,
MUMBAI-400 094.
Website : www.aerb.gov.in

THE CHARTER OF THE ATOMIC ENERGY REGULATORY BOARD

The Government of India set up the Atomic Energy Regulatory Board in 1983 by exercising the powers vested in it by the Atomic Energy Act, 1962.

The Board's responsibility is to enforce the regulatory and safety functions envisaged under the relevant Sections of the Atomic Energy Act. These functions include:

- Carrying out safety reviews of nuclear projects and radiation facilities under design, construction and operation;
- Issuing authorisations for construction, commissioning and operation of nuclear power plants and radiation installations;
- Ensuring compliance by radiation installations with the stipulated safety requirements;
- Organising and conducting regulatory inspections of DAE units and radiation installations and enforcing corrective actions;
- Assessment of radiological safety status with regard to personnel exposures and environmental radioactive releases in nuclear and radiation facilities;
- Administering the provisions of the Factories Act, 1948 in the Units of the Department of Atomic Energy;
- Reviewing the emergency preparedness plans prepared by nuclear installations; and participating in emergency preparedness drills as observers;
- Developing safety documents essential for carrying out regulatory and safety functions;
- Promoting safety research and training activities, as related to the regulatory functions of the Board;
- Keeping the general public informed of major issues of radiological safety significance.

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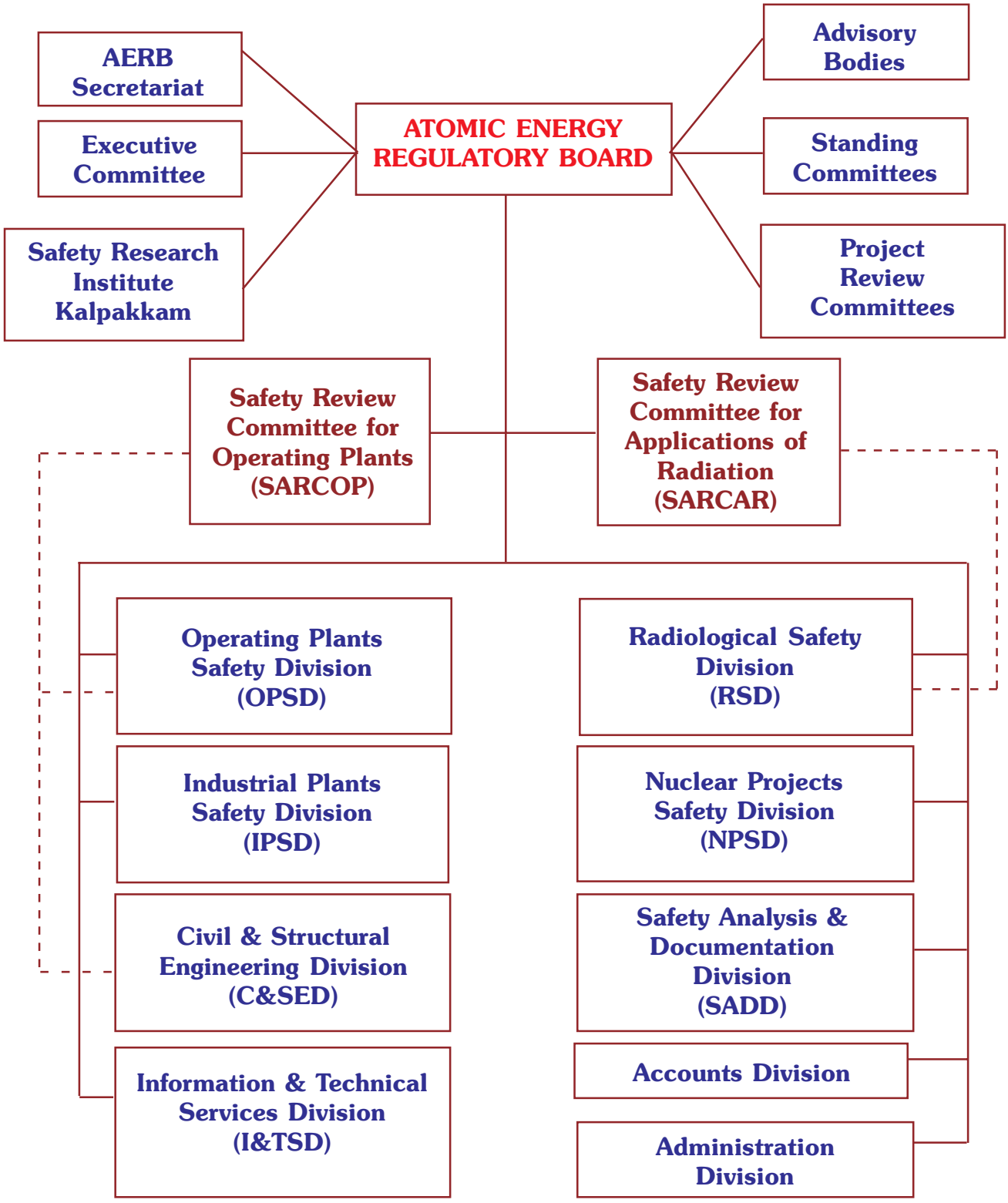
CHAPTER 1 - GENERAL

1.1 COMPOSITION OF THE BOARD

1.	Prof. S. P. Sukhatme (upto January 13, 2005)	...	Chairman
	Shri. S.K. Sharma (From January 14, 2005)	...	Chairman
2.	Shri. S.K. Sharma (Upto July 31, 2004)	...	Ex-Officio Member
	Shri S.K. Chande (From August 1, 2004)	...	Ex-Officio Member
3.	Dr. M.V.S. Valiathan Honorary Advisor Manipal Academy of Higher Education Madhav Nagar, Manipal	...	Member
4.	Dr. K.V. Raghavan Chairman Recruitment & Assessment Centre Defence Research & Development Organisation Ministry of Defence Lucknow Road, Timarpur, Delhi-110 054	...	Member
5.	Prof. J.B. Joshi Professor and Director University Institute of Chemical Technology (UICT) University of Mumbai, Mumbai	...	Member
	Shri D.K. Dave (Upto September 30, 2004)	...	Secretary
	Dr. Om Pal Singh (From October 1, 2004)	...	Secretary

1.2 ORGANISATION CHART OF AERB



1.3 SUMMARY

A wide variety of nuclear and radiation facilities in operation in India come under the regulatory purview of AERB. The nuclear facilities include 14 operating nuclear power plants and a fast breeder test reactor, a nuclear fuel fabrication facility, uranium mines and mills and facilities extracting thorium ore for the next stage of the country's 3-stage nuclear power programme. Nine nuclear power plants are presently under construction at five different project sites. There are over 3300 radiation facilities handling radiation sources for medical, industrial and research purposes, and over 35,000 diagnostic X-ray facilities in India. AERB carried out its charter of activities during the year with the support of the secretariat and specialist committees and under the guidance of the Board, which met four times during the year.

AERB Board Meeting in Progress

Safety Review of Nuclear Power Projects

The multi-tier safety review process for five nuclear power projects under construction namely, Tarapur Atomic Power Project Units-3&4, (TAPP-3&4: 540 MWe each); Kaiga Generating Station Units-3&4, (KGS-3&4: 220 MWe each); Rajasthan Atomic Power Project Units-5&6, (RAPP-5&6: 220 MWe each), Kudankulam Nuclear Power Project-1&2, (KK-1&2: 1000 MWe each) and Fast Breeder Reactor Project (FBRP: 500 MWe at Kalpakkam) continued during the year. The extent of review depends upon whether the project is of 'Repeat design' like KGS-3&4 and RAPP-5&6, 'Evolved design' like TAPP-3&4 or 'New design' like KK-NPP and FBRP. Based on the outcome of the review, the various authorizations/clearances were issued for different stages/sub-stages of construction/ commissioning, as appropriate to the projects.

TAPP-3&4

Construction of TAPP-3&4 was started in March 2000. In-depth design safety review was carried out prior to granting the authorisation for construction and commissioning activities for TAPP-4. Many queries/issues had emanated during the design safety review of the project. The responses of NPCIL to these design and safety issues were categorised based on various sub-stages of commissioning phase for TAPP-4 and were discussed progressively in the meetings of safety committees. Many of the design related issues were resolved satisfactorily and actions have been initiated for the satisfactory resolution of the balance ones.

Construction activities for TAPP-4 were completed and commissioning work was taken up. The regulatory review and authorizations during Commissioning Phase is carried out in three Phases: A, B and C, and a number of Sub-Stages in line with the requirements specified in AERB Safety Guide on "Consenting Process for Nuclear Power Plants and Research Reactors: Document Submissions, Regulatory Review and Assessment of Consent

Applications"; AERB/SG/G-1.

For TAPP-4, Primary Containment Proof Test and Integrate Leakage Rate Test were completed in September 2004 and the test-results were evaluated and found satisfactory. Authorizations for Primary Heat Transport (PHT) System Hot Conditioning and Light Water Commissioning were issued on October 14, 2004 and authorization for loading of fuel in the reactor core was issued on January 20, 2005. The initial core was loaded with bundles of natural uranium oxide, depleted uranium oxide, and deeply depleted uranium oxide. This pattern of fuel loading was chosen for neutron flux flattening as well as to conserve the natural uranium fuel. Fuel loading was completed on February 1, 2005. AERB granted permission for part addition of 40 te of heavy water in moderator system for flushing and heavy water filling of PHT system on February 3, 2005 and these activities were completed smoothly.

NPCIL's application seeking authorization for bulk heavy water addition to moderator system, First Approach to Criticality and Phase-B experiments was reviewed in-depth in multi-tier committees. Based on these reviews, AERB issued authorisation for bulk addition of heavy water to moderator system on February 25, 2005, which was completed satisfactorily on February 28, 2005. Subsequently, after confirming that all the safety related prerequisites including these for exclusion zone and nuclear security have been met and all the relevant tests have been completed satisfactorily, AERB granted authorization to NPCIL for First Approach to Criticality of TAPP-4 on March 03, 2005. First Criticality of TAPP-4 was attained successfully at 1241 h on March 6, 2005. Subsequently, AERB issued authorization for carrying out Low Power Phase-B Experiments on March 19, 2005. These experiments were in progress at the end March 2005.

Construction activities for TAPP-3 are in progress and the Unit is expected to attain first reactor criticality in the first quarter of the year-2006.

KGS-3&4 and RAPP-5&6

KGS-3&4 and RAPP-5&6 are 'Repeat Design' of KGS-1&2 and RAPS-3&4 respectively with minor differences in design and plant layout. The regulatory review process was continued with emphasis on design differences, feedback from operating plants and Preliminary Safety Analysis Reports of these projects. AERB had issued authorizations for erection of major equipment for KGS-3&4 and RAPP-5 during the year 2004. The review towards granting authorisation for equipment erection for RAPP-6 is in progress.

KK-1&2

For Kudankulam Nuclear Power Project, construction and design safety review activities progressed well during the year. Clearance for Construction beyond +17.0 m Elevation of Reactor Building (RB) was issued in June 15, 2004 after completion of safety review of containment liner design.

AERB had put a hold on construction of reactor building containment structure, on noticing failures in demonstration of construction methodology of the pre-stressing scheme at mock-up test set-up erected at site and pending resolution of certain design issues related to the pre-stressing system. The suspension was revoked on September 09, 2005 on successful demonstration of the suitably modified construction methodology and submission of action-plan by NPCIL towards resolution of the balance design issues.

The application seeking authorisation for starting erection of major equipment for KK-1&2 was received and is under review in AERB.

Based on the request from NPCIL, AERB extended the validity period of permission up to December 31, 2005 for continuation of surface mining activity for limestone by M/s India Cements Limited, within the property boundary but outside the exclusion zone at KK project site, after obtaining assurance that no safety/ security problem is envisaged for the project by the activities.

After the Tsunami event on December 26, 2004, an AERB team carried out inspection of the KK-NPP Site on December 31, 2004 and found that there was no impact on the site.

FBR Project

Safety review of FBR project was continued. The earlier clearance for 'Excavation' was extended up to September 2004. The permission for First Pour of Concrete for Ventilation Stack was issued on October 19, 2004 and authorisation for First Pour of Concrete for Nuclear Island Connected Building (NICB) Raft was given on December 15, 2004. Construction of NICB raft was started and the construction activities were progressing well till the site got affected due to the tsunami event of December 26, 2004 when there was ingress of sea water into the raft pit.

AERB asked BHAVINI for a detailed report on the tsunami incident covering the impact assessment, proposed action plans for corrective measures, improvements/changes required, if any, in the design/layout to take care of such external events. From the response and detailed safety assessment, it has been confirmed that there is adequate design safety margin against postulated external flooding of the site. BHAVINI's proposed plan for restarting construction of the NICB Raft, after incorporation of the required changes in the design was under review by AERB Safety Committees at the end of March 2005.

During the year, AERB Inspection Teams carried out a total of 14 regulatory inspections of the above-mentioned projects. Inspections dealing with civil engineering safety aspects and industrial safety aspects were also carried out additionally for some of these project sites. Members of Safety Committees reviewing design and commissioning activities of TAPP-4, inspected/ witnessed important tests at the site. Special Inspections of KK-1&2 and FBRP sites were carried out, as part of impact assessment, within a week of the Tsunami event.

Safety Review of Operating Nuclear Power Plants

All the NPPs and research reactors operated safely. SARCOP reviewed a number of applications from the utilities and issued several authorizations and clearances. Important among these are the following.

a. Permission for restart and operation of RAPS Unit-1 after safety upgradation.

b. Periodic Safety Review and Renewal of Authorization for operation of KAPS Units.

c. Renewal of authorisation for operation of RAPS Units 2, RAPS Units 3&4 and KGS Units 1&2.

Based on safety reviews, the following restrictions were imposed.

i. Suspension of operation of KAPS Units 1&2 for investigations and implementation of corrective measures, following the incident of uncontrolled increase of reactor power

in KAPS Unit 1 on March 10, 2004.

ii. Suspension of construction activities in the spent fuel storage facility being built at RAPS, following the fatal accident of a construction worker.

For TAPS 1&2, a comprehensive safety review was completed for continued operation of the Units in the year 2003. Based on this review, a number of safety upgradations were identified for implementation towards meeting the current safety requirements. Some of these modifications are being implemented during the refuelling outages. The balance jobs will be done during simultaneous shutdown of both the Units planned from July 2005. AERB had also asked NPCIL to address the issues related to severe accident management in TAPS 1 & 2. NPCIL is carrying out detailed assessments in this regard jointly with R&D organizations.

A number of safety related upgradations were carried out in Unit-1 of Rajasthan Atomic Power Station. After extensive review of the safety upgradations and results of inspection of various systems, structures and components of the plant, AERB granted permission for restart of the Unit in January 2004. Initially the Unit operated with low capacity and availability factors. Performance of the Unit improved subsequently and the Unit operated steadily between May 2004 and August 2004. However, the Unit was shut down to attend to light water leaks in the boiler room on October 9, 2004. The Unit continues to remain shut down and a techno-economic assessment is being done presently by NPCIL and DAE to decide whether the unit should be operated in future. AERB took stock of the status of the Unit in December 2004 and issued directives for ensuring safety of the plant during the current extended outage.

In the case of RAPS Unit-2, while the overall safety performance has been satisfactory, the reviews brought out some important issues related to health assessment of feeders in the primary coolant system, need for reduction of tritium content in the primary coolant system for reducing the internal exposures to occupational personnel and the need for a structured programme for ageing management. NPCIL was asked to formulate the action plans to resolve these issues in a time bound manner.

MAPS Unit-1 is remaining under shutdown since August 10, 2003, for en-masse coolant channel replacement. Presently the job of cutting, removal and disposal of the old Zircaloy-2 coolant channels from the reactor is in progress. This will be followed by reinstallation of new coolant channels of Zirconium-2.5% Niobium alloy. During this outage, a number of safety related upgradations would also be incorporated in this Unit, as was done in MAPS Unit 2 earlier.

MAPS Unit-2 operated normally during the year, except when it was shut down on December 26, 2004 due to Tsunami hitting the Kalpakkam coast. Flooding occurred in the sea water pumphouse of the plant due to surge on sea water level on account of the tsunami. Apart from this, there was no damage to the plant due to the incident. An AERB inspection team inspected the Unit after the event. After review, AERB gave clearance for restart and the unit was brought back to operation on January 2, 2005.

KAPS Units 1 and 2 remained shutdown from April 22 to June 5, 2004 and from May 22 to June 18, 2004 respectively, as stipulated by AERB for implementation of corrective measures following the incident of uncontrolled increase in reactor power. The incident reflected weakness in plant safety culture and highlighted the need to improve safety practices further. Appropriate corrective actions were taken in other PHWR units also based on the lessons learnt for this incident.

Both Units of NAPS and KGS, RAPS 3&4 and FBTR operated normally during the year. KAMINI reactor was operated to carry out radiation physics experiments and neutron radiography of irradiated fuel.

During the calendar year 2004, a total of 21 inspections were undertaken in the operating NPPs and research reactors. Of these17 were routine inspections and 4 were special inspections.

Safety Surveillance of Radiation Facilities

On the basis of safety analysis of the performance standards of devices incorporating radioactive materials and radiation generating equipment, AERB issued 234 pre-marketing Type Approval certificates. AERB accorded approval in respect of the nomination of 119 Radiological Safety Officers at these facilities. Design approval and renewal of approval certificates were issued in respect of 12 packages and 12 shipments were approved to be transported under special arrangement. Over 1782 licenses were issued for procurement and import of a variety of radiation sources used for multifarious applications in nuclear medicine, nucleonic gauges, industrial radiography, brachytherapy and teletherapy. Of these, 758 were related to import of radioactive material. AERB accorded clearance to 5 sites for construction of radiation processing facilities in various parts of the country and design approval for an Electron Beam Accelerator at Hyderabad. A license was issued for operation of the first radiation processing facility by a private firm in Kolkata. AERB conducted the regulatory inspection of about 212 diagnostic X-ray installations and issued 325 licenses in the form of registration for operating diagnostic X-ray Units in India.

Regulatory inspection of about 142 radiation facilities was conducted all over the country. Unsafe practices and non-compliance with regulations was observed in 19 facilities and appropriate enforcement actions were taken. AERB also investigated few unusual occurrences such as loss of radiation sources and radiation injuries to personnel handling radiation equipments. Emergency situations involving loss of exposure device housing radioactive sources and damage to the source capsule which resulted in the spread of radioactive contamination in the scrap yard were successfully tackled by AERB officers and normalcy was restored.

As a part of safety promotional activities, AERB organised a special meet for users of gamma radiation processing facilities and a workshop on safe transport of radioactive material by Air at AERB. An awareness programme on Radioactive Material on-board ships was conducted at the Ship Recycling Yard, Alang.

Industrial Safety

Regulatory inspections on industrial and fire safety were carried out in Kaiga Atomic Power Project 3&4, Tarapur Atomic Power Project- 3&4, Kudunkulam Atomic Power Project and Rajasthan Atomic Power Project-5&6 and also in the operating Nuclear Power Stations at Narora, Rawatbhata, Kaiga and Kakrapar, the Heavy Water Plants, the Nuclear Fuel Complex, Electronics Corporation of India Ltd., Indian Rare Earths Ltd., Uranium Corporation of India Ltd., Accelerator facilities at VECC, Kolkata and CAT, Indore, Board of Radiation and Isotope Technology and Atomic Minerals Directorate for Exploration and Research .

Authorisation was issued for processing of depleted uranium (0.3% U^{235}) in Uranium Oxide Plant (UOP), Ceramic Fuel Fabrication Plant (CFFP) and New Uranium Oxide Fabrication Plant (NUOFP) of Nuclear Fuel Complex, Hyderabad and for operation

of the Banduhurang (Jharkhand) open cast mine of M/s UCIL. Safety review of Heavy Water Plants, Nuclear Fuel Complex, Indian Rare Earths Plants, Electronics Corporation of India Limited and Uranium Corporation of India Ltd. were carried out.

There have been six fatalities during the year (April 2004 - March 2005) due to industrial accidents. These accidents were investigated to arrive at the root cause and remedial measures were suggested to the sites to prevent recurrences of such accidents.

Safety Documents

Six safety documents were published relating to the topics of In-Service Inspection of Civil Engineering Structures, Glossary of Terms for Nuclear and Radiation Safety, Methodologies for Environmental Radiation Dose Assessment, Quality Assurance in Siting of NPP, Life Management of NPP and Assessment of Implementation of QA Programme in NPP. Ten documents are in advanced stage of preparation. Four documents were translated in Hindi and another eight documents are being translated in Hindi.

Safety Analysis

Efforts to develop in-house capabilities in deterministic as well as probabilistic safety analysis were continued. A few incidents of VVER-1000 MWe were analysed using the computer code, RELAP5/Mod.3.2. Probabilistic seismic hazard analysis of Kalpakkam site was conducted. Analysis procedures are being established for severe accident analysis and passive systems reliability analysis. A new document is being prepared on 'Technology Independent Criteria' to cater to the design safety review of NPPs of new designs.

Safety Related R&D

At the Safety Research Institute (SRI), studies were conducted on seismic analysis of prototype main control room of TAPP-3&4, analysis of shock wave propagation in liquid media and reliability analysis of safety grade and operating grade decay heat removal systems of FBRP. Some studies on radiation and environmental safety were also carried out at SRI.

AERB promotes safety research in educational institutes and also provides financial support for conducting workshops/seminars/conferences/symposia on topics of AERB interest. During the year, 5 new research projects were approved and 24 seminars/ conferences were financially supported.

Human Resource Development

AERB is involved in the challenging tasks of regulating a large number of nuclear and radiation facilities and the expanding nuclear power program in the country. Special efforts are, therefore, being made to augment the manpower with required knowledge base at different levels. During the year, 20 engineers and 3 supportive staff were inducted at different levels. Special emphasis is placed on training of staff inducted in AERB. During the year, five engineers were trained in Nuclear Training Centre (NTC) and three engineers were given On The Job Training (OJT) of NPCIL. A detailed program is in place for imparting training to a set of 21 engineers in Training course to be conducted at AERB, at NTC and in OJT of NPCIL during the year 2005-2006.

CHAPTER 2
SAFETY SURVEILLANCE OF NUCLEAR FACILITIES

2.1 NUCLEAR POWER PROJECTS

2.1.1 Project Safety Review

Presently, a total of 9 nuclear power Units are under construction in India. These include: 4 Units each of 220 MWe capacity and 2 Units each of 540 MWe capacity Pressurized Heavy Water Reactors (PHWR); 2 Units each of 1000 MWe capacity Pressurized Water Reactors (VVERs) and 1 Unit of liquid sodium cooled Fast Breeder Reactor Project of 500 MWe capacity. All these projects are based on indigenous design except the twin-Unit project of Pressurized Water Reactors, which is based on Russian design. While design of 540 MWe capacity Units is an 'Evolved Design' from earlier indigenously built 220 MWe capacity Units, design of Fast Breeder Reactor Project (FBRP) is a new design. Though, design of Pressurized Water Reactors (VVERs) is proven in Russian Federation and some other countries, this is the first time reactors of this type are being constructed in India.

Utilizing the experience gained during regulatory review of earlier projects, AERB has evolved appropriate technical and administrative mechanisms to carry out systematic regulatory safety review of the projects and to issue related clearances at different stages/sub-stages of the projects. AERB draws upon the expertise from research centres and academic institutions and experience of the experts in the field who have retired from various organizations in the country for the safety review process.

AERB uses multi-tier review mechanism for safety review of on-going projects. The Project Design Safety Committee (PDSC), Civil Engineering Safety Committee (CESC) and associated Specialist/ Working Groups, carry out the first-tier of the review. The corresponding Advisory Committee for Project Safety Review (ACPSR), which include specialist members from the Ministry of Environment and Forests, Central Boilers Board, Central Electricity Authority and Educational/Research Institutions perform the Second-Tier review. The Third-Tier review is by the Atomic Energy Regulatory Board, which reviews the projects at major consenting stages. AERB issues clearances for various projects at different stages taking into consideration the observations and recommendations of the Safety Committees. The process of safety review is supplemented by safety audit, which is carried out through Regulatory Inspections, for verifying compliance by the utilities to the requirements prescribed by the Safety Committees and those in various codes, guides and standards of AERB. Number of meetings of various Safety Committees held in the year is given in Table 2.1.

In addition, a large number of meetings of KK Co-ordination Group and of Specialists Groups, Task Forces and Working Groups constituted by PDSC/ ACPSR/ AERB were held to review specific aspects of the projects.

Table-2.1: Project Safety Review Committee Meetings

Project Committee	Number of Meetings
ACPSR-LWR	10
ACPSR-PHWR	2
ACPSR-FBRP	2
PDSC-KGS-3&4 and RAPP-5&6	5
PDSC-TAPP-3&4	54
PDSC-FBRP	7
CESC	9

Tarapur Atomic Power Project Units-3&4

The Tarapur Atomic Power Project (TAPP) Units 3&4 are PHWR based NPPs, each of 540 MWe capacity. Since, the design of TAPP- 3&4 is an 'Evolved Design'; in-depth design safety review was performed prior to granting of 'Construction Authorisation' and subsequently till the start of commissioning activities for TAPP-4. Many queries/issues emanated during the design safety review of the project. NPCIL responses to these design and safety issues were categorized, prior to the start of commissioning based on various sub-stages of TAPP-4 of the commissioning phase and were discussed progressively in the meetings of Safety Committees. Many of the design related issues have been satisfactorily resolved and actions have been initiated for satisfactory resolution of the others.

Some of the important observations made/ issues emanated during design safety review are as follows:

- Shut-off rods are withdrawn under supervision of Reactor Regulating System (RRS). It is verified that protective function of the shutdown system is not adversely affected by malfunction of any of the components of RRS logic.
- Dynamic response and linearity of output with reactor power, for both Cobalt and Vanadium Self Powered Neutron Detectors used for reactor regulation and protection functions, were found to be satisfactory during their testing in an operating PHWR.
- A common pressurised helium gas tank has been provided for the 6 poison tanks of secondary shutdown system No. 2 (SDS-2). In the case of loss of helium pressure in the tank, the driving force to inject liquid poison into moderator would not be available and thus, the principle of fail-safe design was getting violated. Hence, reactor trip by both shut down systems (SDS-1 and SDS-2) on "Low Helium Gas Tank Pressure" has been introduced and its effectiveness has been demonstrated during commissioning of TAPP-4.
- Independent Verification and Validation (IV&V) of safety significant computer based systems was carried out by a committee constituted by NPCIL. Instrumentation and Control (I&C) expert committee of AERB audited these IV and V reports and based on this review and audit, certain modifications were incorporated in the system.
- In light of the experience from KAPS-2 incident of March 2004 of unwarranted power rise, the coolant temperature, void and power co-efficient of reactivity were reassessed using the 69 groups IAEA cross-section library. It was seen that there is only marginal change in the values of these co-efficients in comparison with earlier assessed values. The changes were found to be acceptable.
- During the remote possibility of the need for draining moderator from calandria, radiation streaming is expected in accessible areas of reactor building. Appropriate precautions to be taken under this condition would be included in the operating procedure.
- For horizontal neutron flux units, additional neutron shielding has been provided to bring down the expected dose rates to be within the permissible limits.
- Revision of the specified test pressure for Integrated Leakage Rate Test of Primary Containment was permitted based on the re-assessment using refined computer codes for the peak pressure attained in the containment during Loss of Coolant Accident.
- The earlier design proposal for permitting valving-in of shut down core cooling system with PHT in hot condition could not be implemented due to non-availability of appropriate pumps for the purpose. Since alternate reliable provision of shut down cooling with PHT in hot condition already exits in the design, deletion of design proposal was permitted.
- The Part Task Training Simulator is made functional and it was used for imparting training to O&M staff for TAPP-4.

Status of TAPP - 3

Most of the major equipment has been installed. Installation of the coolant channels has been completed and installation of inlet and outlet feeders was started on February 1, 2005. Expected criticality date for TAPP-3 is in first quarter of 2006.

Safety Review During Commissioning of TAPP-4

TAPP-4 entered into "Commissioning Phase". The regulatory review and authorizations during Commissioning Phase is carried out in three Phases: A, B and C, and a number of Sub-Stages in line with the requirements specified in AERB Safety Guide on "Consenting Process for Nuclear Power Plants and Research Reactors: Document Submissions, Regulatory review and Assessment of Consent Applications"; AERB/SG/G-1. While granting authorization for any sub-stage of commissioning, AERB ensures through review by specialists that safety significant tests/activities are identified and commissioning procedure for such tests are prepared properly so that accomplishment of design intent can be verified. Also, it is ensured that commissioning tests results are satisfactory and collected data is comprehensive enough to get confidence about the safe operation of the systems and the plant during the next stage. For some of the selected tests/ activities, observers are deputed at site to witness the tests and for ensuring compliance with the regulatory requirements during conduct of these tests/ activities. Examples are: Containment Leakage Rate and Proof Test, Emergency Core Cooling System Integrated Test, First Approach to Criticality, Low Power Phase-B Physics Experiments, Off-site Emergency Exercise etc.

First authorisation related to commissioning phase, that is, Primary Heat Transport System Hot Conditioning and Light Water Commissioning was granted on October 14, 2004. Subsequently, authorisations/permissions were

issued progressively for various sub-stages of the commissioning phase. These were, draining light water from PHT system and moderator system, fuel loading in the core, part addition of Heavy Water (HW) in the moderator system and HW filling in PHT system; Bulk HW addition in moderator system; First Approach to Criticality and Low Power Phase-B Physics Experiments. TAPP-4 attained first criticality on 6th March, 2005.

Some of the important observations/ recommendations made during the review of the commissioning activities carried out so far are as follows:

- Shut down system No. 1 was modified to obtain the design intended drop time. Also modifications were incorporated in the shut down system No. 2 to facilitate accurate measurement of poison injection time.
- In the design, the secondary shutdown system cannot be brought to poised state unless the bulk heavy water addition is completed. In view of this and based on detailed review, adequate concentration of neutron poison (Boron and Gadolinium) was maintained to ensure reactor sub-criticality during filling of heavy water in the moderator system. In addition, an alarm on high neutron count was provided in the control room and administrative-control was instituted to stop the bulk moderator heavy water addition and to manually actuate the Moderator Liquid Poison Addition System on annunciation of the alarm.
- Level indication for one of the Zone Control Compartments (ZCC) of Liquid Zone Control System (LZCS) was found to be erratic. Investigations revealed helium leakage from the threaded joint of a ZCC assembly. The leakage was temporarily arrested using Nitrile O-ring. Permanent sealing method is under development taking into consideration the accessibility and radiation environment.
- Gadolinium is used as neutron poison in the secondary shut down system. Aspects related to precipitation of Gd, vis-à-vis pH of moderator, accuracy of measurement of concentration, selective removal of Gd in presence of Boron etc., have been appropriately taken care of.
- Vibration measurement data for feeders of coolant channels were analyzed by experts from BARC and found acceptable.
- A few thermo-wells (B-2 type) were found to have failed during hot conditioning of PHT system. These thermo-wells were replaced with B-1 type. Broken pieces of the thermo-wells, which could have resulted in partial flow blockage to fuel channels, have been removed from the PHT system.
- Significant quantity of steam was spreading in the area on opening of Atmospheric Steam Discharge Valves. The design of the valves has been modified.
- Sub-soil water was found to be seeping in the spent fuel storage bay along the raft anchor bolts. In addition to the corrective measures to arrest seepage of water, design modifications were incorporated, after the detailed review, in the form of back up carbon steel liner, underneath the stainless steel liner of the bay-floor, with a view to prevent sub-soil water having chlorides coming in contact with SS liner. Further review of this problem and the suggested modifications is continued.
- High leakage rate of carbon-di-oxide through fittings of Annulus Gas System was noticed. The leaky locations were not easily approachable for repairs. The leaks have been rectified by use of specially developed tools and methods, after successful trials on mock-up test set-up. The system operation was checked to be normal after these actions.
- During the commissioning phase, AERB put "Hold" on three occasions on observing certain safety related deficiencies. The resumption of the activity was permitted after ensuring implementation of corrective measures.
- A specially constituted Task Force reviewed the containment proof and leakage rate testing procedures and witnessed the tests for TAPP-4.

KGS-3&4 and RAPP-5&6

KGS-3&4 and RAPP-5&6 are "Repeat Design" of KGS-1&2 and RAPS-3&4 respectively with some differences in design and plant layout. The regulatory review process continued with emphasis on design differences, feedback from operating plants and Preliminary Safety Analysis Reports of these projects. Whereas authorizations were issued for erection of major equipment for KGS-3&4 and RAPP-5 in the earlier year, the review towards granting authorisation for equipment erection for RAPP-6 was in progress.

Civil construction activities for major buildings and structures of all the 4 Units remained in progress. For KGS-

3&4 and RAPP-5, installation of end-shields and calandria shell has been completed and erection of equipment and piping progressed well during the year. After successful review of design basis report and dynamic analysis report of induced draft cooling towers (IDCT) of Kaiga-3 & 4 by CESC, construction of IDCT was permitted.

CESC visiting dome construction of Kaiga-3&4

Some of the important observations made/issues emanated during design safety review are given below.

- Modified design of primary shutdown system rods, having lower thickness of Cadmium absorber (reduction from 1.5 mm to 1.0 mm) and lower weight of the absorber assembly (reduction from 45 to 35 kg) in comparison to the designs adopted in earlier plants of similar type, is under detailed review.
- Report on Seismic qualification of "Calandria End Shields" integral assembly was found acceptable.
- In view of the experience of unwarranted power rise at KAPS-1 during March 2004, the relevant aspects of these 4 Units were reviewed. Required changes in the design and documents would be incorporated by NPCIL.
- Aspects of 'Protection of Safety Related Electrical Equipment' against 'High Energy Piping Failure' would be reviewed by NPCIL team of experts.
- It is confirmed that appropriate procedures and precautions exist to avoid inadvertent radioactive release to the outlet canal.
- Work on Leak Before Break (LBB) studies and demonstration of its applicability for main steam lines continued by NPCIL and the progress reports were discussed in safety committee. The studies carried out so far have indicated that permissible defect (5% of pipe wall thickness) at the manufacturing stage does not grow to through-and-through wall crack even in many plant life times. Also, revised estimation of leakage rate through a given crack size is much higher than the earlier estimated values. Experimental validation is to be performed.

Kudankulam Nuclear Power Project Units # 1 & 2

The construction and safety review of KK-NPP-1&2, progressed well during the year. The Co-ordination Group (KK-CG) along with the Specialist Groups (SGs) carried out the first level of review. The ACPSR-LWR, at the second level, reviewed the recommendations of KK-CG/SG along with the relevant documents.

Based on the recommendations of ACPSR, clearance was granted for construction beyond +17.0 m elevation of RB of Units 1&2 during June 2004. Subsequently, during first and second mock-up for threading of strands of primary containment pre-stressing system, damage to HDPE sheath was noticed. Consequently, civil construction activity of containment was suspended as it could create problems of irreversibility for implementation of the selected pre-stressing system. The suspension was revoked later on successful demonstration of the suitably modified construction methodology and submission of action-plan towards resolution of the balance design issues.

A view of KK-NPP Unit-1 under construction

Site requested extension of the permission for surface mining of limestone within the property wall at about 2 km, so that the natural resources can be gainfully utilized and trees can be planted. Based on the review, the validity period for continuation of surface mining up to December 31, 2005 was extended after obtaining assurance that no safety/security problem is envisaged by these activities.

Site has submitted an application-seeking

authorisation for Equipment Erection (EE). For this stage, NPC-KK is submitting responses progressively towards satisfactory resolution of all the outstanding issues based on the safety review conducted so far as relevant to Equipment Erection. While most of the issues raised during review of PSAR have been addressed, certain issues are still to be responded satisfactorily.

Some of the salient observations/ recommendations made during the review areas follows.

- Un-bonded cables are being used for the first time for internal pre-stressing of containment structures of KK-NPP. In-depth review of the qualification of pre-stressing system was carried out. Mock-up was carried out at site for a horizontal cable with maximum vertical deviation in the profile for demonstration of groutability, threadability and re-threadability. Mock-up of groutability of vertical cables having inverted U-shape would be conducted prior to their in-situ threading.
- Design check reports for reactor building locations, including the proposal for re-engineering of the base raft were reviewed by AERB. Based on the review, the re-engineering scheme was modified.
- The review of safety analyses of containment structure against aircraft impact, air-shock wave and vent stack fall and qualification of the new pre-stressing system for KK-NPP was undertaken.
- Russian experts will be involved in fuel management for until 3rd reload cycle and thereafter the responsibility will be taken over by NPC-KK.
- One of the signals for initiation of ECCS pumps is on decrease of sub-cooling margin to less than 10°C, whereas in PHWRs, it is based on system pressure decrease at a preset temperature of primary coolant system. These two approaches are to be discussed and basis for using decrease in sub-cooling margin is to be given.
- For the main primary and secondary coolant systems, the set points for safety relief devices is such that maximum over pressure is limited to 10 % of the respective design pressure during any transient, though as per Russian Code, the limit is 15 % above the design pressure. The present design of over pressure protection is acceptable.
- In the analysis of unwarranted actuation of "Steam Generator - Emergency Cool Down System" with assumed "Anticipated Transient Without Scram" condition, the total reactivity of core becomes positive and remains positive for some time before becoming sub-critical again, even with actuation of both engineered safety systems for boron addition; Emergency Boron Injection System and Quick Boron Injection System. This is under discussion.
- Aspects related to design, QA, ISI, surveillance etc for Reactor Pressure Vessel (RPV) have been reviewed in detail.
- The top head is perforated ellipsoidal cover and the present Finite Element (FE) model is based on equivalent solid shell concept. Further it has almost twice the penetrations as compared to earlier VVERs. A more detailed 3D model was asked to be performed to evaluate the stresses more realistically in place of simplified approach.
- Towards minimising Radiation Embrittlement, significant effect due to Ni has been taken care by reducing Ni below threshold value (<1.5 %).
- Thermal exposure of (400-600°C) RPV during fabrication/ service can lead to segregation of certain elements (As, Sb, Sn, P, etc.) at grain boundaries leading to embrittlement. For KK-NPP, it is calculated that shift in T_K due to this is taken as 30°C for operation upto 7 years and 5°C for operation beyond 7 years. It would be reviewed further.
- Quantity of surveillance specimens provided are very large as compared to earlier VVER plants and these specimens are located along the vessel wall at core mid-plane unlike earlier plants. In order to conserve the archive specimens towards the end of design life and for further extended life if thought of, efforts are to be put in to plan the surveillance programme accordingly.
- Certain new materials, which are specific to Russians plants, are used in KK-NPP. Actual behaviour of such materials based on testing/service experience and data on end of life properties, are to be obtained from the Russian designers.
- For pipelines such as for primary coolant system (SS-Clad on inner surface), special techniques of welding are required. QA Program would be reviewed.

- For fixation of spent resins, use of cement matrix is proposed. Possibility of keeping an alternative provision in the design to switch over to polymer fixation, if need arises, would be explored.
- The concept of 'retrievable' storage of all categories of solid waste has been proposed and the design envisages provision for storage capacity for a period of 5 years with facilities for inspection, surveillance, retrieval and re-packaging of the containers for shipment, if need arises. Near Surface Disposal Facility (NSDF) would also be constructed as per the current practice.
- After the Tsunami event, inspection of the site reveald that there was no damage to the site. During the event, the maximum water level rise was 2.0 m above Mean Sea Level (MSL), which is well below the DBFL of 7.5 m above MSL. Adequate margin exists against external flooding of the site.

FAST BREEDER REACTOR PROJECT (FBRP)

The design of FBRP has been done by IGCAR, Kalpakkam and is being built by Bharitya Nabhikya Vidyut Nigam Ltd. (BHAVINI). The regulatory reviews focused on those aspects, which are of irreversible nature. Detailed review for other aspects would be performed progressively.

The earlier clearance for "Excavation" was extended upto September 2004 and the balance excavation work was completed. The Permission was issued for First Pour of Concrete for Ventilation Stack and authorisation was issued for First Pour of Concrete for Nuclear Island Connected Building (NICB) Raft after completion of review of the relevant reports by CESC/ PDSC/ACPSR. The reports reviewed included amongst others, PCC backfilling below NICB Raft. QA in design and construction, design specification for RC ventilation stack, design specification for NICB and other safety related buildings, construction methodology, geological mapping, report on confirmatory foundation parameters evaluation for NICB, hydro-geological and geophysical investigations at FBRP site, consequence analysis of risk due to movement of vehicles carrying hazardous materials on east coast road and near new CISF gate, structural analysis and design report for NICB and ventilation stack and concrete mix design report.

Reports related to mathematical modeling, static analysis and seismic analysis including free vibration and response spectrum analysis of NICB and validation reports of computer codes used in these analyses, reports on design response spectral shapes and spectrum compatible time histories and seismic studies and design basis ground motion parameters, design report for raft foundation of NICB and design report for RC ventilation stack were also reviewed.

Following the AERB clearance, construction of NICB Raft was progressing well till the site got affected due to the natural event of tsunami on December 26, 2004. Following this BHAVINI was asked for a detailed report on the tsunami incident covering the impact assessment, proposed action plans for corrective measures, improvements/ changes required, if any, in the design/layout to take care of such external events. From the response and detailed safety assessment, it has been confirmed that there is adequate design safety margin against postulated external flooding of the site. Reconstruction of the NICB Raft, after incorporation of the required changes in the design, would be taken up.

Some of the salient observations/recommendations made during the review are as follows.

- The NICB raft thickness was increased from 2.5 to 3.5 m based on review. The implications of changing the thickness on layout of other buildings and structures and equipment, storm drainage etc. are to be taken care of in the detailed design.
- As per the proposal for reconstitution of NICB raft, after the event of Tsunami Grade Level and Finished Floor Level further increased by 1.4 m.
- The plant layout has undergone a number of changes over the earlier submitted plant layout at the time of seeking 'Excavation' clearance. The changes are to enhance operational convenience without compromising on safety aspects. However, some more safety improvements were incorporated in the layout for fuel building, material air lock, creation of corridor between control building and Reactor Containment Building, etc. based on the safety review.
- The layout was reviewed from the point of view of Industrial and Fire Safety as per the requirements of Atomic Energy (Factories) Rules, 1996. The project has also undergone changes due to implementation of recommendations, as applicable, by NAPS Fire Incident Investigation Committee.
- Based on the review of accident sequence analysis, reactor containment is being designed for 25 kPa pressure.

- The design envisages provision of compressed air cooling from inside the building for high temperature piping penetrations. Such provision would result in possible containment re-pressurization under accident condition but cutting off the air supply would result in rise in concrete temperature. Such aspects are under detailed examination.
- Pressurization of Reactor Building due to severe failure in secondary sodium circuit is not postulated in the design taking credit for the design provisions such as guard pipes, leak detection system, proper drainage, etc.
- The estimated radiation dose values in the control room got revised upward when re-estimated taking into consideration the comments of safety committees. Design provision, to maintain nominal positive pressure in the control rooms under accident condition is to be made to minimise ingress of active air resulting in additional doses to control occupants.
- Design provisions to prevent sodium fires and features to minimise consequences of fire were reviewed in detail and necessary recommendations made.
- Kalpakkam Emergency Preparedness Manual was revised to cover the aspects related to FBRP during construction.
- Deferred decommissioning philosophy is proposed for the project. In view of this, necessary recommendations were made for durability of buildings identified for long-term storage of equipment/components, surveillance aspects, options for storage/disposal of large size components, etc.

2.1.2 Clearances Issued

TAPP-4

- Authorisation for PHT System Hot Conditioning and Light Water Commissioning.
- Hold on heating up of Primary Heat Transport System.
- Permission for Heating up of Primary Heat Transport System.
- Permissions for Draining of Light Water from PHT System and Moderator System.
- Authorisation for Initial Fuel Loading.
- Authorisation for Addition of 40 t of Heavy Water in Moderator System and Heavy Water Filling in PHT System.
- Authorization for Bulk Moderator Addition to Moderator System.
- Authorization for First Approach to Criticality.
- Authorization for Phase-B Experiments.
- "Hold" on making the reactor critical and to carry out Phase-B Experiments as behaviour of RRS and LZCS were inappropriate.
- Permission to continue Phase-B Experiments.
- "Hold" on making the reactor critical and to carry out Phase-B Experiments as Secondary Shut-down system No. 2 actuated on Rate Log-N high.
- Permission to continue Phase-B Experiments.

KK-NPP

- Clearance for Construction Beyond +17.0 m Elevation of RB.
- Suspension on Construction Activities of Primary Containment.
- Permission for Resumption of Construction Activity for PC.
- Extension of Validity Period of Permission for Surface Mining of Limestone upto December 31, 2005

FBRP

- Extension of Validity Period for Site Excavation upto September 30, 2004
- Permission for First Pour of Concrete for Ventilation Stack
- Clearance for First Pour of Concrete Raft
- Hold on construction of NICB Raft

2.1.3 Regulatory Inspections

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

Table-2.2: Regulatory Inspections of Nuclear Power Projects

Site	No. of Inspections
Tarapur Atomic Power Project- Units 3&4	4
Kudankulam Atomic Power Project- Units 1&2	4
Kaiga Generating Station – Units 3&4	3
Rajasthan Atomic Power Project –Unit 5&6.	3
Fast Breeder Reactor Project	-

In addition to these inspections, teams of AERB representatives visited TAPP-4 site to observe certain important commissioning tests or to assess the preparedness of site prior to granting of clearance for the next phase of commissioning activity. Inspections of certain project sites were carried out, as necessary, exclusively by experts in civil engineering fields. KGS-3&4 site was inspected in March 2005 especially to ensure compliance with the recommendations related to industrial safety made by RI team in the previous inspection carried out in February 2005.

FBRP and KK-NPP sites were inspected on December 29, 2004 and December 31, 2004 respectively immediately after the Tsunami event of December 26, 2004 to assess the impact of natural events on these project sites.

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

TAPP-3&4

- During PHT hot conditioning after reaching the system temperature to 200°C while pressuriser was planned to be put in service, six out of eight heaters had tripped on earth fault and hence pressuriser could not be brought in service. Pressuriser was commissioned after rectifying the deficiencies.
- ECCS integrated test was conducted at PHT pressure of 85 kg/cm^2(g) instead of the earlier planned initial condition of 100 kg/cm^2(g) as the temporary blow down valve provided to initiate LOCA test failed to open at 100 kg/cm^2(g).
- Performance of LZCS to maintain the required water levels in each of the ZCC was not satisfactory. The water levels in ZCCs were found to be dropping suddenly and simultaneously in unsafe direction based on generation of false signals due to failures in reactor regulation system. The deficiencies were corrected with appropriate design changes.
- During the integrity test of AGS, pressure drop observed was 40 times the permissible value. Investigations revealed leaks from 14 out of 44 strings and most of these were in coolant channel end-fittings region and were not approachable for leak rectification. The leaks were, subsequently, corrected using specially developed clamps and tools.
- Alternators of two out of four main DG sets got badly damaged during commissioning. These were replaced.
- The personnel spray system in reactor building was not operable as per the design, during PHT system hot conditioning. Suitable administrative control was instituted for actuation of the system, if required.

KGS-3&4

- After grouting of end-shields in position, the concentricity for six lattice tube locations showed deviations (upto 1 mm) beyond the tolerance limit of 0.65 mm. The designers expressed that CT rolling could be done satisfactorily even with 1 mm off-set in concentricity based on experience in earlier built 220 MWe reactors. Also, bending stress on CT corresponding to 1mm off-set is acceptable. However, reductions in safety margins under different plant operating conditions would be estimated and reported to AERB.

KGS3: Reactor Building

- Welding of additional strips on EPs for plane-matching with respect to surrounding concrete wall surface for calandria vault was noticed. This aspect was subsequently reviewed by the designers and the Design Safety Review Committee and was found acceptable.

- The site was asked to get approval of Emergency Preparedness Manual for the Kaiga Site, which has been revised to include also the requirements for protection of KGS-3&4 construction personnel, in the event of emergency arising in operating Units KGS-1 or 2.

- A number of observations/ recommendations related to industrial safety were made during regular RI conducted in February 2005. Based on this, AERB had issued specific notice to the project authorities to take necessary actions, to correct the deficiencies, on priority. The site was inspected again in the month of March specially to assess the improvements made with respect to industrial safety and it was confirmed that most of the recommendations have been complied with.

RAPP-5&6

- One of the truss assemblies to facilitate construction of PC dome of RAPP-5 fell from a height of about 100 mm over the crane brackets on the PC wall and the central tower on the other side, while lifting for alignment. Site would be submitting a detailed report on the incident for review.

- After grouting of end-shields in position, deviations with respect to concentricity of lattice tube locations and certain other deviations have been noticed. The designers and the Design Safety Review Committee would review these deviations.

- Based on RI observations, it is recommended that actions to be taken by site during installation, preservation, ISI, commissioning and operation, as per the requirement specified by designer/ manufacturer should be clearly identified and brought out, in the documents such as Equipment History Documents, Construction Completion Certificates, etc.

RAPP-5: Installation of Dome Truss

KK-NPP

- At certain locations of the compartment for core catcher vessel of Unit No. 1, rust was noticed on welded regions, possibly due to effect of water dripping from the surrounding areas. The truss cantilever was not painted and was exposed to the prevailing environment. Site was asked to take necessary corrective actions.

- Procedure followed for installation of portion of the basket inside the core catcher vessel and cantilever-truss supports were at variation with the guidelines given by the designers from Russian Federation (RF). These deviations have the concurrence of the RF field engineers and would be approved formally.

- Post-installation preservation document for core catcher was not prepared. Site was asked to expedite the preparation of the document, which should also cover precautions to be taken to avoid damage to the installed equipment due to other construction activities.

KK-NPP Pre-Stressing System Mock Up for Strand Threading

- O&M has made detailed post-installation preservation procedures for items such as doors, tanks and filters. The preservation work and relevant records were found in general satisfactory. However, certain points were brought out for further improvements. These are: wherever damage has been reported, required local preservation needs to be done, wherever there is drop in the pressure of gas-filled equipment, it is to be filled up and minimum pressure is to be ensured, warning stickers to be pasted as applicable, and the problem of water logging, protective covering and prevention of

debris falling etc., are to be taken care adequately

- The NDE procedures for vacuum box testing, air pressure leak test, UT and kerosene chalk test as per QA plan of containment metallic liner were checked and found satisfactory.
- For Class 1 & 2 equipments/components, detailed test reports are available along with Equipment History Dockets (EHD), whereas for Class 3 & 4, they are retained at manufacturers end. This is a deviation from the practice adopted for PHWRs. Site clarified that for selected Class 3 items, based on their relative importance to safety, test certificates from Russian can be obtained upon request by NPCIL, as per the terms of contract.
- It was emphasized that AERB's notification with respect to the minimum number of Safety Officers and Safety Supervisor as well as their qualification aspects shall be adhered to for all the stages of the Project. Non-compliance in this regard was brought out and site was asked to explain the reasons for the same urgently and take action for complying with the notifications immediately. Subsequently, site had taken steps to ensure compliance.
- Due to Tsunami event of December 26, 2004 sea water had ingressed into the Unit 1 intake structure construction area from the east and west end of the temporary dyke where the height of the dyke was less than the rest of the dyke. The estimated maximum rise in sea water level during the incident reported was about 2m above MSL in comparison to Design Basis Flood Level of 7.5 m above MSL. Beside the dyke area, water had flown on to the approach road to mini port for a length of about 50m and receded immediately. Areas of the temporary dyke having lower height have been raised after pumping out the collected water.

FBRP

Inspection team visited to the site on December 29, 2004 to have an "on the spot" assessment of the impact of tsunami. There was no damage to the Site Assembly Shop and the Batching Plant. The compound walls of the site on east and north-east side had got damaged and foundation pit of NICB raft was flooded. Huge quantity of sand, muck, etc. got carried to the pit. Construction equipment in the pit got buried in the sand/muck and damaged. Subsequently, measures were taken in a planned manner towards dewatering, muck-removal and restart of NICB raft construction with the required design changes.

FBRP : NICB Pit after Tsunami

FBRP : NICB Pit after Rehabilation

2.1.4 Industrial Safety

Regulatory Inspections on fire and industrial safety aspects were carried out in KAPP- 3&4, TAPP-3&4, KK-NPP and RAPP- 5&6. In each case, a detailed inspection report was sent to the concerned Unit with the major shortcomings highlighted. The major recommendations made are the following.

a) Issue of height pass cards to all workers working at height.

b) Width of working platform at all places should be a minimum of 1 m.

c) The shortage of manpower in industrial safety should be filled at the earliest.

d) First aid centre should not remain unmanned at any time.

e) The wind-warning meter for tower cranes, should be made functional.

g) Fire retardant coating on control and power cables, should be applied.

f) Illumination levels should be measured and improved.

2.2. NUCLEAR POWER PLANTS AND RESEARCH REACTORS

Safety review and monitoring operating Nuclear Power Plants (NPP) and research reactors is carried out by the Operating Plants Safety Division of AERB. The Safety review committee for Operating Plants (SARCOP), the apex committee for overseeing safety of operating plants, held 24 meetings during the calendar year 2004.

The SARCOP Meeting in Progress

The Unit safety committees established under SARCOP have also met a number of times to review safety related issues. The information on number of meetings conducted by various Unit safety committees during 2004 is given in Table- 2.3.

Table- 2.3: Meetings of Unit Safety Committees

Name of Safety Committee	Number of Meetings
TAPS Safety Committee	6
RAPS-MAPS Safety Committee	15
NAPS-KAPS Safety Committee	18
KGS-RAPS-3&4 Safety Committee	10
IGCAR Safety Committee	6
CESCOP	7

2.2.1 Authorisations and Restrictions

All the NPPs and research reactors operated safely. During the year, SARCOP has reviewed a number of applications from the utilities and issued authorizations/ clearances. Important among these are the following

1. Permission for restart and operation of RAPS Unit-1 after safety upgradation.
2. Periodic Safety Review and Renewal of Authorization for operation of KAPS Units.
3. Renewal of authorisation for operation of RAPS Unit 2, RAPS Units 3&4 and KGS Units 1&2.

Based on the safety reviews, SARCOP also stipulated restriction on operation of plants as follows:

1. Suspension of operation of KAPS Units 1&2 for investigations and implementation of corrective measures, following the incident of uncontrolled increase of reactor power in KAPS Unit 1 on March 10, 2004.
2. Suspension of construction activities in the spent fuel storage facility being built at RAPS, following the fatal accident of a construction worker.

Safety status of individual NPPs and research reactors is briefly described below:

2.2.2 Tarapur Atomic Power Station

TAPS Units were operational up to a power level of 160 MWe. TAPS Unit 1 was shutdown for refueling and in-service inspection from November 21, 2004 to December 16, 2004.

Upgradation of TAPS Units-1&2:

TAPS Units-1&2, the boiling water reactor based NPPs, were commissioned in the year 1969. As stipulated by AERB, a comprehensive safety review for continued operation of the Units was completed in the year 2003. The details on the reviews were given in the AERB annual report for the year 2003-2004. Based on these reviews, a number of safety upgradations were identified for implementation to enhance the safety status of these Units towards meeting the present day safety requirements. Important among these are (a) modification in the emergency power supply system for the station inclusive of new diesel generators of higher capacity and Unit-wise segregation of power supplies (b) segregation of shared systems such as shutdown cooling system and fuel pool cooling system, (c) addition of an independent set of CRD (Control Rod Drive) pumps to strengthen the emergency feed water supply to the reactor, (d) addition of a supplementary control room and (e) upgradation of fire protection system. As per a mutually

agreed action plan, these modifications will be implemented in TAPS, during a long shutdown of both the Units planned from June 2005.

Subsequently, AERB reviewed the progress made towards implementation of the identified upgradations. It was found that all the activities related to the upgradations including detailed engineering, procurement and civil construction of new buildings as required are progressing as per schedule. All the activities related to ageing management, which are mainly inspection jobs, have progressed as per schedule.

2.2.3 Rajasthan Atomic Power Station

As reported in the previous years, RAPS Unit 1 which was shutdown on April 30, 2002 for safety upgradations and inspection of various systems/equipment was permitted to restart after extensive reviews by AERB, in January 2004. The Unit was restarted on February 8, 2004 and was operational up to 100 MWe. The Unit is however remaining shutdown since October 2004. RAPS Units 2,3&4 operated normally during the year.

RAPS Unit-2 and 3 were under annual shutdown from July 6, 2004 to August 15, 2004 and from August 15, 2004 to September 16, 2004 respectively, for maintenance, inspection and surveillance activities.

Status of RAPS-1

RAPS Unit-1, the first Pressurised Heavy Water Reactor based NPP in India, was commissioned in the year 1971. In the year 2002, AERB had stipulated that a detailed ageing assessment of systems, structures and components of the Units and upgradations in some of the safety systems should be carried out for continued operation of the Unit. The Unit was shutdown on April 2002 for ageing assessment and upgradation activities. After extensive review of the safety upgradations and results of inspection of various systems, structures and components of the plant, AERB granted permission for restart of the RAPS Unit-1 in January 2004. The performance of the Unit since restart in February 2004 has been generally satisfactory. There were eight outages mainly on account of leakages of heavy water from the PHT system. Due to this, the Unit registered low capacity and availability factors of 38% and 58% respectively. After the initial problems, the performance of the Unit improved and the Unit operated steadily between May 2004 and August 2004. The Unit was shutdown on September 9, 2004 to attend to heavy water leaks from PHT system. After rectification of these leaks, the Unit was restarted on October 5, 2004. The Unit was again shutdown on October 9, 2004, after observing light water leaks in the boiler room. The source of the leak was identified to be the weld joints in the blow down tap off lines on the secondary side of some of the boilers. The Unit continues to remain in shutdown and no attempts were made to repair the leaks and restart the Unit.

As no plan was forthcoming for restart of RAPS Unit-1, AERB took stock of the status of the Unit in December 2004. It was given to understand that NPCIL corporate office is reviewing the status of the Unit and decision regarding resumption of operation would be on the basis of this review. After review of the matter, AERB spelt out the following regulatory position.

- Till the final decisions regarding further operation of the Unit is arrived at, the plant systems shall be maintained in accordance with the Technical Specifications and Station Policies, including the surveillance, monitoring and the inspection requirements. The Plant systems, which are not in operation by virtue of the Unit shutdown, should be maintained in mode of 'preservation' to ensure that they do not undergo undue deterioration during the prolonged outage.
- In case it is decided to continue operation of the Unit, further restart and operation shall be subject to a detailed safety review and clearance by AERB.
- If it is decided to permanently shutdown the Unit, a detailed plan for decommissioning should be prepared and authorisation for taking up this activity should be sought from AERB. Submissions should also be made to AERB regarding the proposed surveillance and monitoring regime that will be followed for ensuring safety during the interim period till the decommissioning activity is taken up.

Renewal of authorisation for RAPS Units-2, 3 & 4

AERB reviewed the applications for renewal of authorisation (ARA) of RAPS Units- 2, 3 & 4. In view of the satisfactory overall safety performance, the authorisation for further operation of these Units were renewed. The authorisation for operation of RAPS Units 3&4 was renewed for a period of three years, up to October 31, 2007.

However in the case of RAPS Unit-2, while the overall safety performance has been satisfactory, the

reviews brought out some important issues such as the need for health assessment of feeders in the primary coolant system, need for reduction of tritium content in the primary coolant system for reducing the internal exposures to occupational personnel, the need for structured programme for ageing management, etc. NPCIL was asked to formulate the action plans to resolve these issues in a time bound manner. Pending resolution of these issues, the authorisation for operation of RAPS Unit-2 was renewed by AERB for a period of one year, up to end of August 2005. Renewal of authorisation beyond August 2005 shall be subject to satisfactory progress made towards resolution of the identified issues.

Fatal Accident at the Construction Site of Away From Reactor Spent Fuel Storage facility at RAPS and Suspension of Construction Activities:

An Away From Reactor (AFR) wet storage facility is being constructed at RAPS site to meet the requirement of safe storage of radioactive spent fuel generated from RAPS reactors. Construction activities for the project began in the year 2003. On March 19, 2004, an employee of the contractor involved in the construction activities met with a fatal accident due to fall from a height of about 15 m. On investigation and review of the incident, AERB observed certain deficiencies in the management of industrial safety at the construction site, which required immediate intervention, such as the following.

- Unsafe working conditions e.g. use of improper scaffoldings & platform without guardrail while working at a height.
- Absence of a system for assessment of workers for their ability to work at height.
- Non-availability of safe working procedures and monitoring & enforcement of use of personal protective equipment.
- Inadequate deployment of safety staff by the project management.
- Non-deployment of safety staff by the contractor in his work force.

Taking serious note of these deficiencies, AERB directed immediate suspension of construction activities at the AFR project and asked the project authorities to take necessary corrective measures. Subsequently, RAPS has taken various steps to address the deficiencies, which were verified by a team of inspectors from AERB. After detailed review of the steps taken, AERB had permitted resumption of construction activities at AFR, on May 17, 2004.

2.2.4 Madras Atomic Power Station

MAPS Unit 2 operated normally during the year.

MAPS Unit 1 is remaining under shutdown since August 10, 2003, for en-masse coolant channel replacement and safety related upgradation activities.

En-Masse coolant channel replacement and upgradation of MAPS Unit-1:

MAPS Unit 1 is under shutdown since August 10, 2003, for en-masse coolant channel replacement. Presently the job of cutting, removal and disposal of the old Zircaloy-2 coolant channels from the reactor is in progress. This will be followed by inspection of reactor components to ascertain their condition and reinstallation of new coolant channels of Zirconium-2.5% Niobium alloy. During this outage, a number of safety related upgradations would also be incorporated in this Unit, as was done in MAPS Unit 2 earlier. These include

- Retrofitting of high pressure injection in emergency core cooling system.
- Incorporation of Supplementary Control Room for use in case the main control room becomes un-inhabitable.
- Incorporation of sensitive leak detection system for coolant channels.
- Upgradation of fire/smoke detection system.
- Installation of fire barriers, fire walls/doors in critical areas.
- Segregation of power and control cables for safety related systems to reduce the potential for common cause failures.

With these upgradations, the safety provisions in MAPS Unit-1 will meet the requirement of current standards in many areas. All these upgradations are being reviewed extensively by AERB, for their acceptability. Taking advantage of the current long outage, NPCIL has also proposed to implement some modifications which will improve the performance and availability of the Unit, as was done earlier in the case of MAPS Unit-2. These include:

- Replacement of hairpin heat exchangers of steam generators.
- Installation of moderator inlet spargers in the calandria for restoration of the original moderator flow configuration.

A dedicated Review Group of AERB is carrying out review and follow-up of safety aspects related to en-masse coolant channel replacement and other upgradation jobs in MAPS Unit1.

Impact of Tsunami on MAPS

The Tsunami waves, caused by the massive earthquake off the coast of Sumatra that hit the east coast of India on the morning of December 26, 2004, affected the operation of MAPS Units, located at Kalpakkam. At the time of the incident, MAPS Unit-2 was operating at 215 MWe. Unit-1 of MAPS was under long shutdown for en-masse coolant channel replacement and safety upgradations, since August 2003.

Following the Tsunami, the water level in the seawater pump house of the plant had risen causing tripping of Condenser Cooling Water (CCW) pumps. The operator manually tripped the turbine-generator, noticing the unavailability of these pumps. Following this, the reactor tripped automatically. Subsequently, the reactor was brought to cold shutdown state by following the emergency operating procedure.

The increase in water level in pump house during tsunami made all the seawater pumps located in this area unavailable except for one process seawater pump, which was utilised for cooling the stations loads in the initial period following reactor shutdown. Subsequently, this pump also became unavailable due to choking of the traveling water screen in the seawater pump house due to heavy ingress of debris caused by the tsunami. Further, cooling of the reactor of MAPS Unit-1 and different loads were achieved by using the firewater system. Though the offsite power remained available throughout the event, Emergency Diesel Generators were started and kept running as a precautionary measure. The plant declared an emergency alert at 1025 h on December 26, 2004, which was lifted at 2143 h on December 27, 2004. The tsunami did not affect the activities in MAPS Unit 2, which was under shutdown. There was no loss of human life or any significant loss of property at MAPS site due to Tsunami.

Subsequent to the Tsunami, as a measure of abundant caution, a detailed radiation survey was carried out at the plant site. As expected, the radiation levels in and around the plant areas were found normal.

An inspection team of AERB visited MAPS and other IGCAR facilities at Kalpakkam on December 29, 2004 to ascertain the impact of Tsunami.

In MAPS, the vital areas of the plant such as Reactor Building, Turbine Building, Service Building, Switch yard, water treatment plant, etc were unaffected by the Tsunami. The damages caused by the Tsunami were limited only to the peripheral areas, such as damage to the cement-brick wall at the plant periphery on sea side and inundation of roads on the east side of turbine building. The jetty of the plant did not suffer any structural damage. A sampling tank installed at the entrance of jetty for collecting the liquid effluents sample got dislodged. A part of the cement brick enclosure provided over the radwaste discharge line on the southern side of the jetty structure was washed away. The portion beyond this was intact. About 60 m length of two out of the three HDPE lines provided for chlorination at the seawater intake structure, laid along the southern edge of the jetty were also washed away. None of the IGCAR facilities were affected by Tsunami.

After a detailed review of the impact of tsunami, AERB permitted restart and operation of MAPS Unit-2. After completion of the restoration of the affected areas, the Unit was restarted on January 1, 2005.

The Tsunami has brought out some important issues, which need detailed review and follow up in the context of safety of NPPs in the event of natural calamities. The telecommunication links to MAPS and Kalpakkam site had suffered severe degradation as the telephone exchange of Kalpakkam was damaged due to Tsunami rendering it unavailable. In the light of this experience, NPCIL has been asked to augment the communication facilities at Kalpakkam site and examine the need for providing diverse and reliable communication channels at NPP sites.

As per the AERB requirement, during siting and design of NPPs, the impact of various potential external events on the safety of the installation is required to be assessed and necessary provisions are incorporated. Tsunami is one such external event considered for NPPs located at the coastal sites in India. The present requirements specified in this regard are in the form of general guidelines with respect

to the flooding level. AERB has decided to review the experience of recent Tsunami and factor the new insights appropriately into the design requiremnts for nuclear facilities at coastal site.

2.2.5 Narora Atomic Power Station

Both Units of NAPS operated normally during the year. NAPS Unit-1 was under annual shut down from June 30, 2004 to September 17, 2004, for maintenance, inspection and surveillance activities.

Special watch on NAPS

The special watch instituted on NAPS by AERB in August 2003 was continued. Under this special watch, AERB has conducted two special inspections of NAPS in February and July 2004 in addition to the regular inspections. These inspections indicate that NAPS has made significant improvements in the area of radiation protection & collective dose reduction and enhancement of security of the plant. Progress was also made towards improving the condition of access roads to NAPS.

Life Management of Coolant Channels in NAPS

NAPS reactors employ coolant channels with Zircaloy-2 pressure tubes having four loose fit garter spring spacers. These pressure tubes on prolonged service in the reactor, undergo degradations due to hydrogen pick up. These pressure tubes may have a lifetime of about 10 to 12 full power years if the pressure tube and the associated Calandria tube do not make contact. If the pressure tube and Calandria tube do come in contact, the safe service life could be affected significantly. This necessitates implementation of a comprehensive life management programme for coolant channels, which involves periodic health assessment of thorough in service inspection, post irradiation examination, estimation of hydrogen pick up and other associated activities.

NAPS Unit-1 has so far completed more than 9.1 EFPYs of operation. As part of life management program for coolant channels. In Service Inspection was carried out for 106 coolant channels and hydrogen pick up assessment by sliver samples was performed for 12 pressure tubes, during the annual shutdown of the Unit during July-September 2004. Based on the information generated from these campaigns and subsequent health assessment of the coolant channels AERB permitted operation of NAPS Unit-1 for a further period of 300 'hot operating days', which is expected to be over by end of July 2005. NPCIL has proposed to take up En-masse Coolant Channel Replacement (EMCCR), thereafter.

A comprehensive in service inspection and life assessment of coolant channels is also planned for NAPS Unit-2 in April-May 2005.

Health of PHT Feeders

The thinning of elbows in the feeder pipes in primary heat transport system of PHWR has been observed in several of the Units. The assessment indicates that the rate of thinning in some of the feeders is 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 induced erosion-corrosion of the feeder pipe. Due to this concern, the scope and coverage of in service inspection feeders have 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. However, in some cases it may limit the safe service life of the feeder and may need replacement.

For NAPS Unit-1, a comprehensive inspection and life assessment of feeders were carried out during its annual shutdown in July-September 2004. Though the results indicated that there was no immediate safety concern, NPCIL has proposed replacement of feeder elbows during the forthcoming long outage of the Unit for EMCCR from August 2005.

2.2.6 Kakrapar Atomic Power Station

Both Units of KAPS were operational. KAPS Units 1 and 2 remained shutdown during the period from April 22 to June 5, 2004 and from May 22 to June 18, 2004 respectively, as stipulated by AERB for investigation and implementation of corrective measures following the incident of uncontrolled increase in reactor power.

Periodic Safety Review for Renewal of Authorisation for operation of KAPS:

As per the existing requirements of AERB, the Authorization for operation of Nuclear Power Plants needs to be renewed once in three years, based on a limited scope review called ARA. Apart from this, a very comprehensive review known as Periodic Safety Review (PSR) has to be conducted every 9 years. The scope and requirements of PSR and the criteria for renewal of authorisation for

continued operation of the Nuclear Power Plant are specified in the AERB Safety Guide on 'Renewal of Authorisation for operation of NPPs'. PSR requirements for safety assessment take into account improvements in safety standards and operating practices, cumulative effects of plant ageing, modifications, feed back of operating experience and development in science and technology.

As per the requirement of PSR, the NPP is required to carry out a comprehensive review covering the 'Safety Factors' identified in the guide. The purpose of the review is to identify strengths and shortcomings of the NPP vis-à-vis the requirements of current standards. Modifications or upgrades required to compensate for safety significant shortcomings are also proposed. AERB reviews the report on the PSR and the adequacy of the proposed action plans for satisfactory resolution of the shortcomings. Based on these reviews and assessments, the renewal of authorisation for operation of the NPP is considered.

Earlier, the authorisation for operation for KAPS was renewed based on review of ARA, in the year 2001 and was valid up to July 14, 2004. KAPS and NPCIL carried out the PSR and sought renewal of authorisation beyond July 2004. The PSR was subjected to a thorough regulatory review by SARCOP and AERB.

The reviews indicated that the operational performance of KAPS has remained satisfactory over the years. The review has also brought out some issues, which will require resolution in satisfactory manner within reasonable time frame. Important issues identified pertain to:

- Radiological conditions and collective dose
- Light water leakage from Calandria Vault of KAPS Unit-1
- Frequent failure of adjuster rod drives in KAPS Units and rehabilitation of stuck adjuster rod in KAPS Unit-2
- Compliance to ISI requirements
- Status of PHT feeders
- Life management of coolant channels
- Revision of Safety Analyses
- Equipment Qualification and Ageing Management programmes
- Configuration Management
- Tritium contamination in ground water at KAPS site.

KAPS and NPCIL have committed to resolve these issues within a time frame mutually agreed with AERB. After taking stock of the overall reviews of PSR, AERB granted renewal of authorisation for KAPS for a period of three years i.e. up to July 2007.

Incident of uncontrolled power rise at KAPS-1 due to failure of reactor regulating system:

An incident involving failure of reactor regulating system resulting in uncontrolled increase in reactor power had taken place in KAPS-1 on March 10, 2004. The reactor power increased slowly and the reactor automatically tripped on high power, as intended in design. The incident did not cause any damage to the plant and there were no radiological consequence. However, the incident indicated weaknesses in the areas of safety culture. The initial investigations and analyses could not adequately explain the reasons for increase in the reactor power encountered during the incident. Noting this anomaly, as a measure of abundant caution, on April 21, 2004, AERB had asked the affected Unit to be maintained under safe shutdown state till the underlying phenomena that resulted in this event is clearly understood.

Further detailed investigations and analyses could explain the behaviour of the reactor during incident to the satisfaction of AERB. It was explained that at the time of the incident, the reactor was being operated in a 'peaked flux configuration' in stead of normally followed 'flattened flux configuration'. This was adopted as a policy of NPCIL in all PHWR based reactors to maximise the utilisation of natural uranium fuel. Due to this, there has been significant increase in the average core fuel burn up from about 3000 MWD/T to 4900 MWD/T. This had affected the magnitude of inherent reactivity feedback coefficients, which when taken into account in the analyses could explain the behaviour of the reactor during the event.

The review of the incident and investigations in AERB brought out several shortcomings/lapses on the part of KAPS and NPCIL management. Important among these were:

- Failure of NPCIL management to impress upon the station management and operators, the implications of reactor operations at lower power with peaked flux configuration.
- Failure to readjust the limiting safety system setting for the reactor in accordance with its permitted power level for operation.
- Failure of the operator to promptly take note of unavailability of reactor regulating system.

- Inappropriate operator action, which led to inhibition of automatic actuation of ALPAS (Automatic Liquid Poison Addition System) during the event.
- Failure on the part of operator to manually trip the reactor even after observing uninhibited increase in reactor power.
- Failure to implement the design modification in the reactor regulating system in KAPS, to address potential for common cause failure, though the same was identified and corrected in other Units.

A number of corrective measures were identified to address the deficiencies observed in this event and to improve the safety culture and operating practices in NPCIL and its stations. These involved modifications in hardware, procedures, training and management systems. AERB had stipulated that the operations of both KAPS Units could be permitted only after all the identified short-term measures were completed. As directed by AERB, KAPS Unit-2 was also shutdown on May 21, 2004. After ascertaining the satisfactory implementation of the measures, which included refresher training and relicensing of operating and management personnel of KAPS, AERB permitted restart of the Units in the first week of June 2004.

2.2.7 Kaiga Generating Station

Both the Units of Kaiga Generating Station operated normally during the year.

Renewal of authorisation for KGS Units-1&2.

AERB reviewed the applications for renewal of authorisation (ARA) of KGS Units- 1&2. In view of the satisfactory overall safety performance, the authorisation for further operation of these Units were renewed. The authorisation for operation of KGS Units 1&2 was renewed for a period of three years, up to May 31, 2007.

2.2.8 Indira Gandhi Centre for Atomic Research (IGCAR)

Fast Breeder Test Reactor (FBTR)

FBTR remained shutdown for a major part of 2004, for replacement of certain equipment and overhauling of turbine generator. After completing these jobs, reactor was restarted in October 2004 and was operational up to a power level of 15 MWth.

Burn-up limit for FBTR fuel

The fuel used in FBTR consists of a mixture of Plutonium carbide and Uranium carbide. Since the experience on the performance of this fuel is limited, the burn up limits on this fuel is being increased in steps after careful review of the fuel performance (The fuel 'burn-up' in nuclear reactor refers to the energy extracted from the fuel before it is discharged from the reactor). Post Irradiation Examination (PIE) of the irradiated fuel sub-assemblies is carried out to study the in-reactor behavior of the fuel and to ascertain the permissible safe burn-up of this fuel. The last of such PIE was done by IGCAR on a fuel subassembly removed from FBTR after it has undergone irradiation of about 100 Gigawatt-day/tonne (GWd/t). After detailed review of results of this PIE and the life assessment based on the same, AERB permitted irradiation of FBTR fuel up to a maximum burn-up of 150 GWd/t.

Kamini

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

Authorization for reprocessing irradiated FBTR fuel pins in Lead Mini Cell (LMC) Facility at IGCAR:

Fast reactor fuel reprocessing, being a complex technology is being implemented in stages. These include testing of equipment and systems in the engineering laboratory and then integrating them in a hot cell for radioactive runs.

FBTR fuel reprocessing is being carried out in the Lead Mini Cell Facility (LMC), which is a pilot plant set up in Reprocessing development lab of IGCAR. The objective of this LMC is mainly to validate the process and equipments developed so far.

Earlier AERB had authorized four campaigns of reprocessing of low burn-up FBTR fuel pins in LMC in stages. Since then, IGCAR has completed these campaigns successfully and requested for authorisation 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 two more campaigns of reprocessing at LMC.

2.2.9 Regulatory Inspections

Regulatory Inspections of Operating Nuclear Power Plants and Research Reactors is carried out periodically to,

- check for any radiological and industrial unsafe conditions existing at the Nuclear Power Plants/ Research Reactors,
- confirm the plant operation is as per the approved Technical Specifications and AERB/ SARCOP directives, and other safe practices.

- 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 inspections have been rectified.

The regulatory inspections 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 also been prepared by AERB. The draft manual is presently under review by the Advisory Committee for preparation of Code and Guides on Governmental Organization for Regulation of Nuclear and Radiation Facilities (ACCGORN). Presently regulatory inspections are carried out once in six- months, for nuclear power plants and once in a year for research reactors. Due care is taken in planning to ensure that the inspections cover all the following aspects, at least once in a year.

- Adherence to requirements and procedures for reactor start-up, shutdown and normal operation.
- Reactor physics and fuel management.
- Compliance to surveillance requirements.
- Reliability of safety and safety related systems.
- Maintenance activities, in service inspections and quality assurance.
- Radioactive waste management.
- Maintenance of emergency preparedness.
- Health and environmental aspects.
- Training of personnel.
- Industrial and fire safety.

During the calendar year 2004, a total of 21 inspections were undertaken in the operating NPP and research reactors, of which 17 were routine and pre-planned as per the regulatory inspection programme. The remaining 4 were special inspections. Two special inspections were carried out at NAPS as per the requirement of the board. One special inspection was carried out at KAPS to review the power transient incident. One inspection was carried out at MAPS after Tsunami incident (to check the status of the plant). Inspection of LMC also included as a part of regular inspection from 2004 .

The observations made during the inspections are categorized into 5 different groups depending upon their significance, as given below.

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	Short comings 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.

Category wise distribution of observations made during the inspections of various plants in 2004 is given in Table-2.4 below.

Table 2.4: Categorization of Deficiencies Observed During Inspections

UNIT	Number of Inspections		Cat -I	Cat -II	Cat -III	Cat -IV	Cat -V
	Planned	Special					
TAPS-1&2	2	0	1	9	3	43	11
MAPS	2	1	1	4	1	36	13
RAPS -1&2	2	0	0	9	4	56	8
NAPS	2	2	0	6	0	36	15
KAPS	2	1	0	4	7	31	10
KGS-1&2	2	0	0	1	4	13	21
RAPS-3&4	2	0	0	3	3	32	16
RAPPCOF	1	0	0	0	0	1	1
FBTR & KAMINI	1	0	0	1	2	22	11
LMC	1	0	0	0	0	1	3
Total	17	4	2	37	24	271	109

Some of the important observations made during the regulatory inspections and the follow up actions taken are summarized below.

1. At KAPS the fire detectors in moderator room were found failing very frequently and causing spurious alarm. These detectors were failing due to radiation field. Station has installed additional detectors at locations away from the pump, the performance of these detectors is under review.

2. At KGS-1, during monthly test of ECCS, failure of a check valve occurred and the test was aborted. Station had not met the surveillance requirement and this was not reported.

3. At MAPS-2, power supply of 415 V MCC-M was lost during plant operation. The supply was restored after 47 minutes, during this period ECCS remained unavailable and so the Technical Specification requirement was violated.

4. At MAPS-2, some of the instruments (neutron power, channel temperature monitoring, ECCS pressure transmitters) were not calibrated within the time period as specified in Technical Specifications.

2.2.10 Licensing of Operating Staff

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

2.2.11 Significant Events

It is obligatory for all operating NPPs to report promptly to the Regulatory Body, certain events happening in the plant which have or may have impact on operational safety. Under the reporting system established by AERB, the events reportable to the regulatory body are divided into two categories termed as,

a) Events and

b) Significant Events

This categorization depends on the safety significance and importance to operational safety experience feedback. Based on the reporting criteria, NPP submits Event Reports (ER) and Significant Event Reports (SER).

The SERs received from the operating NPPs are also rated on the International Nuclear Event Scale (INES). The INES system of the International Atomic Energy Agency (IAEA) rates events at seven levels (1 to 7) depending on their safety significance. The accident at Chernobyl nuclear power plant 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

Table 2.5: Licensing of Operating Personnel

Plants	No. of Candidates cleared for the Positions						Licensing Committee Meetings
	Management	SCE	ASCE	ASCE(F)	CE	CE(F)	
TAPS	-	3	-		1	-	1
RAPS 1-2	3	2	-	2	6	2	1
MAPS	-	4	5	2	8	2	2
NAPS	2	6	4	2	6	1	2
KAPS	-	7	2	3	4	3	3
KGS	1	3	5	2	8	2	2
RAPS 3-4	-	2	4		1	1	1
FBTR	-				1	4	1
Total	6	27	20	11	35	15	13

Abbreviations : SCE: Shift Charge Engineer; **ASCE:** Asst. Shift Charge Engineer; **CE:** Control Engineer; **CE (F)**: Control Engineer Fuel Handling

Table-2.5: Licensing of Operating Staff

at level 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 in Fig.2.1.

The number of SERs for each year from 2000-2001 and their ratings on INES are given in Table-2.6. In the year 2004, a total of 44 significant events were reported from the operating plants. In the year 2003, the number of significant events was 42. RAPS-1, which was under long shutdown from April 30, 2002 to February 8, 2004, had four SERs since February 2004. The classifications of SERs for the year 2004 on INES scale is given in Table-2.7. One event (at KAPS) was rated at level 2 on INES. The details of this event is given in section 2.2.6. The system wise classification of SERs in NPPs is given in Fig. 2.2.

There were a total of four events rated at level 1 on INES. Two events, one each at MAPS and RAPS 3&4, were rated at level 1 because of exposure of temporary workers beyond their annual limit of 15 mSv. The exposures to temporary workers were lower than the limits prescribed by AERB for the departmental workers.

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

INES Levels	2000-2001	2001-2002	2002-2003	April-Dec 2003	2004
Out of Scale	2	0	0	0	0
0	42	43	26	21	39
1	10	2	5	10	4
2	0	0	1	0	1
3	0	0	0	0	0
>3	0	0	0	0	0
Total	**54**	**45**	**32**	**31**	**44**

Table-2.7: Classification of SERs in Individual NPPs (2004)

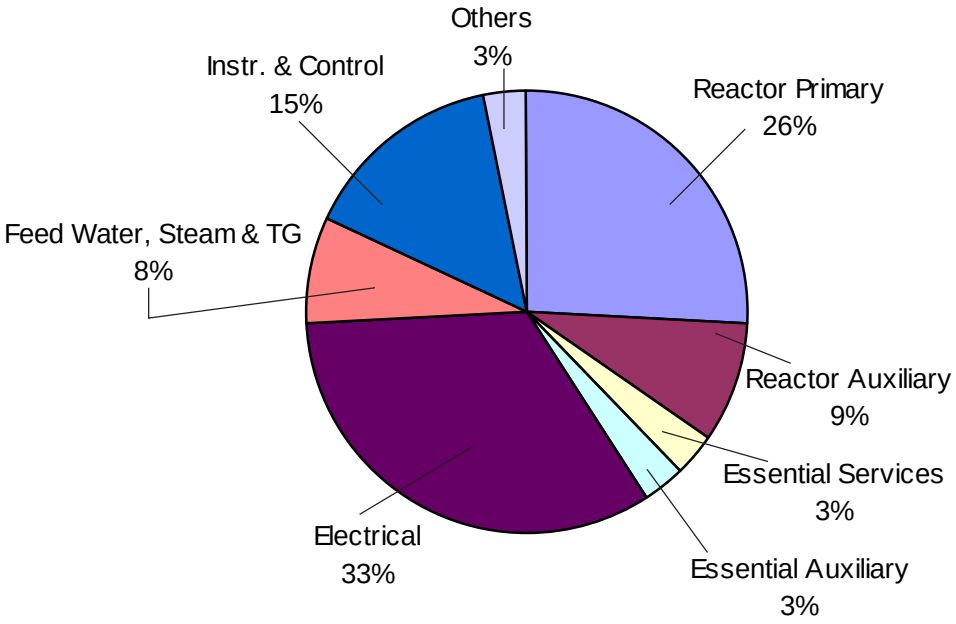
Plant Name	Out of Scale	International Nuclear Event Scale					
		0	**1**	**2**	**3**	**> 3**	**Total**
TAPS		0	0	0	0	0	0
RAPS 1&2		10	1	0	0	0	11
MAPS		3	1	0	0	0	4
NAPS		5	0	0	0	0	5
KAPS		5	1	1	0	0	7
KAIGA		9	0	0	0	0	9
RAPS 3&4		7	1	0	0	0	8
Total	**0**	**39**	**4**	**1**	**0**	**0**	**44**

Table-2.6: Classification of SERs in NPPs as Rated on INES

Figure 2.1: 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	

Figure 2.2 : System Wise Classification of SERs in NPPs (Year 2004)



There were seven events where deviations from Technical Specifications requirements were noticed. Out of these, three events were at KAPS and two each at RAPS 3&4 and KGS 1&2. Some of these are given below.

1. In an event at KAPS-1, unintended reactor power increase took place. Prior to the event, KAPS-1 was operating at a power level of 70 % full power. While carrying out certain maintenance work, power supply to all the adjuster rods of the reactor regulating system failed and the regulating rods became inoperable. Further, operator inhibited the automatic liquid poison addition system to prevent addition of the boron poison to the moderator which could have arrested the reactor power rise. The reactor power rise could not be arrested by the regulating system and reactor tripped at a power level of 98 % full power. The reactor trip settings were corresponding to 90 % full power as against the operating power level of 70% full power. The incident reflected weakness in plant safety culture and highlighted the need to improve safety practices further. The event was rated at level 2 on INES.

2. On June 14, 2004, another event of reactor power rise took place at KAPS-1 during refuelling of a coolant channel. The reactor regulating system rods were not in position to compensate for positive reactivity addition due to refuelling. Operator further raised the reactor demand power, which prevented the addition of boron poison to the reactor. The event was rated at level 1 on INES.

3. In an event at RAPS-2 during Unit start up, subsequent to partial loss of class IV power supply failure, reactor was tripped manually. The event was rated at level 1 on INES, as there was a procedural deficiency, which allowed reactor to remain operational under 2 % full power without an automatic trip.

4. At RAPS-4, during surveillance testing, one of the redundant ECCS valve was found not operating. It was not possible to rectify the valve during Unit operation. Since this was not in accordance with Technical Specifications of the plant, the plant management was directed to shutdown the Unit and rectify the problem.

5. AT KGS-2, ECCS nitrogen gas accumulator got slightly depressurised during monthly surveillance testing. This

accumulator is used for light water injection under pressure to the PHT system during loss of coolant accident. ECCS accumulator remained depressurised for three hours while the Unit was operating. This resulted in deviation from Technical Specifications of the plant.

2.2.12 Industrial Safety

Regulatory Inspections on fire and industrial safety aspects were carried out in NAPS, RAPP-1 to 4, KAPS-1&2 and KGS-1&2. The major recommendations made are the following:

a) Replacement of faulty fire/smoke detectors.

b) Implementation of procedure for initial and periodic inspection/testing of portable tools.

c) Caution board on both the sides of the overhead line.

d) Investigation of first aid injuries by Safety Officer.

e) Regular checking of eye wash fountain in chlorination plant.

f) Relocation of diesel pipelines from day tank to DG set away from cable trays.

2.3 FUEL CYCLE FACILITIES AND OTHER NUCLEAR FACILITIES

Review and monitoring of safety status of fuel cycle facilities and other Nuclear Facilities is carried out by the Industrial Plants Safety Division (IPSD) of AERB. The facilities being monitored by IPSD include the Nuclear Fuel Complex, Heavy Water Plants, Indian Rare Earths Limited, Uranium Corporation of India Limited, Variable Energy Cyclotron Centre (VECC), Centre for Advance Technology (CAT), Board of Radiation and Isotope Technology (BRIT), Electronics Corporation of India Limited (ECIL), Atomic Minerals Directorate for Exploration and Research. In performing the safety review activities, the IPSD received assistance of various unit safety committees of these facilities, established by AERB, under the framework of SARCOP. Highlights on safety status and the reviews carried out with respect to these facilities are given below.

2.3.1 Nuclear Fuel Complex (NFC)

All the plants of Nuclear Fuel Complex, Hyderabad operated normally during the year. The radiological and industrial safety status of these plants has been satisfactory, in general. The Safety Committee of Nuclear Fuel Complex, Hyderabad (NFCSC) and SARCOP reviewed a number of proposals from NFC, during the year. The proposals were accepted after ensuring satisfactory compliance to the safety requirements. Important among these were:

- Proposal for processing and fuel fabrication from depleted uranium in Uranium Oxide Plant (UOP), Ceramic Fuel Fabrication Plant (CFFP), New Uranium Oxide Fabrication Plant (NUOFP).
- Proposal for commissioning of New Zirconium Sponge Plant (NZSP).

NFC has initiated construction of a new complex for production of Zirconium from ore and manufacture / fabrication of components of zirconium alloys, in order to meet the increased demand for the same, in the country. The facility is being set up at Palayakayal near Tuticorin in Tamilnadu state. Presently, IPSD, AERB and NFC Safety Committee are reviewing the Design Basis Report and the Application for authorisation for construction of the facility.

The Zirconium Sponge Plant (ZSP) building at NFC Hyderabad, which was in operation since 1971, had undergone significant degradation of its structural members due to prolonged exposure to various chemicals employed for the plant processes. After thorough review of structural safety of the building, AERB had suspended operation of ZSP from March 31, 2004. Subsequently NFC had proposed to take up extensive structural repairs to rehabilitate the building, so that life of the plant could be extended. After extensive review of the proposal with respect to the stability of the building vis-a-vis rehabilitation methodology, quality assurance and safety plans, NFC was permitted to take up the repairs in the building. After repairs and necessary testing, the building is expected to be ready by July 2005. AERB had stipulated that apart from structural repairs, NFC should undertake upgradations in the plant, covering equipment, ventilation and safety measures. After rehabilitation and upgradations, restart and operation of ZSP will be subject to safety review and clearance from AERB.

2.3.2 Heavy Water Plants (HWP)

The Heavy Water Plants at Kota, Manuguru, Tuticorin, Thal and Hazira operated normally during the year. Re-commissioning of the Heavy Water Plant at Baroda, which had undergone major modifications in the process

systems (HWP- Baroda Revival Project), was completed in July 2004. The plant is now operating steadily. HWP (Baroda) has now made an application to AERB for authorisation for regular operation. Review of this application is presently in progress, along with the operational experience during and after commissioning.

The Heavy Water Plant, Manuguru has a coal fired Captive Power Plant (CPP) to supply energy as well as steam required for production of heavy water. The fly ash generated from the plant is stored as slurry, in the two ash ponds constructed near the HWP premises. On January 17, 2004, there was an incident of breach in the bund of ash pond number 1, resulting in escape of fly ash slurry from the pond into the public domain. The escaped slurry found its way into the nearby fields and in the river Godavari through connecting nallahs. About 19.5 acres of cultivated land and 8.5 acres of barren land were affected. The slurry discharge was brought under control by the morning of January 19, 2004. Considering the damage to the crop and cultivated lands in the nearby areas, Heavy Water Plant had disbursed compensation to the affected villagers as advised by the District Collector on January 31, 2004.

Based on investigations, it was established that the failure of the bund was due to improper drainage provision of water from the ash pond. This deficiency led to accumulation of excess water in the pond and the resulting hydrostatic pressure initiated the failure. As a short-term measure, Heavy Water Board had worked out and implemented a scheme for repair of the affected portion of the bund of ash pond and also construction of a decanting structure for proper drainage of water from the pond. These jobs were completed before onset of monsoon of 2004. The scheme for strengthening the remaining portion of the ash pond bunds as well as a programme for periodic maintenance & surveillance of the bunds, are being worked out as long-term measures. Pending completion of these long-term measures, further pumping of ash slurry to ash pond no.1 will not be permitted.

On January 23, 2005 at 1700 hrs, an incident of failure of coal transfer ropeway had taken place at Heavy Water Plant, Manuguru. The incident took place near Toggudem village on the road to Manuguru railway station. The track rope of the ropeway had broken in section 5 of the ropeway, resulting in fall of 21 buckets to the ground. No persons were injured in the incident. Subsequently after replacing the affected wire rope and implementation of the recommendations of the committee, which investigated the event, HWP was allowed to restart the ropeway operations. One of the important steps taken subsequent to the failure was augmentation of the maintenance and inspection requirements for the ropeway system.

2.3.3 Indian Rare Earths Limited (IREL)

The IREL plants at Chatrapur, Manavalakurichi, Chavara and Udyogamandal operated normally during the year. The Safety Committee for IRE plants (IRESC) and SARCOP reviewed the safety status of the plants and certain proposals. The proposals were accepted after ensuring satisfactory compliance to the safety requirements. Important permissions / clearances issued for IREL plants were:

- Interim clearances for retrieval and processing of thorium concentrate stored in the silos at IRE Udyogamandal, for recovery of uranium, in Project THRUST (Thorium Retrieval, Uranium recovery and Storage). The clearances were issued in two occasions, initially for retrieval and processing of 300 tons of thorium concentrate and subsequently for retrieval and processing of additional 1000 tons of thorium concentrate. These clearances were issued after extensive reviews and implementation of a number of modifications in the plant systems including total revamping of ventilation system, as stipulated by AERB.
- Clearance for re-packing of thorium concentrate from corroded Mild Steel drums to HDPE Jumbo bags at IGCAR and construction of 2 more trenches at IRE OSCOM (Chatrapur), for monazite storage.

2.3.4 Uranium Corporation of India Ltd. (UCIL)

Meetings of the UCIL Safety Committee (USC) and Advisory Committee for Project Safety Review of Fuel Cycle Facilities were held to review the following documents/reports and made recommendations/authorisations.

- Safety Committee reviewed the Environment Impact Assessment (EIA) report, Safety Report and Radiological Assessment of Banduhurung opencast mining report. These reports were further deliberated in the meetings of ACPSR-FCF. UCIL submitted the data required by ACPSR-FCF through the document " Appraisal of Environmental Management, Banduhurung Mine". Both USC and ACPSR-FCF visited the site. Subsequently the proposal was further discussed in the Board meeting and based on the recommendations of ACPSR-FCF, authorization was issued for operations of the mine to UCIL.

- UCIL has carried out manganese mapping around Jaduguda by taking five sets of readings throughout the year. However, a final report indicating the possible reason for higher manganese value at ETP outlet is awaited.
- Safety Committee reviewed the Tumallapalle Exploratory Mining Project in Andhra Pradesh. AERB approved exploration of ore upto 200 Tons and transport the same to Jaduguda for pilot plant study, subject to certain stipulations.
- The Environmental Impact Assessment and Ventillation reports of Bagjata mine were reviewed by USC.

2.3.5 Licensing of Plant Personnel

Licensing Committee for licensing of operating personnel for Heavy Water Plants met at HWP -Kota, Thal, Hazira, Manuguru and Tuticorin and authorised/re-authorised 89 operation personnel.

2.3.6 Regulatory Inspections

Regulatory inspections on industrial safety aspects were carried out during 2004-2005 under the Atomic Energy (Factories) Rules, 1996 in the following plants, that is, Heavy Water Plant-Baroda, Talcher, Thal, Hazira, Manuguru, Tuticorin, Nuclear Fuel Complex- Hyderabad, Indian Rare Earths Ltd.,-Udyogmandal, Indian Rare Earths Ltd.-OSCOM, Indian Rare Earths Research Centre-Kollam, Indian Rare Earths- Chavara, Indian Rare Earths-Manavalakurichi, Uranium Corporation of India Ltd.Jaduguda, Turamdih, Bagjata Mines, & Jaduguda Mill, Board of Radiation and Isotope Technology, Jonaki-Hyderabad, Board of Radiation and Isotope Technology, ISOMED, Electronics Corporation of India Ltd., Atomic Minerals Directorate for Exploration and Research, Gogi site, Center for Advance Technology, Indore, Variable Energy Cyclotron Centre, Kolkata.

In each case, a detailed inspection report was sent to the concerned Unit highlighting the observed deficiencies. Some of the major recommendations made by AERB to HWPs, NFC, IREL are as given below:

Heavy Water Plants

- Fire header leakages should be identified and rectified at the earliest.
- Provision of automatic sprinkler system for fire mitigation on the 8 MVA, 10MVA, 25 MVA transformers as per 'Standard of Fire Protection Systems of Nuclear Facilities'.
- Hydro testing of pressure vessels to be carried out as per the provisions of Rules 35 of the Atomic Energy (Factories) Rules, 1996.
- In the Nitrogen Plant, acetylene, hydrocarbons and impurities contained in air and liquid air should be analysed periodically as per methods provided by supplier.
- Testing and examination of lifts should be carried out once in a period of six months.
- The ISI document should be reviewed and updated based on the existing loops of the plant.
- Illumination level in the belt conveyor area of Captive Power Plant (CPP) should be maintained as per Atomic Energy (Factories) Rules, 1996.
- For filling of Breathing Air set (B. A. set) cylinders greater than 50 numbers, a license from Department of Explosives should be obtained.
- Procedure for testing and examination of slings should be established.
- Staff strength in fire station should be augmented as per AERB's 'Standard of Fire Protection Systems of Nuclear Facilities'.

Nuclear Fuel Complex

- The Limiting Condition of Operations (LCO) and Limiting Safety System Settings (LSSS) mentioned in the technical specifications should be adhered to in NUOFP (O).
- Illumination and noise levels should be measured periodically and values to be recorded.
- Frequency of Sectional Level Safety Committee meetings should be improved.
- Interlocks on the machine should always be kept in line.
- Damaged tiles in some of solar evaporation ponds should be replaced.
- Integrity of HDPE lining should be checked.

Indian Rare Earths Plants

- In IREL, Udyogmandal, the operation manual should be prepared as per the new procedure based on THRUST project.

- Stack monitoring for radioactive elements should be done periodically in Mineral Separation Plants.
- Interlocks should be provided for burner system of dryers in Mineral Separation Plants.
- Analysis should be done in Thorium Plants for TBP in Thorium nitrate solution.
- Periodic training should be conducted on fire fighting and first-aid.
- Hydro testing of air compressor-heat exchangers/vessels should be done as per Atomic Energy (Factories) Rules, 1996.
- Painting of corroded structures should be done periodically.
- Spillage should be controlled in the mineral separation plant.
- Fire hydrant systems should be hydro tested periodically.

Uranium Corporation of India Ltd.

- Pulmonary function test should be carried out for workers exposed to dust in mill & mine
- Radiological Safety Officer and Industrial Safety Officer should be appointed.
- Use of radon dosimeters by miners should be ensured.
- The staff strength of Health Physics Unit should be augmented in view of the new projects.
- Appointing safety officers, one for all mines and one for Jaduguda Mill.

2.3.7 Siting Committee for Fast Breeder Fuel Cycle Facility, IGCAR (SER/FRFCF)

The Siting Committee for Fast breeder Fuel Cycle Facility at IGCAR met twice during this period to review the site evaluation report for the facility. Two working groups have been constituted by the committee for the in-depth review of the documents submitted in this regard.

Working Groups of SER/FRFCF reviewed the documents submitted in relation to the ground motion parameters, flood level, design basis wind speed, geotechnical parameters, atmospheric dispersion modeling, hydro-geological investigations, etc. The interim review report of the working group was submitted to SER/FRFCF.

2.4 OTHER NUCLEAR FACILITIES

2.4.1 Variable Energy Cyclotron Centre (VECC)

VECC & CAT Safety Committee discussed the following reports/issues pertaining to VECC.

- Compliance report of regulatory inspection.
- Approval for siting the 30 MeV 500 μA Medical Cyclotron at Chakgaria, West Bengal.
- Safety Report on Radiation Ion Beam Facility at VECC.
- Safety Report on Super Conducting Cyclotron Facility.
- Status of access control system and the revised Safety Report of the existing Cyclotron.
- Pending issues like formation of a dedicated Safety Organisation and competent persons.
- Health Physics Reports.

Some of the important recommendations of the regulatory inspections carried out were formation of Safety organisation, installation of fire detectors, submission of Safety Reports.

2.4.2 Centre for Advanced Technology (CAT)

VECC - CAT Safety Committee discussed the following issues pertaining to CAT.

- Proposal for operation of Indus-I was discussed and based on discussions in VCSC, AERB has issued license for operation of Indus-I for a period of three years.
- Proposal for trial operation of 15 Mev Free Electron Laser–Linear Accelerator (FEL-LINAC)) was reviewed and Chairman, AERB approved the proposal for a limited period.
- Safety Committee reviewed the proposal for extension of authorisation for trial operation of 750 keV DC and Chairman, AERB granted the authorization for one year.
- A proposal for increasing the beam energy of Indus-I booster synchrotron from 450 Mev to 700 MeV was reviewed and Chairman, SARCOP granted the authorisation.
- Request for transporting the 700 MeV Beam from

Booster Synchrotron of Indus-1 to TL-3 upto Indus-2 was discussed by VCSC. The proposal has been forwarded to SARCOP.

- Proposal for trial operation of stage II, III, and IV of 10 MeV Electron Linear Accelerator (LINAC) at CAT Indore was discussed and Chairman, AERB approved the proposal.
- Chairman, AERB approved for siting and design of Agriculture Radiation Processing Facility at CAT, Indore.
- Health Physics Reports.

Regulatory Inspection of CAT, Indore was carried out in September 2004 and February 2005. Some of the important recommendations were; identification of critical parameters for operation of Indus I and Indus II and specify the same in the technical specifications, identification of equipments that require emergency power supply in Indus I and Indus II, authorisation of operators for regular operation of Indus II, implementation of permit to work before injecting beam to Indus-II and increase in the strength of qualified Safety Officers and Fire Staff.

2.4.3 Board of Radiation and Isotope Technology (BRIT)

Regulatory inspections of BRIT, Jonaki-Hyderabad and ISOMED, BRIT on industrial safety aspects were carried out during 2004. Some of the important recommendations were;

- The Local Safety Committee should meet at frequency of once in three months.
- The structural stability of the lower houseroom in BRIT-Jonaki should be reviewed.
- A dedicated health physicist should be available.
- Illumination level at various work places in the plant should be maintained as per Rule 11(1) of the Atomic Energy (Factories) Rules, 1996.
- The fire hydrants and associated valves should be tested at periodicity of one month as required by the AERB fire standard.
- The ISOMED plant should carry out reassessment studies of all the safety parameters and report should be submitted to AERB for future extension of life of the plant.

2.4.4 Electronics Corporation of India Ltd. (ECIL)

Regulatory inspection of Electronics Corporation of India Ltd. Hyderabad was conducted. The major recommendations are the following.

- Increase in the strength of qualified Safety Officers.
- License from a competent authority under Gas Cylinder Rules, 1981 should be obtained for storing LPG and hydrogen in the plant premises.
- The civil structural integrity of the plating shop of NID should be ascertained and the safety of the building should be ensured.
- Competent persons under sections 6, 21(2), 36 & 41(c) should be appointed.
- Fire Hazard Analysis should be carried out for NID, MID etc.
- Provision of automatic sprinkler system for fire mitigation of oil filled transformers above 5MVA, as per AERB's 'Standard of Fire Protection Systems of Nuclear Facilities'.

2.4.5 Atomic Minerals Directorate for Exploration and Research

Regulatory Inspection was carried out on August 19, 2004 at Gogi site. The major recommendations are the following.

- To measure noise level at rig installation and conduct audiometric tests of the crew members yearly if noise level exceeds 85 decibels.
- To provide first aid and fire fighting training to some of the crewmembers.
- Proper storing of diesel drums with provision of fire extinguishers in storeroom.

2.5 ENFORCEMENT OF THE FACTORIES ACT, 1948

2.5.1 Approvals Granted

Approval was granted to Competent Persons under various sections of the Factories Act, 1948 in the following Units.

1) Eight persons of Tarapur Atomic Power Project-3&4.

2) Three persons of BHAVINI

3) One person of Kaiga Generating Station.

4) Three persons of Heavy Water Plant-Thal.

5) Two persons of Heavy Water Plant-Baroda.

6) Six persons of Heavy Water Plant-Manuguru

7) One person of Indian Rare Earths Ltd. – Chavara.

8) Two persons of Indian Rare Earths Ltd. – Manavalakurichi

9) One person of Variable Energy Cyclotron Centre.

10) Five persons of Kudankulam Nuclear Power Project.

11) One person of Heavy Water Plant-Hazira

12) Two persons of Heavy Water Plant-Tuticorin.

2.6 SAFETY UP-GRADATIONS

● An expert group was constituted by Chairman, AERB to review the uranium content in the drinking water. The group has submitted their report to AERB.

A discussion meeting on "Enhancement of Industrial Safety in DAE Units" was held in AERB on July 15, 2004. The use of appropriate fall protection devices and job hazard analysis in construction sites was discussed. AERB decided to look into the possibility of various types of fall protection devices in the market and their suitability for different jobs and circulate the information to all Units. A report is drafted on two main aspects i) Classification of fall protection device equipment depending on the use at different situations ii) Information on supplier and certification on various types of safety belts available in market and the specific purposes for their use. A report has also been drafted regarding the listing of jobs for Job Hazard Analysis in construction site.

CHAPTER 3
SAFETY SURVEILLANCE OF RADIATION FACILITIES

3.1 SAFETY REVIEW OF RADIATION EQUIPMENT AND TRANSPORT AND DISPOSAL OF RADIOACTIVE MATERIAL

The radiation facilities in India can be broadly classified as Medical, Industrial and Research. Medical facilities include diagnostic X-ray machines, telegamma units, linear accelerators, brachy-therapy units and nuclear medicine centers practicing diagnosis and therapy. Industrial installations include gamma and X-ray radiography equipment, gamma radiation processing plants, ionising-radiation gauging devices (nucleonic gauges) including well logging devices and facilities manufacturing certain consumer products. Research installations include universities and other research institutes handling a variety of sealed and unsealed radiation sources, high-energy particle accelerators and X-ray facilities for research purposes.

The various radiation installations and radiation devices, which are regulated by AERB as on December 31, 2004, are shown in Table 3.1.

Table-3.1: Radiation Installations Regulated by AERB (as of 31.12.2004)

S.No.	Type of Application	No. of institutes	No. of Devices in Use	
1	Diagnostic X-ray	~ 30,000	~ 35,000	
2	Radiotherapy	209		
	Teletherapy		Telecobalt	267
			Telecesium	5
			Accelerators	55
			Gamma Knife	3
				330
	Brachytherapy		HDR	65
			LDR	37
			Manual (Intracavitary)	76
			Manual (Interstitial)	29
			Opthalmic (^{90}Sr)	20
			Opthalmic (^{125}I)	1
			Opthalmic (^{106}Ru)	1
				229
3	Nuclear Medicine		Not applicable	
	● RIA Centres	437		
	● Diagnostic Centres	101		
	● Therapy Centres	25		
4	Research	585	Not applicable	
5	Industrial radiography	454		
	● Radiography cameras		1191	
	● X-ray units		210	
	● Accelerators		9	
6	Gamma Irradiators	8	NA	
7	Nucleonic Gauges	1364	~ 7000	
8	Consumer Products			
	● Gas Mantle	61		
	● Lamp starters	22		
	● Smoke detectors	95	Not applicable	

3.1.1 Type Approval of Equipments and Devices

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 radiation devices, issued by AERB. The Safety Review Committee for Application of Radiation (SARCAR) examines the design safety features of each device and recommends issuance of Type Approval. The SARCAR held four meetings during the year and based on its recommendations AERB issued 358 Type Approval Certificates to the manufacturers / suppliers of devices incorporating radioactive materials and radiation generating equipment. A list of the devices Type Approved during the year is given in Table 3.2.

Table-3.2: Type Approvals Granted in 2004
(Radiation Generating Equipment and Equipments Containing Radioactive Material)

Sr. No.	Type of Equipment	Number of Approvals
1	Medical diagnostic X-ray Units	234
2	Mammography Units	3
3	Bone Densitometers	1
4	Radiotherapy Simulators	1
5	Computed Tomography (CT) Units	12
6	Combined PET-CT Units	2
7	Telegamma Therapy Units	3
8	Gamma Knife Units	1
9	Medical Linear Accelerators	8
10	Remote Controlled after-loading Brachytherapy Units	3
11	Gamma Chambers	4
12	Install and Operate Gamma Radiation Processing Plants	1
13	Nucleonic Gauging Devices (IRGDs)	54
14	Ionisation Chamber Smoke Detectors	1
15	Baggage Inspection Systems	6
16	Encapsulation for Sealed Sources for Transport	3
17	Industrial Gamma Radiography Exposure Devices	3
18	Industrial X-ray Units	1

3.1.2 Approval of Radiological Safety Officers

During the year, Approval Certificates were issued in respect of 271 Radiological Safety Officers (RSOs). The break-up is given in Table 3.3.

Table-3.3: Approval Certificates Issued for RSOs

Sr. No.	RSO Level	Number Approved
1	RSO Level-III (Medical)	119
2	RSO Level-III (Industrial radiography)	11
3	RSO Level-II (Industrial radiography)	13
4	RSO Level-II (Nuclear medicine diagnosis)	31
5	RSO Level-I (Nucleonic gauges)	76
6	RSO Level-I (Research applications)	21

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. However, all Type B (U)/(M) packages are subjected to a stringent approval procedure and are required to fulfill the regulatory standards. Details of Type Approval certificates issued by AERB during the year are given in Table 3.4.

3.2 LICENSE / AUTHORISATION AND REGULATORY INSPECTION

3.2.1 Licence / Authorisation

Clearances were accorded to 5 sites for construction of radiation processing facilities and design approval was

Table-3.4: Package Design Approvals

Sr. No.	Identification Mark	Package Identification	Gross Weight (Kg.)	Source And Activity
1	IND/021/B (U) T-96	COF-100	5000	Co-60 3700 TBq (100KCi)
2	IND/016/B (U) T-96 Rev-1	BRIT Lead Container BLC-100	5000	Co-60 3700 TBq (100KCi)
3	IND/020/B (U) T-96	Install and Operate Irradiator	18700	Co-60 14.8 PBq (400 KCi)
4	IND/02/B (M), Rev-06	Gamma Chamber GC-900	3000	Co-60 185 TBq (5000 Ci)
5	IND/04/B (M), Rev-06	Gamma Chamber GC-4000 A	5360	Co-60 370 TBq (10,000 Ci)
6	IND/011/B (M), Rev-04	ROLI-1 (Serial numbers 91001to 91059)	37	Ir-192 1.3 TBq (35Ci)
7	IND/011/B (U)-96, Rev-04	ROLI-1 (Ser. numbers 94060 and up)	37	Ir-192 1.3 TBq (35 Ci)
8	IND/012/B (U)-96, Rev-2	Gamma Chamber GC-5000	7000	Co-60 518TBq (14000Ci)
9	IND/013/B (U)-96,Rev-2	Blood Irradiator BL-2000	3830	Co-60 30 TBq (810 Ci)
10	IND/014/B (U)-96, Rev-2	PANBIT Flask FP-100k	5500	Co-60 3700 TBq (100KCi)
11	IND/017/B (U)-96, Rev-1	Low Dose Irradiator LDI-2000	3830	Co-60 30 TBq (810 Ci)
12	IND/018/B (U)-96,Rev-1	Gamma Chamber GC-1200	4600	Co-60 185 TBq (5000 Ci)

given for an Electron Beam Accelerator at Radiant Cables, Hyderabad. License for operation was issued to the high capacity gamma radiation processing plant of M/s Organic Green Foods Ltd., Kolkata.

AERB issued a number of Licenses (in English and Hindi) as Certificate of Registration to diagnostic X-ray installations upon confirming that the applicable regulatory requirements are duly satisfied. Details of licenses / NOCs issued for procurement, export and disposal of radioactive sources during the year are given in Table 3.5.

Table-3.5: Licences / NOC Issued

A. Procurement of Source

Sr. No.	Type of application	Licenses/NOCs/Registrations issued	
		Local	Import
1	Diagnostic X-ray	325	—
2	Radiotherapy		
	● Telecobalt	14	8
	● Telecaesium		0
	● Accelerators		11
	● Gamma Knife		0
	Brachytherapy		
	● HDR		67
	● LDR		0
	● Manual (Intracavity)	5	0
	● Manual (Interstitial)		0
	● Opthalmic Sr-90	2	0
	● Opthalmic I-125		0
	● Opthalmic Ru-106		2
	● Check Sources		
	● **Total**	**21**	**88**
3	**Nuclear Medicine**		
	RIA facilities	10	191
	Diagnostic	25	93
	Therapeutic	28	75
	Research	99	92
4	Industrial Gamma Radiography Exposure Devices	769	0
5	Gamma Irradiators	3	0
6	Nucleonic Gauges	69	135
7	**Consumer Products**		
	● Gas Mantle		10
	● Lamp starters		5
	● Electron capture devices		45
	● Smoke detectors		24

B. Export and Disposal of Sources

Nature of consent	Export		Disposal of sources		
	By BRIT	By other user	At BRIT	At WMD, BARC	At CWMF, Kalpakkam
Authorization	30	45 (Disused Sources)	186	377	26

3.2.2 Shipments Approved under Special Arrangement

Consignments which do not meet with all the applicable requirements of the transport regulations due to specific reasons, may be transported under special arrangements which includes the provision of compensatory operational controls so that overall level of safety in transport shall be at least equivalent to that which would be provided if all the applicable requirements had been met. During the year 2004, 12 shipments were approved to be transported under special arrangement.

3.2.3 Regulatory Inspections

Particulars relating to regulatory inspections carried out during the year are given in Table 3.6.

In such inspections, sometimes one finds non-compliance with the regulatory requirements. The generic non-compliance observed during inspection includes carrying out of radiation practices at unauthorised sites, inadequate security measures for radiation sources, non-availability of emergency handling tools, inadequate / non-availability of quality assurance devices, non-availability of safety accessories for handling sources, non-availability of personnel monitoring services to radiation workers, non-availability of qualified and trained staff, alteration of approved lay out plan of the facility without approval, etc.

The non-compliances with regulatory provisions observed during inspection are reviewed in the AERB Standing Committee for Investigations of Unusual

Table-3.6: Regulatory Inspections in 2004

Sr. No.	Type of Application	No. of Institutes existing	No. of Inspections Carried out
1	Diagnostic X-ray No of Units Surveyed	~ 35,000	18 212
2	Radiotherapy	209	6
3	Nuclear Medicine RIA centres Diagnostic centres Therapy centres	 437 101 26	 — 35 3
4	Research	585	3
5	Industrial Radiography	454	Surprise: 16 Planned: 46 Total: 62
6	Gamma Irradiators	8	6
7	Nucleonic Gauges	1364	15
8	Consumer Products ● Gas Mantle ● Fluorescent Lamp starters	 62 22	 8 4

Occurrences in Radiation Facilities (SCURF), which meets at least once in two months. SCURF investigates unusual occurrences and recommends appropriate regulatory actions for enforcement based on radiological consequences. 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 installation.

3.3 RADIOLOGICAL SAFETY SURVEILLANCE

3.3.1 High Intensity Gamma Radiation Processing Facilities

The following gamma radiation processing facilities are operating in the country for sterilisation of healthcare products and preservation of food products. AERB carried out inspections of the gamma radiation processing facilities listed at S.No.1 to 5, during 2004.

1. Radiation Sterilization and Hygenisation of Medical Products (RASHMI), Bangalore.
2. Raksha Anusandhan Vikas Irradiator (RAVI) facility, Defence Laboratory, Jodhpur.
3. Shriram Applied Radiation Centre (SARC), Delhi.
4. Radiation Processing Facility, BRIT, Vashi, Navi Mumbai.
5. Isotope in Medicine (ISOMED), BRIT, Mumbai.
6. Radiation Vulcanisation of Natural Rubber Latex (RVNRL), Rubber Boad, Kottayam.
7. Panoramic Batch Irradiation Technology (PANBIT), Thiruvnathapuram.
8. Vikiran (Organic Green Foods Limited) Kolkata

Based on the inspections, AERB gave general directions to improve the status of radiological and industrial safety at these facilities. These include adherence to the preventive maintenance schedule for safety systems, availability of adequate number of certified personnel, augmentation of radiation monitoring systems and updating of emergency response plans.

Three new multipurpose gamma radiation processing facilities are under construction in the country. AERB issued permission for installation of these facilities at the following sites,

1. M/s Universal Medicap, Vadodara.
2. M/s Microtrol Sterilization, Bangalore.
3. M/s Five Star Iso Radio Technic Private Limited, Chennai.

The Safety Committee for Gamma Radiation Processing Plant (SCOGRAPP) held five meetings during the period to monitor safety status of operating gamma radiation processing plants and reviewed design of five new facilities. The compliance with the requirements stipulated in the AERB Safety Code on Operational and Land Based Stationary Gamma Irradiators was verified. SCOGRAPP recommended approval to the modifications in the design of source rack and conveyor system at M/s Shriram Radiation Application Centre, Delhi. The modifications in these safety system have been carried out to improve operational performance of the facility without compromising built-in-safety features in the design. SCOGRAPP has recommended the reassessment studies of all the safety parameters of ISOMED facility for the extension of the plant., as it was commissioned in 1974. SCOGRAPP has carried out detailed review of design of five new radiation facilities, mainly to verify and assess the compliance with requirements stipulated in the AERB Safety Standard entitled, "Radiological Safety for the Design and Installation of Land-Based Stationary Gamma Irradiators". The Task Group for Review of Dosimetry for Food Irradiation has carried out inspection of the radiation processing facility at Vashi, Navi Mumbai, twice in the year 2004 as required under the Atomic Energy (Control of Irradiation of Food) Rules, 1996. It was confirmed that dosimetry results for radiation processing of spices was within the acceptable limits. The amendment to certificate of approval was issued to Board of Radiation and Isotope Technology, Mumbai for this facility after replenishment of source.

3.3.2 Radiation Diagnostic and Therapy Facilities

Six teletherapy and brachytherapy installations in the country were inspected. On the basis of pre-commissioning safety analysis, AERB issued authorisations for the commissioning of 19 radiotherapy units and 8 remote after-loading brachytherapy units during the year, and for the decommissioning of nine teletherapy and brachytherapy units. Permissions were accorded for re-starting four telecobalt and two accelerator facilities and three new radiotherapy centres. Thirty five

nuclear medicine facilities where unsealed radioactive materials are used for diagnostic and therapy purposes, were inspected. Licenses were issued to 8 new nuclear medicine laboratories. AERB inspected 212 medical X-ray diagnostic installations for confirming compliance with the regulatory requirements. Registration certificates were issued for 325 medical X-ray units. Deviations and violations of regulatory requirements, which were observed during the inspections, were taken up for appropriate actions, which induced suspension of license, in some cases.

3.3.3 Industrial Radiography

There are 454 industrial radiography facilities in India, employing 1191 industrial gamma radiography exposure devices. Since radiography work may be carried out only at authorised sites, authorised users seek AERB's permission for movement of their radiographic devices from one approved site / storage to another. During the year, a large number of source movements were approved for carrying out radiography activities at various sites. Sixty-two industrial radiography sites and installations were inspected for confirming compliance with the regulatory requirements. Each user is required to send monthly safety status reports. These reports were reviewed for confirming compliance with the regulatory requirements.

3.3.4 Nucleonic Gauging Devices

There is a significant growth in use of nucleonic gauges for measuring & monitoring various industrial parameters such as level monitoring, thickness gauging, density measurement, moisture detection etc. in 1364 different types of industries such as steel, paper, plastic, textile, cement, power, coal and oil exploration. AERB inspected over 230 nucleonic gauges used in 15 installations. Each user is required to submit six-monthly safety status reports. These reports were reviewed for confirming compliance with the regulatory requirements. Where discrepancies were observed, necessary clarifications were obtained. A database of the radioactive materials used in nucleonic gauging was compiled.

3.3.5 Manufacture of Consumer Products

Consumer products like Ionization Chamber Smoke Detectors (ICSD), fluorescent lamp starters and thorium gas mantles use very small quantities of radioactive materials and are manufactured by authorized installations. In order to maintain a high level of safety in the manufacturing units of such products, twelve inspections were conducted. It was found that the practices followed were in conformity with the regulatory requirements.

3.3.6 Transport of Radioactive Materials

Safety in transport of radioactive materials in public domain is ensured by strict compliance with the "Surveillance Procedures for Safe Transport of Radioactive Materials, 1987" and AERB Safety Code on "Transport of Radioactive Materials, 1986". Regulatory activities include safety assessment and package design approval for transport and renewal of package design approvals.

Twelve authorizations for transport of radioactive material were issued and three regulatory inspections of packages were carried out during the year. Testing of one Type B(U) packaging by BRIT and NPCIL was witnessed. AERB regularly communicates with other Government authorities for the safe transport of the radioactive material in and out of the country. The concerned nodal agencies are Director General of Civil Aviation, New Delhi, Port Trusts, Indian Railways, Airport Authority and Customs. Eleven recommendations were sent to port authorities for prompt clearance of the radioactive consignments arrived at Indian ports. Indian customs authorities are well informed about the requirements of the NOC from AERB for export/import of radioactive material by any private/Government organisations. Data on package design approvals issued by AERB were furnished to IAEA in the prescribed format for inclusion in the IAEA PACKTRAM database.

3.3.7 Disposal of Radioactive Sources

The users send decayed radioactive materials from medical, industrial and research institutes for safe disposal to one of the approved radioactive waste disposal facilities in India. The number of consignments transported for disposal were 44. Number of sources disposed off are:

Export to original supplier	75
Sources transferred to domestic supplier	186
Sources transferred to WMD, BARC (including 330 smoke detectors)	337
Sources transferred to CWMF, Kalpakkam	26

3.4 UNUSUAL OCCURRENCES

3.4.1 Industrial Radiography

Incident-1

An industrial radiography exposure device model Techops-660 with source having activity of 2.5 Ci of Ir-192 was stolen from pit room of one of the radiography institute. The incident was reported to AERB and immediate actions were initiated to recover the device. AERB experts recovered the source from one of the scrap dealer with the help of the police.

Follow Up Actions

a) Regulatory actions involving suspension of authorisation for procurement of radiography sources were initiated against the institute.

b) The damaged source pigtail (source capsule intact) is stored in a lead pot which is kept inside a storage room available with the radiography agency since it is in judicial custody of Trichy court and can not be disposed off till the case is over.

c) The institute was asked to implement enhanced security measures with prior approval of AERB to strengthen the physical security of all the radiography exposure devices.

Incident-2

A certified radiographer incurred radiation injury while carrying out the radiography work with exposure device model Techops 660 containing Ir-192 (~25 Ci) source. On enquiry, it was noted that radiographer got misled about the retraction of the source in the exposure device due to heavy rains at the site and handled the guide tube containing Ir-192 source with bare hand for about 10 minutes. He observed radiation burns on his hand after about 4-5 days. Radiographer did not use radiation survey meter to verify the retrieval of source in exposure device and he was not wearing personnel monitoring badges while doing radiography work.

Follow Up Actions

a) The Chromosome Aberration (CA) test of the radiographer was carried out at BARC. The test showed no biological detectable dose received by the radiographer.

b) The exposure device involved in the incident was withdrawn from radiography work and radiography work at the site of incident was suspended.

c) The institute was asked to submit the detailed radiation protection program to be followed to ensure adherence with safe work procedures in respect of industrial radiography practice.

Incident-3

Trainee radiographer received overexposure (46.7 mSv) while carrying out radiography work. He didn't use survey meter to verify retrieval of the source. At the time of incidence, the safety site-in-charge was working in the dark room and certified radiographer had gone out for some other work.

Follow Up Actions

a) The exposure device involved in the incident was withdrawn from radiography work and radiography work at the site of incident was suspended.

b) Certificates of certified safety site-in-charge and radiographer withdrawn.

c) Institute was directed to nominate the above trainee radiographer to undergo a training course on safety aspects of industrial radiography.

d) The institute was asked to prepare and submit the detailed radiation protection program followed by the institute to ensure adherence with safe work procedures in respect of industrial radiography practice.

3.4.2 Nucleonic Gauges

Incident -1

An over exposure occurred while carrying out the repair work of nucleonic gauge source housing 12 Ci Cs-137 source, used for thickness measurement of hot steel plates. The source housing was inadvertently removed from the gauge in order to rectify the problem associated with the pneumatically operated shutter mechanism. The personnel involved in repair work were unaware about the proper positioning of the source assembly inside the gauge and handled the source housing with source assembly close to bare hands during the repair work for a few minutes to an hour. Persons involved in the repair

work observed blackening of fingers/palms of both the hands. The incident occurred mainly because of violations such as repair work carried out without prior approval of AERB and in the absence of safety coverage provided by certified radiological officer of institution, survey meter and personnel monitoring badges not used by personnel.

Follow Up Actions

a) Chromosome Aberration (CA) test and visual examination of hands of exposed personnel was carried out by medical experts from BARC. The CA test confirmed a dose in the range of 25 mGy to 330 mGy to the persons involved in the repair work.

b) AERB arranged inspection of all the nucleonic gauges handled by the institute and issued show-cause notice conveying violations/unsafe procedures, which lead to this incident.

c) The institute was asked to nominate more personnel for safety training on regulatory aspects and radiation safety in handling the nucleonic gauges.

Incident -2

Nucleonic gauge containing about 190 mCi of Co-60 was sold to one of the steel scrap dealers. The device was laying unattended for a long time awaiting for the safe disposal. Inadvertently, the device was sold in auction to a scrap dealer. Subsequently, the scrap dealer cut open the device by gas cutting, which resulted in damage to the source capsule. This led to the side spread radioactive contamination of the premises of the scrap dealer. The incident occurred mainly because the user institute failed in monitoring the safe storage and security arrangement provided to nucleonic device awaiting for safe disposal. Further, there was considerable delay by the supplier of the source for collecting the source for disposal.

Follow Up Actions

a) Experts from AERB and BARC along with the representatives of supplier of source immediately visited the site of the incident and decontaminated the premises.

b) The contaminated soil and sand was collected and filled in 17 gunny bags and stored in an exclusive storage room.

c) AERB stopped the authorisation for the use of the gauge and issued notices to the supplier of the source and institute.

d) Waste generated from the incident has been safely disposed off.

3.4.3 Nuclear Medicine

Incident

A female patient aged 58 y died after administration of 256 mCi of I-131 for the treatment of thyroid cancer (metastasis) in the isolation ward of the hospital. The body burden at the time of death was estimated to be 90 mCi. Measured external radiation levels at the neck was 1.5 R/h; at the shoulder 900 mR/h; at 1 m away from the body 15 mR/h. 90 mCi activity exceeds the regulatory discharge limit for cadaver (10 mCi). In order to combat the social pressures from the relatives of the deceased, for the release of the body and sending it to Hyderabad for funeral, was permitted under controlled conditions to minimise radiation exposures to relatives and general public during transport to Hyderabad by road and subsequent burial of the body. Dose assessment indicated that no individual received more than 40 mR of radiation dose.

Follow Up Actions

As a follow-up of the incident, following points will be included in the AERB Safety Code on Nuclear Medicine Facilities, AERB/SC/Med-4, which is under review:

1. The attending nuclear medicine physician shall obtain informed consent from the relatives of the patients before performing high dose therapy.

2. Provision in the code will be made for release of body with higher activity under specific conditions. The RSO in consultation with the attending nuclear medicine physician shall obtain prior approval of competent authority for release of cadavers containing radioactivity exceeding the limits specified by the code.

3.4.4 Radiotherapy

Incident

AERB inspected one of the radiotherapy center to verify compliance with regulatory provisions in respect of use of teletherapy practice. Inspection revealed various

violations such as radiation instruments not in working conditions, non-congruence of radiation and optical field, non-conduct of QA procedures and non-return of unused Cs-137 tubes for disposal etc.

Follow Up Actions

AERB issued show-cause notice and thereafter directive suspending radiotherapy operations till the institute rectifies the discrepancies observed and demonstrates strict compliance with regulatory provisions.

3.4.5 Other Cases

a) Radioactive contamination was detected in remote after loading high dose brachytherapy sources. The unit is decommissioned and safely disposed off.

b) Thirty four unclaimed packages were collected from Delhi International Airport which were laying for more than 15 years and disposed off safely at BARC.

c) The guide tube of radiography exposure device was involved in fire, when the source was in exposed condition. Owing to prompt actions initiated by radiographer, the source was retrieved safely in the radiography device.

3.5. REVIEW OF NON-COMPLIANCE WITH REGULATORY PROVISIONS

3.5.1 Industrial Radiography

During inspections, it was observed that eight industrial radiography institutes violated the regulatory provisions stipulated for industrial radiography. These include carrying out radiography work at unauthorised sites, movement of industrial radiography devices from one site to another without obtaining prior permission from AERB, inadequate physical security for exposure device, overexposure to radiographers and non-availability of emergency handling tools. All these instances were investigated and enforcement actions were taken against such institutes such as issuance of warning letters, suspension of radiography work and authorizations to procure radiography sources for interim period, submission of detailed report on radiation safety programme being followed in defaulting institutes and withdrawal of the certificates of radiography personnel.

3.5.2 Radiotherapy Centres

Inspections of radiotherapy centres were conducted in many parts of the country. The instances of non-compliance observed include, inadequate quality assurance procedures, non-availability of basic quality assurance devices and dose measuring instruments, non-availability of accessories for handling brachytherapy sources, improper location of gamma zone monitors, non-availability of approved Radiological Safety Officers, non-submission of annual safety status report and presence of disused decayed radiotherapy sources. Enforcement actions taken against the defaulting institutes include, issuance of warning letters, revocation of license issued to operate teletherapy units and denial of fresh licenses until the safety status conformed to the regulatory standard.

3.5.3 Nuclear Medicine Centres

The instances of non-compliance with the regulatory requirements in nuclear medicine centers included non-availability of personnel monitoring services to persons, non-availability of nuclear medicine technologist, alteration of approved lay out plan of the facility, procurement of radioactive material without obtaining authorisation and transfer of radioactive material without approval. The enforcement actions taken against the defaulting institutes included, issuance of warning letters, suspension of licence issued to handle radioactive material and denial of licence to handle additional radioactive material until the safety status of the centre conformed to the regulatory standard.

3.6 OTHER ACTIVITIES

3.6.1 Handling of Naturally Occurring Radioactive Materials (NORM)

- Inspection of M/s Metallurgical Products (India) Pvt. Ltd., Taloja (MPIL) plant for extracting tantalum and niobium metals from Tantalite and Columbite ores was carried out.
- Application from M/s Seal Chemicals, Delhi for processing of tantalum and niobium metals from Tantalite and Columbite ores is being examined.
- A code on handling NORM was further discussed by the Safety Committee on NORM.

3.6.2. Accreditation of Laboratories

AERB developed an accreditation programme for institutes certifying the radioactivity content in commodities. AERB carried out the inspection of the

following laboratories for accreditation and issued accreditation certificates after ensuring compliance with recommendations made during inspections.

- Low Level Counting Lab, EAD, BARC, Mumbai
- ESL, HPD, BARC, Mumbai.
- ESL, MAPS, Kalpakkam.
- Laboratory at RSS, RSD, IGCAR, Kalpakkam

3.6.3 Training and Awareness Programmes

Members of AERB served as faculty in BARC training school and for the training courses for the Diploma in Radiological Physics conducted by RP&AD, BARC. Training programmes were conducted for X-ray service engineers, nuclear medicine technologists, medical physicist cum RSOs in radiation therapy facilities, technicians for radiotherapy and radiography facilities and for qualifying technicians and RSO's of gamma radiation processing facilities.

3.6.3.1 Awareness Programme for Manufacturers/ Vendors of Industrial Ionising Radiation Gauging Devices (IRGD)

On June 16, 2004, an awareness programme for manufactures & suppliers of IRGDs was organised. The main objectives of programme were i) to familiarize manufacturers / vendors of IRGDs/Nucleonic Gauges on current radiation safety and regulatory requirements ii) to explain the role and responsibilities of manufactures / vendors in implementation of radiation protection programme of AERB relevant to IRGDs and iii) to obtain feedback from them on existing regulatory procedures in ensuring radiation safety while handling IRGDs. The programme was attended by 35 representatives from manufacturers / suppliers of IRGDs in India and two representatives from abroad (England & Germany), BRIT, RPAD and AERB.

The deliberations brought out several recommendations such as

- conduct of such programs at least once in two years,
- organization of such programmes for the personnel from the Department of Customs, Airport and Port Authorities,
- circular to be issued to user institutes of IRGDs informing them to declare to AERB the possession of IRGDs/ radiation sources which are procured without the knowledge of AERB,
- organization of a joint meeting with representatives from AERB, the Directorate General of Civil Aviation (DGCA) and Manufacturers / Vendors of IRGD to discuss the procedures for air transport of IRGDs/Sources,
- the Board of Isotope & Radiation Technology (BRIT) to initiate measures, by interacting with manufacturers/ vendors, to make possible the indigenous availability of IRGDs/source/source assemblies, and
- manufacturers/vendors to keep track of end users to whom IRGDs are supplied and to ensure that the schedule for servicing and maintenance is adhered to and manufacturers/suppliers to provide information to AERB on the IRGDs/sources which are being used in industries without obtaining prior approval of AERB/ BARC or without any knowledge of regulations.

3.6.3.2 Special Meet for Users of Gamma Radiation Processing Facilities

A special meet for Users of Gamma Radiation Processing Facilities was organized on February 27, 2004. About 25 participants attended the meet consisting of senior representatives of the management, facility-in-charges, radiological safety officers, operators from various operating and new gamma radiation processing facilities. The deliberations during special meet brought out several recommendations such as conduct of exclusive training course for RSOs for gamma radiation processing facilities, arranging more number of training courses for operators, necessity for the amendment of "Atomic Energy (Control of Irradiation of Food) Rules, 1990 in respect of Technological Conditions & Qualifications of personnel, standardization of the deigns of radiation processing facilities by BRIT and improvement of safety culture among personnel of such facilities. Participants expressed that such special meets should be conducted at least once in two years to provide close interaction between users and the regulatory body.

3.6.3.3 Safety Awareness Programme on Radioactive Material on- Board the Ship

The Gujarat Maritime Board (GMB), Gandhinagar, requested Chairman, AERB, Mumbai to provide the guidance in the matter of radioactive substances contained in the ships due for breaking at Alang which is one of the biggest ship breaking yard in the world. The request came in line with the directive of the Hon'ble Supreme Court to GMB

to consult AERB in case of radioactive substances present in ships, which are brought to Alang for breaking. AERB conducted a 'One Day Radiation Safety Awareness Program on Radioactive Material (RAM) on Board the Ship' on June 3, 2004 at Recycling Yard, Alang, Bhavnagar. GMB invited the representatives of the Gujarat Pollution Control Board, Indian Ship Breakers' Association and Indian Coast Guard. There were altogether 25 participants in the awareness programme.

The lectures followed by lively discussions among the participants. A feedback response was collected from the participants. Some highlights of the feedback are i) periodic conduct training of such kind for the ship breaking industry including the workers ii) inclusion of the basic radiation safety in the syllabus of the training course conducted by GMB for the workers of ship breaking industry iii) installation of radiation monitors in the ports and premises of ship breaking companies and iv) preference of conducting such training courses in local language particularly for the workers.

There was a panel discussion at the end of the program. GMB expressed their desire to send some of their staff for training in BARC and the trained personnel be authorized by AERB to inspect and issue radioactivity free certificate to any ship due breaking at Alang.

A detailed radiological safety survey of a naval ship having five storeys and weight of 12000 tonnes and meant for breaking at the Alang Ship Recycling Yard, was also carried out in the morning of 3rd June 2004 and no radioactive material was found on the ship.

3.6.3.4 Workshop on Safe Transport of Radioactive Material by Air

In view of the fact that large number of radioactive consignments including those of short half-life sources used in medicines are transported by air, a one day workshop on the safe transport of radioactive material by air was organized by AERB. There were about 40 participants from air carries, Airport Authority of India, Customs and clearing agents in the workshop. The workshop was arranged to have a direct interaction among the different authorities/organizations involved with the transport of radioactive material so that they can have a better coordination among themselves to smoothen the safe transport of radioactive material by air.

3.6.3.5 Accreditation of Nuclear Medicine Technologists

To overcome the shortfall of trained nuclear medicine technologists for the nuclear medicine centres, it was agreed to accreditate science graduates having five years working experience in nuclear medicine centres through a three week training programme which would cover topics related to nuclear medicine technology, radiation safety aspects and other related topics. Two such courses were conducted through RP&AD, BARC (during November-December, 2004) of three weeks duration, for accreditation of science graduates with working experience in nuclear medicine departments. A total of 40 candidates appeared for the training programme out of which 32 successful candidates have been accredited to function as Nuclear Medicine Technologists.

In addition, an accreditation programme had been conducted by CMC, Vellore in Vellore during Nov 29 to Dec 11, 2004 in association with AERB and RP&AD, BARC for the DNMT candidates who have undergone their diploma course before 2004 following pre-revised syllabus. Eighteen candidates were accredited to function as nuclear medicine technologists through this programme. AERB officers were involved as faculty in the above training programmes.

3.6.3.6 Accreditation of Centres for Conducting Courses in Nuclear Medicine Technology

AERB has accredited the following two centres to conduct courses in nuclear medicine technology with prescribed syllabus. Each centre takes 6-8 candidates every year. Successful candidates from these centres are recognized by AERB to function as nuclear medicine technologist. Availability of nuclear medicine technologist is a mandatory requirement in nuclear medicine centres. Thus, about 15 candidates (to function as nuclear medicine technologist) each year since 2004 become available for nuclear medicine centres from the above programs.

1) Christian Medical College, Vellore – DNMIT (2 years) Diploma after BSc.

2) Manipal Academy of Higher Education, Manipal – BNMT (4 years) Bachelor Degree after Higher Secondary.

3.6.3.7 Certification Course on the Safety Aspects of the Beach Sand Mineral and NORM Industry

A certification course on the safety aspects of the beach sand mineral and NORM industry was organized at SRI, Kalpakkam by AERB in collaboration with Indian Association for Radiation Protection (Kalpakkam Chapter). This training program was arranged to train the personnel working in the beach sand mineral exploration to impart them the first-hand knowledge about radiation safety and to appoint a trained person as RSO in the institute so that appropriate regulatory controls can be applied by coordinating better with the appointed RSO. The participants were from Indian Rare Earths Ltd and other private industries. Altogether, there were seventeen candidates in the training course. All the participants successfully passed the examination and viva voce conducted at the end of the training course.

3.6.4 Safety Review Committee for Medical, Industrial and Research Accelerators (SCMIRA)

The above committees had two meetings each. The committee reviews the status of the accelerators and inspect them on regular basis. The break-up of accelerator facilities monitored by the committee are:

Medical Electron Accelerators	56
Medical Cyclotron Facilities	02
Industrial Accelerators	14
Research Accelerators	19
Industrial Accelerators for Radiation Processing	02

3.6.5 Committee for Procedural Amendment of the Atomic Energy (Control of Irradiation of Food) Rules, 1996.

The Department of Atomic Energy constituted a committee for procedural amendment of the current Atomic Energy (Control of Irradiation of Food) Rules, 1996 as recommended by the National Monitoring Agency, Government of India. Committee consisted of experts from Atomic Energy Regulatory Board, Bhabha Atomic Research Centre, Board of Radiation & Isotope Technology, Department of Atomic Energy and the Food & Drug Administration, Government of Maharashtra. About 10 meetings were held in the Atomic Energy Regulatory Board office to revise the above rules. The final draft rules entitled, "Atomic Energy (Radiation Processing of Food and Allied Products) Rules 2004." have been prepared and would be forwarded to the Department of Atomic Energy for further action.

CHAPTER 4
ENVIRONMENTAL SAFETY AND OCCUPATIONAL HEALTH AND SAFETY

4.1 ENVIRONMENTAL SAFETY

The Environmental Survey Laboratories (ESL) of the Health, Safety and Environment Group, BARC carry out environmental surveillance of all the operating plants under DAE. The radioactivity released to the environment during the year 2004 from the operating units was only a small fraction of the prescribed Technical Specification limits. Fig.4.1a-4.1e show the liquid and gaseous discharges from the plants. Data for previous years is also included for comparison. Fig.4.2a and 4.2b show the committed dose to the members of public due to release of radioactive effluents from the plants. Radiation dose to members of the public near the operating NPPs is estimated based on measurements of radionuclides concentration in terms of diet, i.e., vegetables, cereals, milk, meat, fish, etc. and through intake of air and water. It is seen that in all plants the effective dose is much less than the AERB yearly dose limit of 1 mSv.

4.2 OCCUPATIONAL EXPOSURES

No worker in industrial plants of DAE (IRE-Udogamandal, IRE-Chavara, IRE-Manavalakurichi, IRE-OSCOM, NFC and UCIL) received radiation dose greater than the Investigation Limit of 20 mSv during the year 2004.

The number of workers who received radiation doses between 20 mSv and 30 mSv (Annual regulatory limit is 30 mSv) during the years 1999-2003 in industrial plants of DAE is given in Table 4.1 and for NPP during the year 2000 to 2004 are given in Fig. 4.2a. Radiation dose received by workers in medical, industrial and research institutes are given in Table 4.2b.

Table-4.1: Number of Workers in Industrial Plants of DAE Who Received Radiation Exposure between 20 mSv (Investigation limit) and 30 mSv (Annual Limit)

Year	1999	2000	2001	2002	2003
IRE- Udyogamandal	1	10	1	0	4
IRE- Manavalakurichi	0	0	1	0	0
NFC	0	0	0	0	1

4.3 OCCUPATIONAL HEALTH AND SAFETY

4.3.1 Advisory Committee on Occupational Health (ACOH)

Two meetings of ACOH were held during the year 2004-2005 and with certifying surgeons from all DAE Units participating. Topics like countersignature of medical certificate of contractor workers at construction sites, medical examination of contractor's workers, role of certifying surgeons in issuing certificate of fitness to other than occupational workers, long illness certificate etc were discussed. The committee arrived at the conclusion that Factories Act and Factories Rule does not call for endorsement of medical certificate issued by other doctors. The other important issues discussed in these meetings are problems for fillings the form for Health Status and Industrial Hygiene Surveillance report and the infrastructure required for carrying out the Occupational Health Centre of different Units etc.

Guidelines for Pre-employment Medical Examination and Fitness Tests for various work areas were finalized by ACOH and these are being further processed in AERB.

4.3.2 Fire Safety

The Advisory Committee on Fire Safety (ACFS) visited and reviewed fire safety arrangements in Heavy Water Plant, Manuguru, Narora Atomic Power Station and Electronics Corporation of India Limited, Hyderabad and made recommendations for improvements.

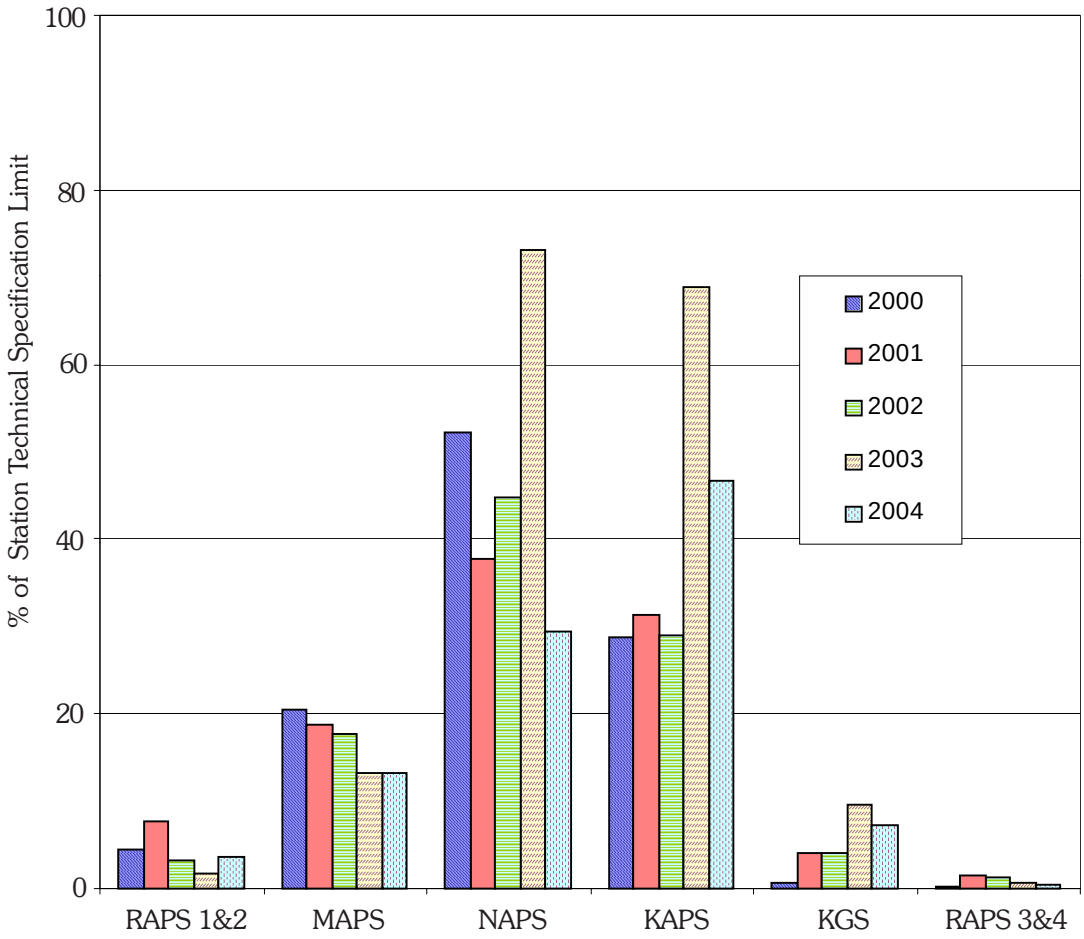
Sometime back a Fire Safety Audit Checklist was developed by AERB for use in DAE plants. A workshop on "Effectiveness of Implementation of Fire Safety Audit Checklist and Feedback on Implementation of ACFS Recommendations" is being planned to be held shortly.

Fire Safety in Resin Fixation System at NAPS

A fire safety and industrial safety aspects review related to resin fixation systems set at NAPS was carried out. Review report was discussed in SARCOP. Some of the measures suggested for improvement are:

- Hazard Operability (HAZOP) study should be undertaken for this process.
- A systematic assessment of operation experience of resin polymerization process at NAPS and KAPS should be carried out.

Figure 4.1a : Liquid Waste Discharges From NPPs (Tritium)



Note:

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

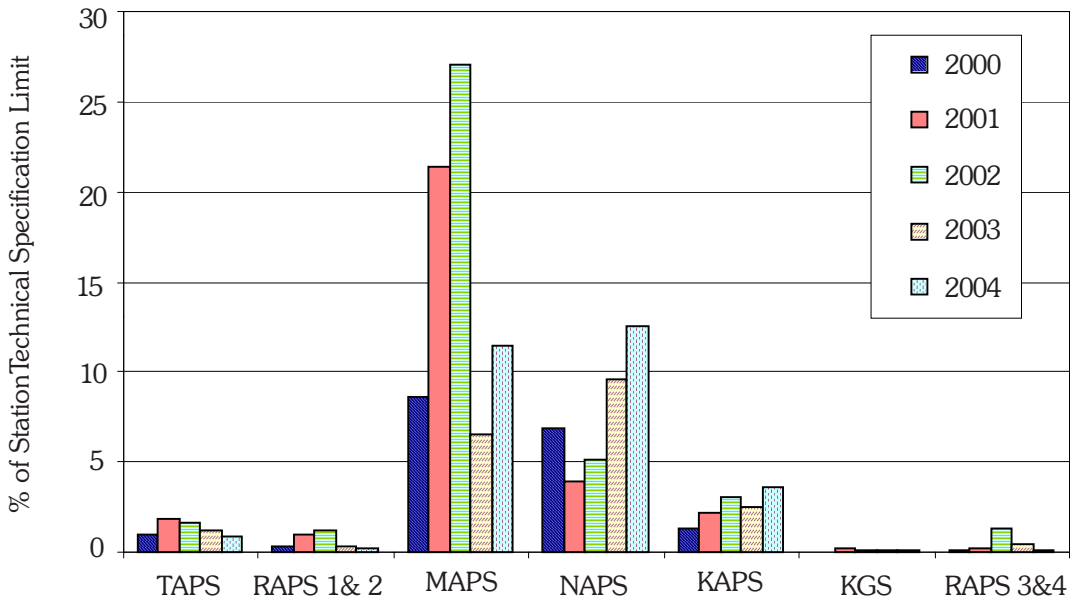
2) The data of MAPS pertains to transfer of liquid waste to Centralised Waste Management Facility, Kalpakkam for processing & discharge to the environment.

3) During 2003 RAPS-1 was shut down throughout the year.

4) During 2002, MAPS-2 remained shut down throughout the year and during 2003 it remained shut down for the first six months owing to EMCCR activities.

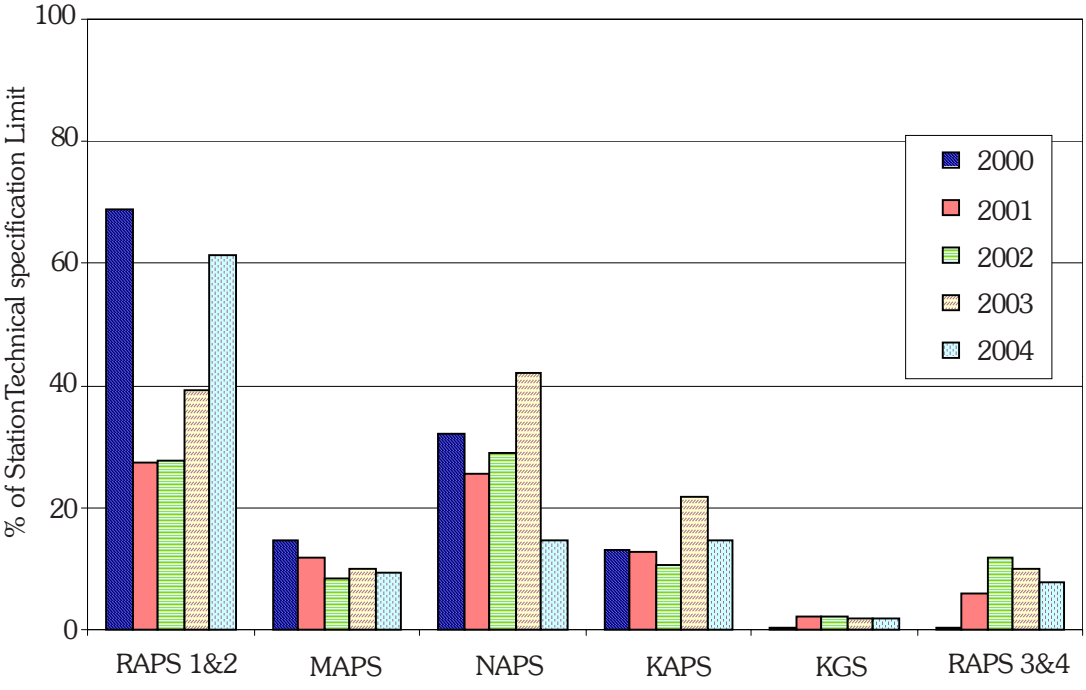
5) During 2003, MAPS-1 remained shutdown for 4½ months.

Figure 4.1b: Liquid Waste Discharges from NPPs (Gross Beta)



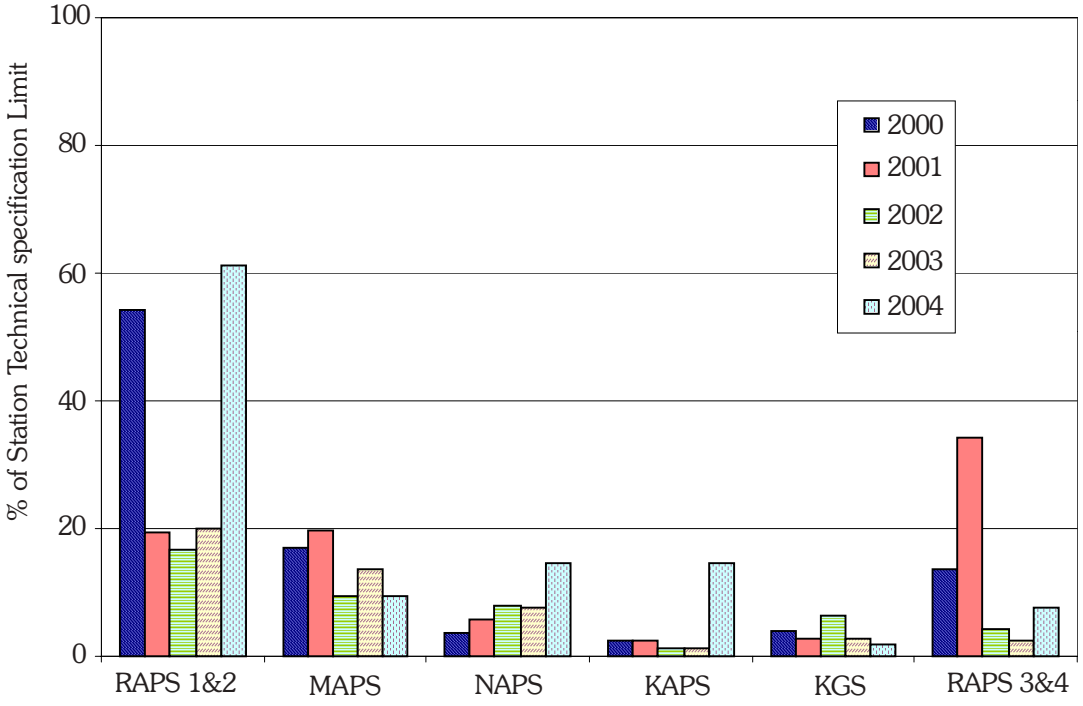
Note: The data of MAPS pertains to transfer of liquid waste to Centralised Waste Management Facility, Kalpakkam, after which it is processed and then discharged to environment.

Figure 4.1c : Gaseous Waste Discharges From NPPs (Tritium)



Note: TAPS is a Boiling Water Reactor. Hence, there is no generation/discharge of Tritium.

Figure 4.1 d : Gaseous Waste Discharges From NPPs (Argon-41)



Note: TAPS is a Boiling Water Reactor. Hence, there is no generation/discharge of Ar-41.

Figure 4.1e : Gaseous Waste Discharges from NPPs
(Fission Product Noble Gases)

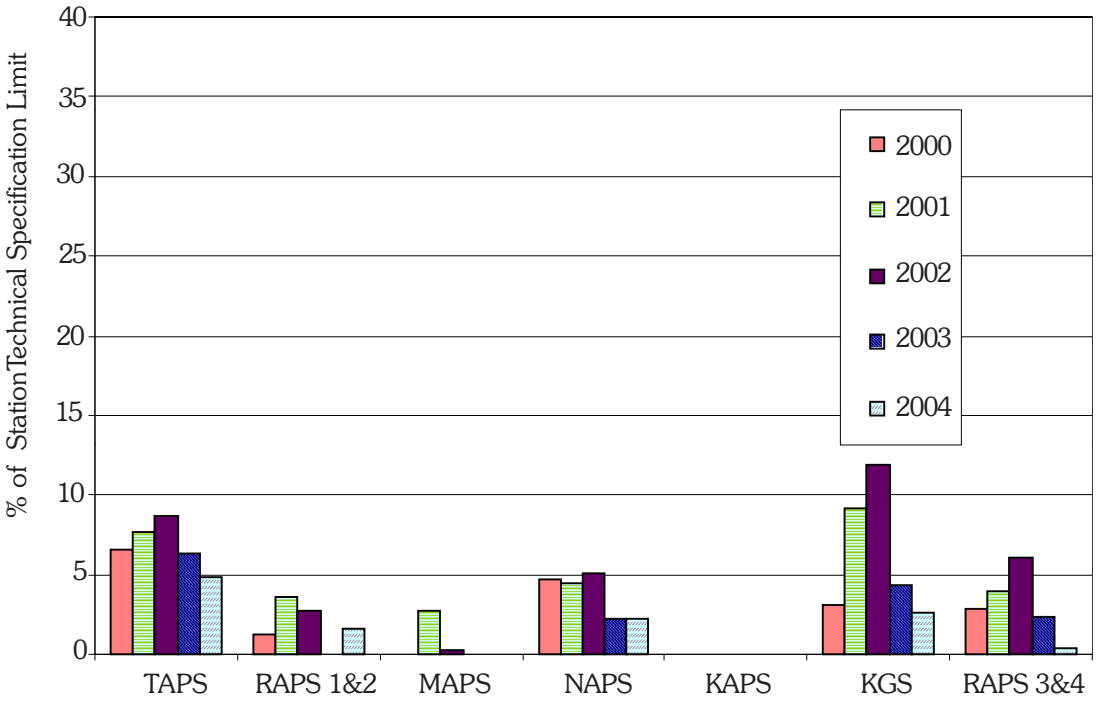


Fig 4.2a: Public Dose at 1.6 km Distance from NPPs-
(AERB Prescribed Annual Limit is 1000 micro-Sv)

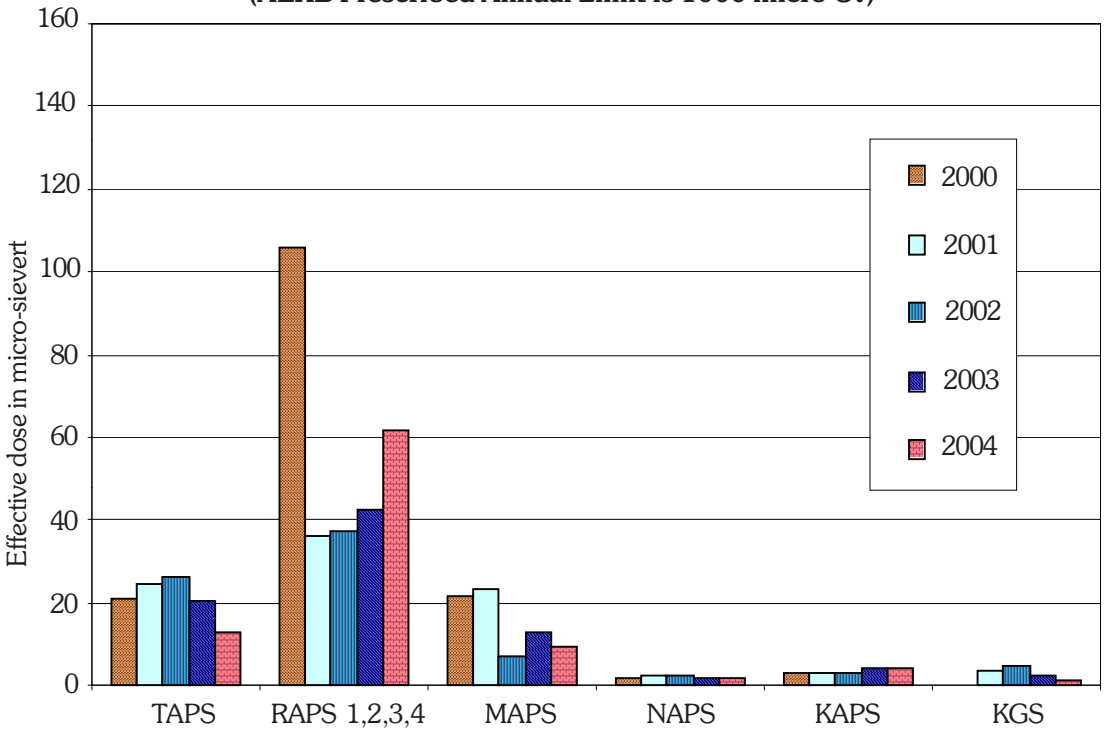


Fig 4.2b: Total Effective Dose in Different Zones during the Year 2004
(AERB Prescribed Annual Limit is 1000 micro-Sv)

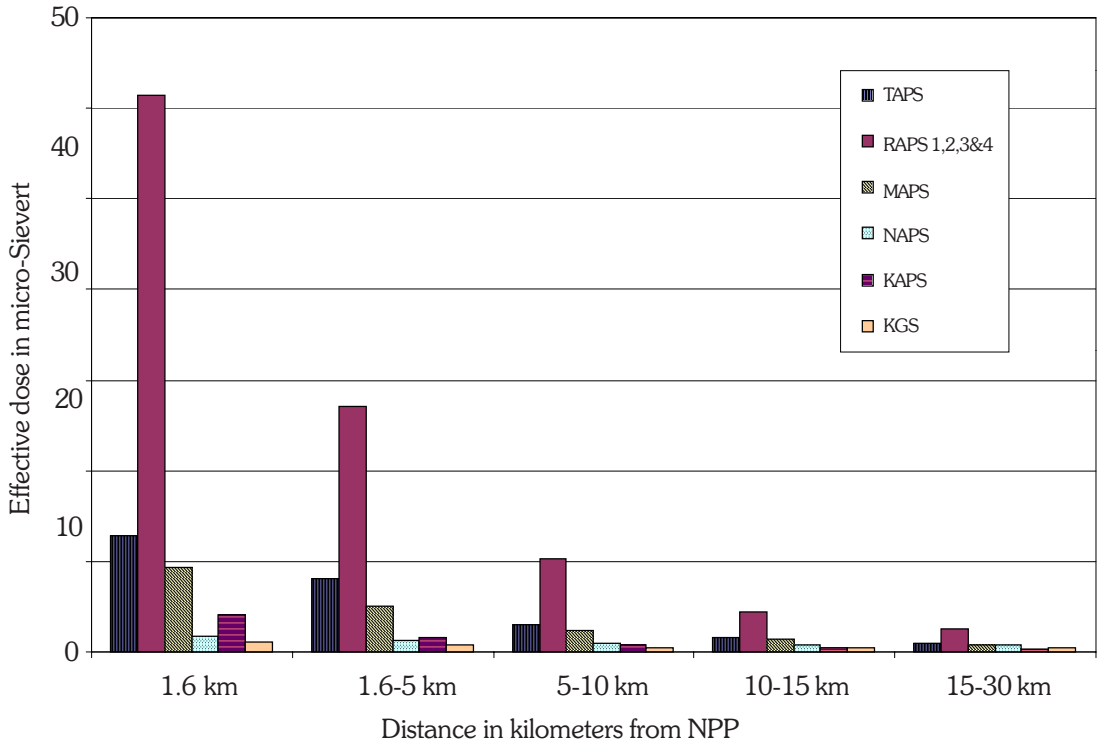


Table 4.2a. Number of Workers in NPPs exposed to > 20 mSv (Investigation limit) & > 30 mSv
(Annual Limit)

Year	2000		2001		2002		2003		2004	
	20-30mSv	>30 mSv	20-30mSv	>30 mSv	20-30mSv	>30 mSv	20-30mSv	>30 mSv	20-30mSv	>30 mSv
TAPS	0	0	0	0	2	0	0	0	0	0
RAPS1&2	1	0	37	1	0	0	0	0	0	0
MAPS	1	0	0	0	2	1	0	0	0	0
NAPS	10	1	16	1	10	1	1	0	0	0
KAPS	0	0	1	0	1	0	3	0	1	0
KGS	0	0	0	0	0	0	0	0	0	0
RAPS3&4	0	0	0	0	0	0	0	0	0	0

Table 4.2b: Radiation Dose Received by Workers in Medical, Industrial and Research Institutes

Category of Radiation Worker	No. of Monit-ored Persons	Average Dose for Monitored Persons (mSv)	Average Dose for Exposed Persons[1]	Number of Workers Receiving Annual Individual Dose Excluding Zero Dose, D (mSv)					
				0 < D ≤20 (mSv)	20 < D ≤ 30	30 < D ≤ 35	35< D ≤ 40	40 < D ≤50	D > 50 Diagnostic[2]
Diagonstic X-rays	16206	0.54	1.24	7066	11	1	1	3	6
Radiation Therapy	5920	0.36	0.80	2653	2	-	-	-	1
Nuclear Medicine	978	0.83	1.40	577	-	-	-	-	1
Industrial Radiography & Radiation Processing	5068	0.96	2.22	2155	21	5	4	4	7
Research	2900	0.11	0.51	636	-	-	-	-	-

[1] This average dose is for those persons who have received dose above recording levels whereas monitored persons include those who received no dose.

[2] Out of 15 cases receiving more than 50 mSv, only 4 cases have slightly exceeded 100 mSv.

CHAPTER 5
EMERGENCY PREPAREDNESS

Nuclear Power Plants (NPPs) provided with adequate safety features to minimize the probability of any accident. The safety features such as containment help in mitigating the consequences of any accident. However, in the extremely rare event of a nuclear accident, it may be necessary to take mitigating measures in the public domain such as evacuation of persons in the vicinity of the plant. This requires a high degree of preparedness. Site specific emergency preparedness plans are drawn up and maintained at all stations. To test these plans, periodic emergency preparedness exercises are carried out and involve the station authorities, district administration and the members of public.

During the year 2004, offsite emergency exercises were carried out as given in Table-5.1. The response of the plant personnel, officials and public involved in the exercise and general level of the awareness amongst the public was satisfactory.

Presently, 14 NPPs are in operation and 9 plants are under construction. One of these plants, the 540 MWe reactor at Tarapur TAPS-4, is being commissioned and would be operational very soon. Detailed emergency preparedness plans are also being drawn out for these new plants. Seven of the nine reactors (except the two Units in Kudankulam) are being constructed at the existing sites. Plant Emergency Exercise (PEE), Site Emergency Exercise (SEE) and Off-site Emergency Exercise (OSEE) are carried out once in quarter, once in a year and once in 2 years respectively.

Table 5.1 : Number of Emergency Exercises

PLANT	PEE	SEE	OSEE
TAPS	4	1	–
RAPS 1&2	3	1	1
MAPS	3	1	–
NAPS	3	1	–
KAPS	4	1	1
KGS	4	1	–
RAPS3&4	3	1	1

PEE : Plant Emergency preparedness Exercise
SEE : Site Emergency preparedness Exercise
OSEE : Off-Site Emergency preparedness Exercise

CHAPTER 6
DEVELOPMENT OF REGULATORY DOCUMENTS

One of the important functions of AERB is to develop safety documents, which include safety codes, standards, guides and manuals for nuclear and radiation facilities and other related activities. The various working groups and Divisions of AERB and Advisory Committees on codes and guides for design, operation, quality assurance and siting and Advisory committee on Nuclear Safety are involved in the preparation of these documents. Safety Analysis and Documentation Division coordinates the preparation and publication of these documents.

During 2004-2005, the following new safety documents were published by AERB.

(1) In-service Inspection of Civil Engineering structures, Important to safety of Nuclear Power Plants (AERB/NPP/SM/CSE-2).

(2) Glossary of Terms for Nuclear and Radiation Safety (AERB/SG/GLO).

(3) Methodologies for Environmental Radiation Dose Assessment (AERB/NF/SG/S-5).

(4) Quality Assurance in Siting of Nuclear Power Plants (AERB/NPP/SG/S-10).

(5) Life Management of Nuclear Power Plants (AERB/NPP/SG/O-14).

(6) Assessment of Implementation of Quality Assurance Programme in Nuclear Power Plants (AERB/NPP/SG/QA-7).

The following existing safety documents were translated in Hindi.

(1) Code of Practice for Safety in Nuclear Power Plant Siting (AERB/SC/S)

(2) Code of Practice and Design in Pressurised Heavy Water Reactor (AERB/SC/D)

(3) Code for Brach Therapy Sources, Equipment and Installations (AERB/SC/MED-J)

(4) Code on Operations and Maintenance of Land Based Stationary Gamma Irradiation.

The following safety documents are under development.

(1) Consenting Process for Nuclear Power Plants and Reactors (AERB/NPP/SG/G-1)

(2) Consenting Process for Nuclear Fuel Cycle and Related Industrial Facilities (AERB/NF/SG/G-2)

(3) Containment System Design (AERB/NPP/SG/D-21)

(4) Document Control and Record Management for Quality Assurance in Nuclear Power Plant (AERB/NPP/SG/QA-9)

(5) Near Surface Disposal of Radioactive Solid Waste (AERB/SG/RW-4)

(6) Decommissioning of Nuclear Fuel Cycle Facilities other than Nuclear Reactor (AERB/SG/RW-7)

(7) Establishing and Implementing Quality Assurance Programme for Nuclear Power Plants (AERB/NPP/SG/QA-6)

(8) Operational Safety Experience Feedback on Nuclear Power Plants (AERB/NPP/O-13)

(9) Site Considerations of Nuclear Power Plants for Off-site Emergency Preparedness (AERB/NPP/SG/S-8)

(10) Radiation Protection for Nuclear Facilities (AERB/NF/SM/O-2)

CHAPTER 7
SAFETY ANALYSIS AND COMPUTER CODE DEVELOPMENT

7.1 SAFETY ANALYSIS

7.1.1 During the deputation of one of the AERB engineer to the Division of Nuclear Power Safety at Royal Institute of Technology, Sweden, the following analyses were carried out.

(a) Station Blackout with and without operator action on Pilot Operated Relief Valve (PORV) for VVER-1000/V320

(b) Station Blackout coincident with Loss of Coolant Accident with and without containment bypass for VVER-1000/V320

It was found from the analyses that in the case of the operator's actuation of the PORV, the vessel would get depressurized and hence does not lead to high pressure melt ejection. In case of no operator action on PORV, the vessel would fail at about 180 bars and leads to high pressure melt ejection. Even in this case also, the reactor containment pressure remains below 5 bars and hence there is no serious threat to the containment integrity.

The analysis also indicated that the instrument channels located in the cavity around the pressure vessel could serve as a containment bypass through which melt can get transported to the instrument room below the cavity basemat. The analysis also indicated that a melt-through of the cavity basemat, which is about 3.6 m thick, is possible. But this could occur in 3 to 5 days period.

(c) Spent fuel pool coolability analysis using RELAP5/MOD 3.2

The calculations showed that under the conditions of the failure of make-up system, the bundles discharged within 107 h, will not be coolable soon after the water boil-off process uncovers these fuel bundles. The bundles resident in the pool from 2 years to 5 years, the clad temperatures do not come close to the Zircaloy oxidation threshold temperatures even when the water in the spent fuel pool is completely evaporated.

(d) Severe accident analysis for VVER-1000 using ASTEC code for Station black out and comparison of the results with MELCOR

The analysis carried out with the MELOCR code predicted the vessel failure, whereas the analysis with ASTEC code did not predict it. The analysis showed significant differences in the oxidation heat generation predictions by ASTEC and the MELCOR. It appears that there are differences in the models used for oxidation heat generation in the two codes.

(e) Thermal Hydraulic analysis for BWR using RELAP5/MOD 3.2

The steady state results have been obtained and the transient analysis is in progress.

7.1.2 To assess the maximum compressive force on fuel assemblies during LOCA, calculations were carried out for drag forces on fuel assemblies under two phase conditions. It was found that these drag forces are several times higher than the normal forces and should be taken into account for evaluating fuel assembly integrity.

7.1.3 The calculations were carried out for minimum critical heat flux ratio under different operating conditions and calculation of critical heat flux ratio along the length of the fuel was also carried out for four loop operation of KK- VVER. The results obtained were compared with those presented in Preliminary Safety Analysis Report (PSAR) of KK-VVER. Subsequently similar calculations were carried out for two loop and three loop operation. It was found that, by and large, the results presented in PSAR are more conservative.

7.2 INTER-COMPARISON EXCERSIES

AERB decided that some of the safety analyses done using the Russian codes for KK-NPP should be carried out using other internationally available codes for the purpose of inter-comparison. The analyses were carried out for the following incidents using RELAP5.

- Station Black Out.
- Pressuriser Relief Valve Stuck Open

It has been observed that all the trends shown in PSAR of KK-NPP were in agreement with the prediction of RELAP5 but magnitudes and the time scale showed some differences. However PSAR results are found to be more conservative.

A similar exercise was carried out for the postulated severe accident of the double ended rupture of four steamlines for KK-NPP. The SCADAP code was used for the analysis. In this case also all the trends predicted by SCADAP and PSAR results are in agreement but the time scale for different events are different. However, again the PSAR results are more conservative in all the cases.

7.3 SAFETY CRITERIA

In view of the growing number and types of Nuclear Power Plants, which are likely to be licensed in India in near future, a draft document on 'Technology Independent Safety Criteria for NPPs' has been prepared. The document is under review in AERB.

7.4 DEVELOPMENT OF COMPUTER PROGRAMS

A computer program in MATLAB was developed to estimate the fuel clad temperatures under natural circulation of air in spent fuel pool after complete loss of water.

7.5 ESTABLISHMENT OF ANALYSIS PROCEDURES

Severe accident (Accident beyond the design basis accidents causing significant core degradation) analyses are gradually becoming mandatory worldwide for licensing of NPPs and for developing severe accident management programmes. A severe accident analysis procedure for Pressurized Heavy Water Reactors with severe core damage has been developed. A sample calculation is in progress for demonstrating the procedure.

Passive systems are being increasingly incorporated in the advanced designs of Indian Nuclear Power Plants. The reliability of these systems depends not only on mechanical integrity of the constituent components but also on thermal hydraulic phenomena. The procedures for calculation of reliability based on thermal hydraulic phenomena (virtual components) are being established. Isolation condensers based on natural circulation are used as an example and a number of cases are being analysed for establishing the acceptable procedures.

The format for submission of Preliminary Safety Evaluation Report (PSAR) and for reporting analyses results was developed. This is to bring standardizations in reporting and ease in the review process.

7.6 PROBABILISTIC SEISMIC HAZARD ANALYSIS (PSHA) OF KALPAKKAM SITE

Seismic risk is considered to be an important contributor in the total plant risk due to external events because of the pervasive nature of earthquakes. PSHA enables the user to identify the major sources and magnitudes of earthquakes, which are controlling the seismic hazard at site.

AERB undertook a pilot study for conducting the PSHA for a site and assimilate various issues related to it. Kalpakkam was selected as a sample site for conducting this study. The data of historical seismicity around Kalpakkam site was collected and processed for uniformity and consistency. The information of seismo tectonic provinces around the area was also collected. Software 'EQRISK', with some modifications made in-house, was used for conducting the study. The results of the study were presented in the second workshop on Earthquake Engineering for Nuclear facilities: Uncertainties in seismic hazard assessment, organized by IAEA, held at Trieste, Italy from 14-25 February 2005.

CHAPTER 8
SAFETY RESEARCH INSTITUTE

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

- Nuclear Plant Safety Studies.
- Radiation Safety Studies.
- Environmental Safety Studies.

Besides research, other components of SRI activities include

- Organising Workshops and Seminars.
- Archiving of Technical and Research Reports, Course Materials, Safety Related Computer Codes and Management of Data Bases.
- Support to the Radiological Safety Division of AERB for regulatory inspection activities in the southern region.

8.1 NUCLEAR PLANT SAFETY STUDIES

8.1.1 Seismic Analysis

Seismic analysis of Prototype Main Control Room Panel of TAPP- 3&4 was done for its qualification under postulated events like Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) using the Finite Element Analysis (FEA) software CASTEM2001. The analysis has been done in collaboration with Mechanical & Hydraulics Division of IGCAR, Kalpakkam. The objective of this analysis was to supplement the qualification by shake table testing. The analysis includes the following main features.

- Panel skeleton is modeled using beam element. Thin plates and minor stiffeners are modeled as bracing members to avoid local vibrations and buckling of plates under dynamic loads.
- Response spectrum analysis is done for calculation of displacement and stress developed in the panel under OBE and SSE.
- Time-History analysis is also performed for calculation of displacement and response history of panel under OBE and SSE.
- The results are validated with the experimental results obtained from accelerometers and strain gauge mounted on the panel during shake table test of the panel.

The results obtained show that the main control room panel of the reactor, qualifies with substantial margin, for the postulated OBE and SSE.

8.1.2 Core Disruptive Accident: Analysis of Shock Wave Propagation in Liquid Media.

A new approach based on finite volume technique is employed for analyzing the shock wave propagation in liquid media. This formulation is based on upwinding scheme with advection upstream splitting method (AUSM). It is planned to solve the problem using Eulerian approach in flow-field and subsequently using Lagrangian (allows mesh distortion) followed by combination of these two methods for evolving efficient numerical algorithms. The latter technique will allow tracking the bubble propagation with time. As a first step, Eulerian formulation was applied to a spherical symmetric problem, with the shock wave propagating from the center radially and bounded by a square. Further studies with Eulerian approach for better stability and accuracy by using HLLC flux splitting scheme are in progress.

8.1.3 Reliability Analysis of Safety Grade Decay Heat Removal System

The design for the 550 MWe Fast Breeder Reactor (FBR), provides for Decay Heat Removal (DHR) of FBR-500 through one of the two diverse heat transport systems, viz. 1) Operational Grade Decay Heat Removal System (OGDHRS) and 2) Safety Grade Decay Heat Removal System (SGDHRS). OGDHRS is the normal heat transport path for operational as well as DHR functions. However when there is a failure of OGDHRS due to component failures in secondary or steam water circuit or Loss of Offsite Power (LOSP), SGDHRS is called into operation to remove decay heat. Reliability analysis has been carried out for SGDHRS in collaboration with Reactor Physics Division (RPD) of IGCAR, Kalpakkam to evaluate the probability of failure on demand for various Design Basis Events (DBE).

SGDHRS consists of four independent and diverse thermal siphon loops, with a heat removal capacity of 8 MW /loop. Residual heat from the hot pool is transferred to the intermediate sodium circuit through the sodium to sodium heat exchanger (DHX). Intermediate circuit transfers the heat to atmospheric air, through sodium to air heat exchanger (AHX). Air flow through the AHX inlet and outlet ducts, is controlled by two sets (2 at air inlet and 2 at air outlet) of air dampers. A tall air stack (30 m) is provided to help set up the natural convection. For SGDHR to be successful, adequate coolant flow by natural circulation is required in the primary circuit. The forced convection in the primary sodium circuit is provided as a defense in depth safety measure.

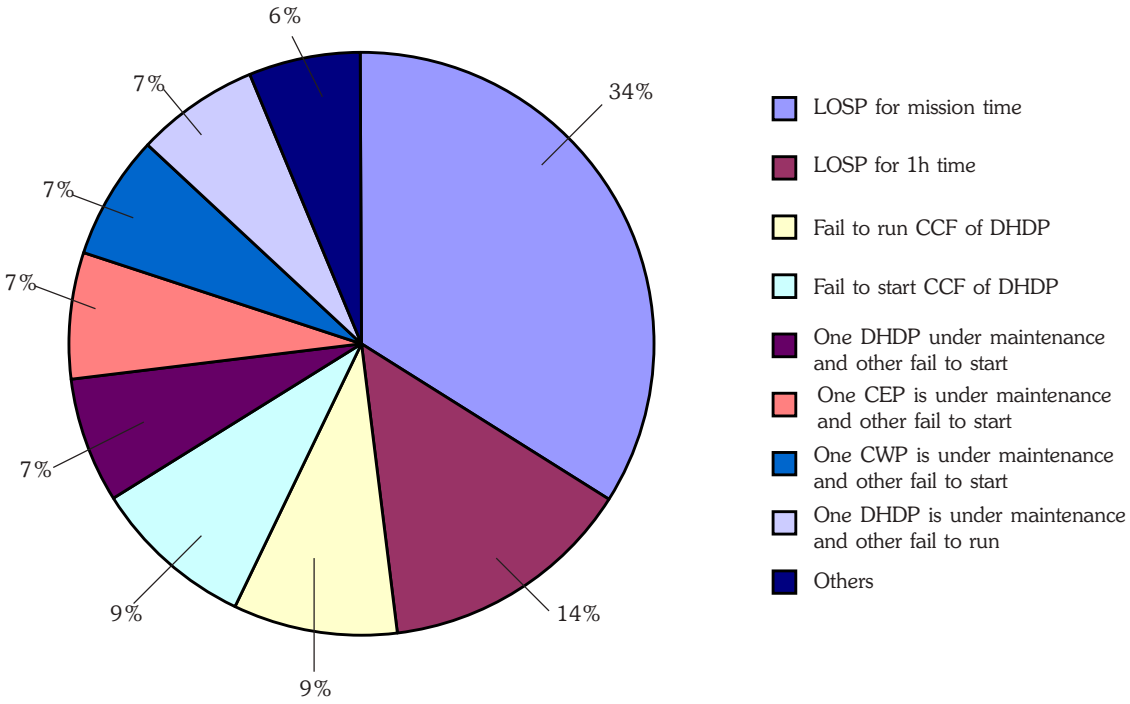
Fault Trees (FT) are constructed for the non-availability of Primary Heat Transport (PHT) passive path and for SGDHRS with 4 intermediate and air circuits using immediate cause approach. Common Cause Failure (CCF) analysis is done with beta factor model. The human error probability assessments are based on NUREG/CR-1278, VOL.3. The probability of failure of SGDHRS on demand ranges from 2.5×10^{-8}/d to 2.0×10^{-7}/d depending on the success configuration and mission time. Considering the annual frequency of loss of off-site power which puts maximum demand on SGDHR, the estimated frequency of loss of DHR function is 1.5×10^{-7}/y which is close to the target frequency of 1.0×10^{-7} per year. This is acceptable as large conservatism is involved in the analysis (such as neglecting the possibility of repair of Steam Water system) and pessimistic values of CCF factor used in the analysis.

8.1.4 Reliability Analysis of Operating Grade Decay Heat Removal System

Reliability analysis is carried out for the OGDHRS using fault tree method in collaboration with RPD. Apart from the function of effective removal of decay power from the core, OGDHRS also fulfils the following requirements.

- To decrease sodium temperature at a controlled rate.
- Maintain the plant in hot shutdown condition at 350° C up to 8 h.
- Maintain the plant at cold shutdown conditions at 200° C (for fuel handling operations and /or maintenance, the requirements of which can be for up to 30 days).

Fig. 8.1: Unavailability Contribution by Various Events



For these requirements, a special decay heat removal sub-system (with 4 Decay Heat Removal Condensers) is provided in addition to the ordinary Steam Water System. The unavailability of OGDHRS on demand is calculated in the range from 1.2 x 10^{-2}/d to 1.7 x 10^{-3}/d depending on the mission time which ranges from 8 h to 720 h. Sensitivity analysis is carried out to find the top event unavailability responses to variations in basic input data. From the analysis, it is found that for LOSP, CCF of Decay Heat Drain Pump (DHDP), Condensate Extraction Pump (CEP), Condenser Cooling Water Pump (CCWP) and fail to start failure mode of DHDP, CEP, CCWP are dominant contributors (Fig. 8.1). Uncertainty analysis is carried out using Monte-Carlo simulation. For each basic event, failure rates are sampled from log-normal distribution. This analysis indicates that the top event result is uncertain by a factor 3.

8.1.5 Failure Modes and Effects Analysis (FMEA) of Safety Grade Decay Heat Removal System

A FMEA has been carried out on the SGDHR of FBR-500 in collaboration with RPD, IGACAR, Kalpakkam. A thorough Failure Mode Effect Analysis (FMEA) is required as a prerequisite for Fault Tree analysis. FMEA is a systematic, analytical bottom-up approach, to properly plan for defect prevention and mistake proofing. It is a technique for identifying and focusing on those areas in the design and manufacturing process for the prevention, reduction, and elimination of non-conformances in a system. The final result of the analysis is the generation of a Risk Priority Number (RPN) for each component of the system and remedial action for those components, which has unacceptably high RPN.

For convenience of analysis, FMEA for SGDHRS is divided into two parts. Part 1 addresses the components for a single loop, including redundancy within the loop. In part 2, FMEA is done for 4-loop case by including only significant components from part 1. CCF is done using beta factor method. The occurrence frequency ranking criteria is modified, to adequately cover the range of failure probability for SGDHRS. A complementary logarithmic equation for converting the occurrence probability to occurrence rank is proposed. That is, Occurrence Rank = $C1 + C2 \log_{10}(P)$, where, $C1 = R_L - C2 * \log_{10} P_L$ and $C2 = (R_U - R_L) / \log_{10}(P_U/P_L)$. Here, P is the occurrence frequency; P_L and P_U are the lower and upper limits of the occurrence frequency and R_L and R_U are the lower and upper occurrence rank respectively. This formula is used in the work sheet for 4-loop case. The impact of component failure modes on overall system function is identified and a Risk Priority Number (RPN) is arrived at for each of the components and its failure mode.

The FMEA has verified that the Fault Tree (FT) analysis performed for reliability analysis of SGDHR is correct. The RPN will be used further to prioritize corrective actions to improve reliability and to screen the components for more refined Fault Tree analysis.

8.2 RADIATION SAFETY STUDIES

Radiation Streaming Studies for FBR-500

Primary Sodium Pump (PSP) of FBR-500 is immersed in the primary coolant sodium pool and penetrates through the Roof Slab (concrete). Annular gaps exist between Roof Slab and PSP penetration shell resulting in radiation streaming at the accessible areas above Top Shield. The streaming dose rate at the accessible locations above the Top Shield near the PSP, during reactor operation is computed using the Monte Carlo N-particle (MCNP) radiation transport code. The results are compared with the one obtained from semi-analytical methods. The MCNP code is selected in order to represent the three-dimensional model of the exact geometry for the radiation transport calculations. A maximum streaming dose rate of 120 mSv/h is estimated above the top shield. To reduce the dose rate to 10 μSv/h, annular stepped complementary shields are proposed. The maximum dose rate above the top shield with the proposed complementary shields gets reduced to7.0 μSv/h.

Similar computations are performed for Inclined Fuel Transfer Machine, which is meant for transporting fresh and irradiated fuel sub assemblies in and out of the vessel. Based on the analysis, it has been recommended to close the air gap, meant for cooling of roof slab concrete, in order to keep the dose rates within the prescribed limits.

Dose mapping studies in various locations around Reactor Containment Building and inside control rooms of FBR-500 under a Core Disruptive Accident due to bottled up activity have been initiated for planning plant emergency response actions and mitigation efforts. The areas include various rooms opposite to Personal Air Lock. A closed corridor is provided with walkway in the western side of the RCB for a person movement from Control Room to Backup Control Room. The cumulative doses were computed during transit time for various delayed departure

of personal from control room.

8.3 ENVIRONMENTAL SAFETY STUDIES

8.3.1 Remote Sensing and Geographic Information System

The main objective of the study is to establish a digital database and information system for carrying out Environmental Impact Assessment (EIA) for all the nuclear power plants in the country. Kalpakkam nuclear power plant site has been taken up in the first instance. It is also envisaged to create necessary infrastructure related to Remote Sensing (RS) and Geographic Information System (GIS) facilities for carrying out EIA on regular basis at SRI. In continuation of collaborative project with Space Application Centre (SAC), Ahmedabad, the ground survey was carried out in an area of 50 km radius around MAPS and detailed mapping of the information is in progress. The procedures developed under the EIA study is to provide information on various planning scenarios to create a sustainable environment for better living and working in and around the nuclear power plants. Fig.8.2 shows the typical Land use/Land Cover Map covering 50 km around Kalpakkam Plant Site generated with RS-GIS software. Inundation Zone Mapping for Kalpakkam Plant site and Kalpakkam Township due to December 26, 2004 Tsunami, is presented in Fig.8.3. These figures demonstrate the utility of RS-GIS in EIA studies.

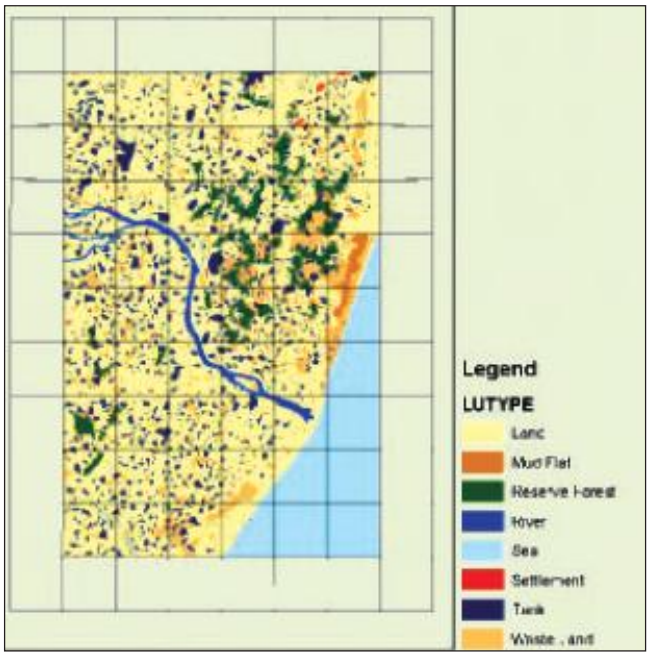


Fig.8.2: Land Use/Land Cover Map Covering 50 km Around Kalpakkam Plant Site

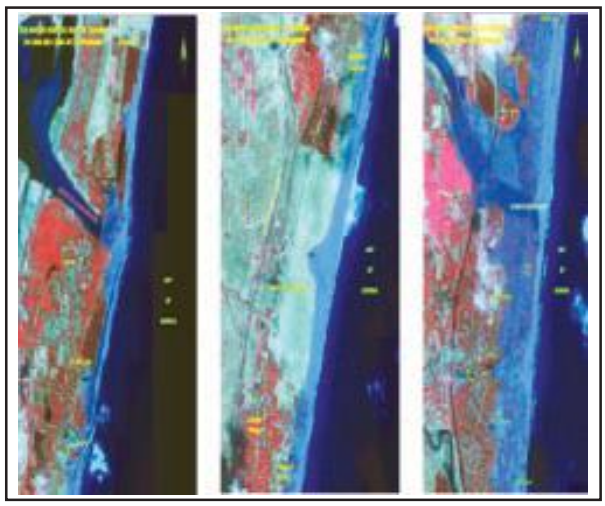


Fig.8.3: Inundation Zone Mapping for Kalpakkam Plant Site and Township due to December 26, 2004 Tsunami

8.3.2 Online Emergency Response System (ONERS) for NPPs

In the ONERS collaborative programme, various groups from BARC, IGCAR, SRI and ISRO have been identified. The function of various groups is well delineated. Among other tasks, initially SRI group has provided the required RS-GIS support, viz., the Digital Elevation Model (DEM), soil texture data, landuse/land cover data of Kalpakkam site in the required grid format to IGCAR in running the MM5 computer code and atmospheric dispersion code. To have a first hand knowledge on the use of GIS, the Officers from AERB and other DAE organizations underwent a week long hands on training at Regional Remote Sensing Service Centre (RRSSC) at Nagpur. The training was imparted by experienced officers from ISRO and RRSSC, Nagpur and was helpful in obtaining an idea regarding the vast capabilities of GIS. SRI has also provided the digital database containing village boundaries with integrated census data, road and rail network to RRSSC, Nagpur to develop decision-making tools to assist in ONERS. The demonstration of part of ONERS programme was carried out at Kalpakkam on 10th February 2005 during the visit of Chairman, AEC. Further work is in progress.

8.3.3 Hydrological Investigations at Kalpakkam

Field studies have been undertaken to generate fence diagram to facilitate in delineating hydrogeological layers and also carry out monthly water table measurements to generate monthly ground water contour maps and velocity flow field. The data has been collected over last 6 months and groundwater contour and velocity vector maps have been generated for the above period (Fig 8.4). The water samples are also collected every month and are being analysed for physico-chemical parameters with a view to draw iso-concentration curves. Efforts are underway to generate a ground water model for Kalpakkam aquifer using Visual MODFLOW software.

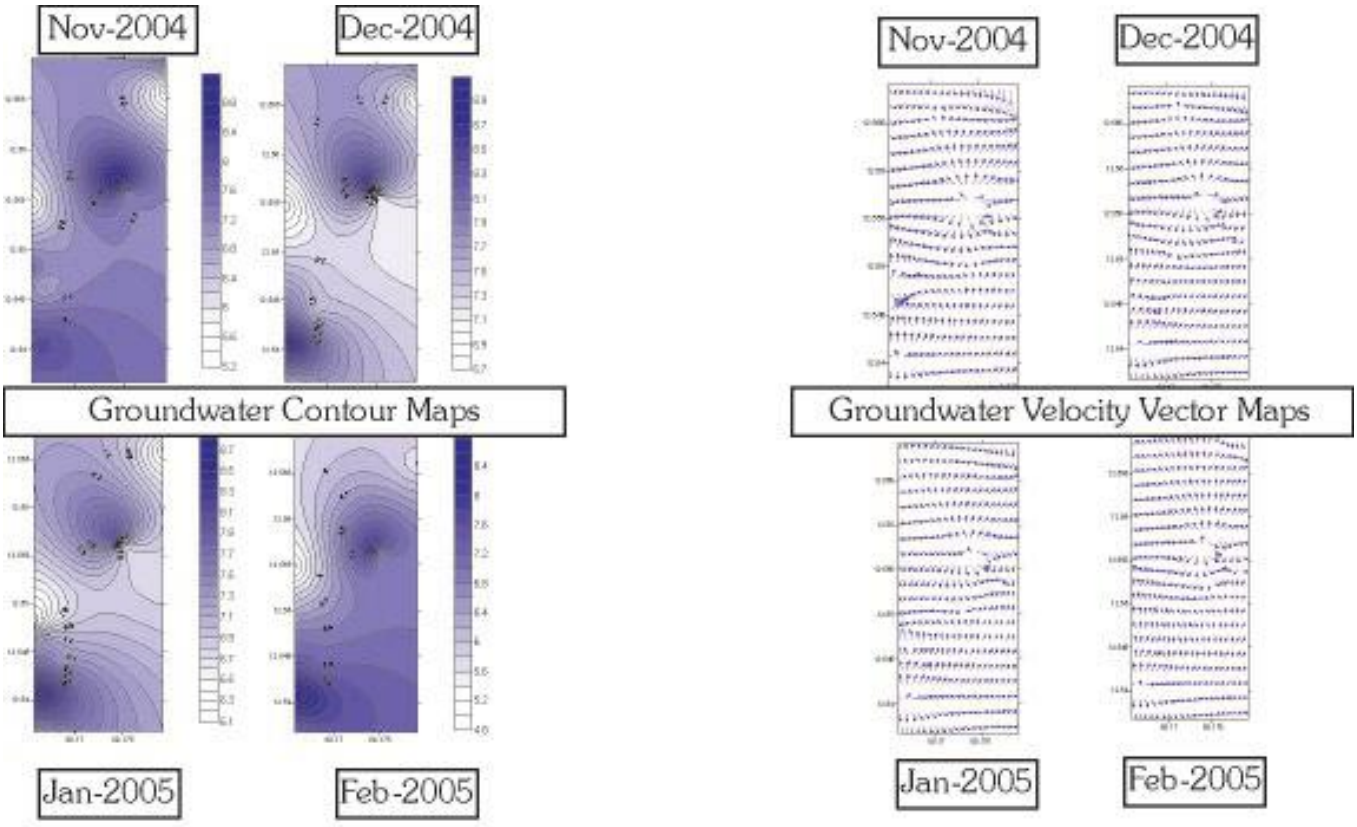


Fig. 8.4: Hydrological Investigations at Kalpakkam

8.3.4 Marine Dispersion Studies at MAPS Jetty Area, Kalpakkam

Studies have been initiated to develop a marine dispersion model based on the dilution factors of key radionuclides discharged into the sea. Dilution factors will be evaluated based on discharge volume and discharge activity and the concentration levels of these radionuclides around MAPS Jetty. Studies would help in assessing the background concentration levels near MAPS discharge location. Preparations for sampling of seawater around MAPS Jetty area have been completed. Preliminary data available for the last year period on waste dilution, discharge volume and duration and radioactivity levels have been collected from MAPS and CWMF officials to evaluate the total waste discharge and waste activity. The monitoring studies will jointly be carried out by SRI and ESL, Kalpakkam for one year. The samples would also be analyzed simultaneously for water quality parameters viz., pH, Salinity, total suspended solids, chlorophyll content and microbiological parameters to assess the impact of radioactivity discharge in marine environment. Field data collected for the one-year period would be interpreted and used to develop long-term marine dispersion model. Meanwhile, suitable softwares like CORMIX and MIKE21 to model the dispersion phenomenon is being evaluted with National Institute of Ocean Technology (NIOT), Chennai.

8.3.5 Migration of Radionuclides in Porous Media

The transport of radionuclides in ground water environment through the fractures in the porous rock is an important safety problem. The governing diffusion equation has to be solved by numerical methods. Explicit code for this problem has been written by finite differencing scheme. In order to improve the accuracy of solution to advection diffusion equation for porous flow problem, higher order schemes like Crank Nicolson and backward difference formula (BDF) have to be used. As a test case, Crank Nicolson and BDF are to be applied to a simple diffusion equation. Crank Nicolson scheme has been completed and observed to be promising. BDF implementation is in progress. The problem is being solved in collaboration with IGCAR, Kalpakkam.

8.3.6 Environmental Impacts of Power Plant Discharges on Entrained Organisms

The present study was undertaken to understand

the effects of power plant discharge with chemical biocides on Zooplankton and Phytoplankton in the vicinity of a power plant. Earlier studies reveal that chemical biocides like chlorine that is being used for biofouling control, also poses damage to all the entrained organisms. Phytoplankton is the primary producer of the marine food chain. Zooplankton also plays a significant role in a marine food chain. They form the basic food material for higher organisms. These organisms are chiefly entrained into the cooling water circuits of a power plant that uses once through cooling water systems. Various experiments are being carried out to study the effect of chlorine and other major stresses on these organisms. The study is being done in collaboration with Water Steam Chemistry Laboratory of BARC.

Field studies: To study the impact of chlorine on the plankton community (zooplankton and the phytoplankton) seawater samples were collected fortnightly from the sampling stations in and around MAPS, viz., Intake Point, Pump house and Outfall. From the water samples collected the following results were obtained. The number of organisms were found to be abundant in the Intake point and the number ranges from 2666 to 9000 cells/m^3 where as the number of organisms were least in the pump house and it was ranging from 266 to 1400 cells/m^3 . Members belonging to the group copepode was found in abundance in all the sampling stations.

For determining the biomass of phytoplankton the amount of chlorophyll *a* was found out by extracting the filterate of the seawater with 90 % acetone. The chlorophyll *a* values were found to be higher at the intake point and ranged from 1.7-15.71 mg/m^3 due to seasonal variation. The phytoplankton biomass was found to be the least in the outfall point where the values ranged from 0.17-2.4 mg/m^3. The total residual oxidants and the chlorination byproducts were analyzed and found to be below the detectable level in the intake point and the mixing point but it was found to be higher in the pump house and outfall. In the pump house, the values were 0.1 and 0.6 mg/l respectively for normal and shock dose chlorination where as at the outfall the values were 0.1 and 0.45 mg/l respectively for normal and shock dose chlorination. Macronutrients like the Nitrates, Nitrite, Ammonia, phosphate and Silicate were measured spectrophotometrically. All the nutrients were higher in pump house and outfall. The amount of silicate found in intake was higher as compared to the outfall.

Laboratory studies: Zooplankton collected from the intake point was isolated and induced into filtered seawater that has been previously inoculated with Phytoplankton cultures used as feed. Pure diatom cultures isolated from the coastal areas are used for short term laboratory studies to understand the effect of different dosage of residual chlorine on the biomass and growth rate of the single diatom species. The method is being standardized.

8.4 DISCUSSION MEETINGS AND TRAINING COURSES

Seven-Day Certification Course on "Safety Aspects in Beach Sand and NORM Industry"

SRI and Indian Association for Radiation Protection Physics (Kalpakkam Chapter), jointly organized a certificate course on "Safety Aspects in Beach Sand and NORM Industry", during July 13-19, 2004 at Kalpakkam. The meeting was attended by 17 delegates from various industrial organisations and DAE units. The faculty was drawn from SRI and IGCAR.

Three-day Workshop on 2-phase Flow and Heat Transfer

SRI and Indian Institute of Chemical Engineers (Kalpakkam Regional Centre) jointly organized a 3-day Workshop on 2-phase flow and heat transfer with particular reference to Indian Nuclear Reactors, during Sep. 13-15, 2004 at Kalpakkam. About 50 delegates drawn from various Units of DAE and AERB attended the meeting. The faculty was from AERB, BARC, IIT- Bombay and IIT- Madras.

Inaugural function during the seminar on "Two Phase Flow and Heat Transfer to Indian Nuclear Reactors": From left: Shri S.K. Chande (Director, SRI), Prof S.P. Sukhatme (Chairman AERB), Dr. Baldev Raj (Director, IGCAR) Shri M. Rajan (President, IIChE, Kalpakkam Regional Centre)

Two-day Seminar on " Safe Handling of Plutonium"

SRI and Indian Society for Radiation Physics Kalpakkam chapter organized a two day seminar on "Safe

Handling of Plutonium" at SRI Kalpakkam during March 22-23, 2005. About 80 participants from various Units of DAE, in particular from Fuel Reprocessing Facilities, attended the seminar. Experts in the chosen topic were selected to serve as the faculty.

8.5 OTHER ACTIVITIES

Regulatory Inspections

Regulatory inspections of radiation installations in southern region were continued based on requirement from the RSD of AERB. During the year, regulatory inspections were carried out in 14 nuclear medicine centres in the states of Tamil Nadu, Kerala and Pondicherry. These included diagnostic as well as therapeutic facilities carrying out treatment of thyroid cancer cases. Most of the centres were following the regulatory requirements. Wherever violations were observed, such cases were referred to appropriate regulatory actions. All the nuclear medicine centres in the state of Kerala were covered.

Accreditation Programme

SRI also participated in the accreditation programme for nuclear medicine technologists conducted at CMC hospital, Vellore by RSD of AERB. SRI took part in the Programme of renewal of certificates for Radiation Safety Officers and Radiographers in Industrial Radiography conducted at BHEL, Trichy and National Test House, Taramani, Chennai. In all, about 170 Radiation Safety Officers and Radiographers attended the above programme.

Computer Code Depository

SRI continues to be a depository of computer codes and makes them available for the interested users. The codes on Radiation Transport, viz., ANISN (1-D Radiation Transport Code) and DORT (2-D Radiation Transport Code) were added in the depository during this year. These codes are being employed to study FBR-500 reactor core physics and shielding problems.

Setting up of Environmental Chemistry Laboratory (ECL)

An Environmental Chemistry Laboratory (ECL) has been set up at SRI to carry out chemical and radiochemical experiments relating to environmental studies, site characterization, waste characterization and other field studies. The ECL also includes facilities for chemical analysis and radiation counting.

SRI and SRI Guest House

Further augmentation of facilities at SRI and SRI guest house was done as per plan. The SRI project has thus been completed by end of March 2005.

Shri S.K. Sharma, Chairman, AERB inaugurated the Environmental Chemistry Laboratory on March 21, 2005. Shri S.K. Chande, Vice Chairman, AERB released a brochure highlighting the activities of Environmental Safety Studies.

CHAPTER 9
PUBLIC INFORMATION

9.1 PRESS RELEASES ISSUED DURING 2004-2005

9.1.1 Unit-1 of Kakrapar Atomic Power Station Shut Down as per Directive of AERB (April 22, 2004)

The Kakrapar Atomic Power Station (KAPS) situated near Surat in Gujarat has two Units of 220 Megawatts each. On 10 March 2004, when Unit-1 was in operation generating 170 Megawatts of electricity, an event involving rise of reactor power occurred.

For controlling reactor power, adjuster rods are provided which move in or out of the reactor core as per the command from the Automatic Reactor Power Control System. While carrying out some maintenance work, power supply to these rods failed rendering them inoperable. At the same time, another design feature of the reactor power control system, called Automatic Liquid Poison Addition System got inhibited due to erroneous operator action. Also, the reactor overpower trip was not appropriate to the operating power level at that time. Reactor power increased slowly and the reactor tripped automatically on sensing of higher than permissible power by the reactor safety system as per design intent. The incident did not result in any damage to the plant or the reactor fuel and there was no radiological consequence. However, the event reflected certain weaknesses in safety culture at the plant and need for improving safety practices. Taking all these factors into account, AERB provisionally rated the incident at level-2 of the International Nuclear Event Scale (INES). Levels 1 to 3 of INES relate to safety significant nuclear events and levels 4 to 7 are assigned to accidents. India is a participant in the INES reporting system.

KAPS and Nuclear Power Corporation (NPCIL) were asked to carry out investigations to identify causes of the incident. Results of investigations and analyses by Expert Groups were discussed at length by the Safety Review Committee for Operating Plants of AERB on 31 March and again on 21 April 2004. Since the exact reasons for reactor power rise have not yet been clearly established, AERB directed the Unit to be shut down as a measure of abundant caution. The station and NPCIL have been asked to carry out further detailed investigations. Accordingly, KAPS Unit-1 was shutdown in the early hours of 22 April 2004.

9.1.2 New Director of Information and Technical Services Division, AERB (April 23, 2004)

On the retirement of Dr. K.S. Parthasarathy on January 31, 2004, who was the Secretary, Atomic Energy Regulatory Board (AERB) and Director, Information and Technical Services Division (ITSD), Dr. Om Pal Singh from Indira Gandhi Centre for Atomic Research (IGCAR) has been designated as Director, ITSD. Before joining AERB, Dr. Om Pal Singh was heading Reactor Physics Division of IGCAR. He has been responsible there for the core physics, shielding and physics related safety design of Fast Breeder Reactor Project (FBRP) which is under construction at Kalpakkam. He has also been responsible for safety and operational studies related with Fast Breeder Test Reactor (FBTR) plant in operation at IGCAR. Apart from this, he has lot of experience in R&D of fast reactors on problems like inherent safety, developing techniques in detecting malfunctions in their incipient stage and mathematical modeling for kinetics and accident analysis of fast reactors. He has served as IAEA Expert in Indonesia several times and has to his credit publications of more than 150 technical papers.

9.1.3 Indian Delegation Visits USNRC (September 6, 2004)

A six-person delegation led by Shri S.K. Chande, Vice Chairman, Atomic Energy Regulatory Board (AERB), India visited United States of America from August 30 to September 3, 2004 to continue the ongoing nuclear safety dialogue with the United States Nuclear Regulatory Commission (USNRC). The discussions covered several topics related to the safety on nuclear power plants including license requirements for new reactor designs, operational safety, fire risk and Probabilistic Risk Analysis (PRA) technology, regulatory inspection methods and experiences and emergency preparedness issues. The AERB team also shared their safety review experiences with PHWRs and recent improvements in PHWR Design. Experts from both regulatory agencies had held useful discussions on three separate occasions earlier over the last two years.

9.1.4 Shri S.K. Chande Appointed as Vice Chairman, AERB (October 25, 2004)

Shri S.K. Chande has been appointed as Vice Chairman and Member of the Atomic Energy Regulatory

Board in place of Shri S.K. Sharma who retired on superannuation on July 31, 2004.

Shri Chande is a B.E. (Hons.) in Mechanical Engineering. After graduating from the 12th Batch of Bhabha Atomic Research Centre (BARC) Training School in 1969, he started his career in the Fast Reactor Section of Reactor Engineering Division, BARC. He had extensive training in plant-operation in CIRUS research reactor and at Rajasthan Atomic Power Station. He was also trained for a period of one year at Rapsodie, Fast Reactor in France. He worked in Indira Gandhi Centre for Atomic Research, Kalpakkam for a period of 22 years in Commissioning, Operation & Maintenance of Fast Breeder Test Reactor (FBTR). He held the post of Commissioning Superintendent of FBTR. In 1993 he joined Atomic Energy Regulatory Board and worked in the area of Safety Review of Operating Plants. He held the posts of member-secretary, Safety Review Committee for Operating Plants and Director, Operating Plants Safety Division (SARCOP) from April 1, 2000 to July 31, 2004. His field of specialisation is Commissioning and Operation of Nuclear Power Plants, Nuclear Safety & Training of Personnel. He is a Fellow of the Institute of Engineers (India).

He is also involved in nuclear safety research and currently holds the position of Director, Safety Research Institute of AERB.

9.1.5 New Secretary, AERB (October 25, 2004)

Dr. Om Pal Singh has been appointed as Secretary, Atomic Energy Regulatory Board (AERB) with effect from October 1, 2004 in place of Shri D.K. Dave who retired on superannuation on September 30, 2004. Dr. Singh joined AERB on February 19, 2004 and was appointed Director, Information and Technical Services Division of AERB.

9.1.6 Safety Advice to Dealers in Metal Scrap and Owners of Steel Foundries and Mills (November 10, 2004)

Low levels of radioactivity were recently detected in some of the steel door handles made by an Indian firm. Though the level of radioactivity was too low to pose any significant hazards to the handling personnel or to the users or public at large, its presence was undesirable and the matter was probed by the Atomic Energy Regulatory Board (AERB). The investigation has shown that it is likely that the steel door handles were made out of steel produced in a steel foundry where imported or domestic metal scrap (containing some cobalt-60 radioactive material) has been used. The radioactive material was probably a disused source that was accidentally melted with the scrap.

While tracing the process through which the radioactive material got included in the steel, AERB's team identified some contaminated material at the concerned firm and in a nearby steel foundry which supplied the material for fabrication of the door handles. This was done with the help of radiation detection instrument. The contaminated material has been segregated and sealed and arrangements are being made for its safe disposal.

In the year 2001, a similar incident had come to the notice of AERB where the contaminated steel was identified, withdrawn from circulation and disposed off safely. Similar incidents have been reported from time to time in other countries also. Fortunately, the incidents are isolated and the radiation levels detected in the contaminated metal have been low. However, there is always a possibility that more contaminated products are made if a higher level radioactive source gets mixed up with metal scrap.

In view of above incidents, it is necessary that metal scrap is checked by dealers for radioactive contamination. In addition, the scrap should be checked at steel foundries prior to feeding it into furnaces for melting. Steel mills should also institute checks for products received from foundries. All metal scrap dealers, steel foundry and steel mill owners, small or big, are advised to regularly scan the metal scrap or the products with them for the presence of radioactivity with the help of radiation detection instruments. If radiation is detected in any material, AERB should be notified immediately so that appropriate control can be instituted over the contaminated material. Radiation detection instruments are readily available and can be procured indigenously or imported. Their use would not only minimize the radiation risk, but would also help in removing the need for withdrawing contaminated material after it has been processed into a final product.

9.1.7 Status of Nuclear Reactors at Kalpakkam (December 30, 2004)

There has been concern about the status of the nuclear power reactors and other facilities in Kalpakkam in view of the Tsunami hitting the east coast. To assess the status of their health, the Atomic Energy Regulatory Board (AERB) deputed a Senior Level Team consisting of five members. The team visited the site on 29 December 2004, and inspected the affected areas.

At the time the Tsunami struck the Kalpakkam coast,

Unit-2 of the Madras Atomic Power Station was operating at its authorised power. Following entry of seawater into the pump house, Unit-2 was tripped and the reactor was brought to a safe shutdown state. Unit-1 of the station has been shutdown for some time for refurbishment.

The AERB Team inspected all the important areas of the plant including the reactor building, the control room, the turbine building, the pump house, jetty, firewater pump house and outer peripheral areas of the service building. All systems, services and structures were found to be in good condition. All radiological conditions in the plant are normal and there has been no release or discharge of radioactivity from the plant. The AERB team also noted that the operator response to the event had been correct and timely. After completing its comprehensive inspection, the team has concluded that the plant is in a healthy state and is ready to resume power generation.

The Fast Breeder Test Reactor and other facilities in the Indira Gandhi Centre for Atomic Research at Kalpakkam were also inspected by the team. It was observed that there has been no impact on these facilities.

9.1.8 Shri S.K. Sharma Appointed as Chairman, AERB (January 17, 2005)

Shri S.K. Sharma has been appointed Chairman of the Atomic Energy Regulatory Board (AERB) in place of Prof. S.P. Sukhatme who relinquished office on January 14, 2005 on expiry of the term as Chairman, AERB. Prior to this Shri Sharma was Vice Chairman, AERB and Chairman, Safety Review Committee for Operating Plants (SARCOP) from January 1, 2003 till his superannuation on July 31, 2004.

A Graduate in Chemical Engineering from the Banaras Hindu University, Shri Sharma has earlier served BARC in different capacities from 1963 onwards. As Director, Reactor Group, he had the responsibility for operation and utilization of three research reactors APSARA, CIRUS and DHRUVA, at Trombay. He was also responsible for carrying out extensive refurbishing of CIRUS, after which this old facility has been brought back into operation.

Shri Sharma has made invaluable contributions in several senior level committees of AERB earlier. He was the Chairman of Safety Review Committee for Operating Plants (SARCOP) which is the Apex Committee for reviewing safety of all operating plants of DAE. He is the Vice-chairman of AERB's Advisory Committee on Nuclear Safety which advises AERB on generic matters of nuclear safety and which carried out the review of a large number of safety documents. As Vice-Chairman of the Advisory Committee for Project Safety Review of Light Water Reactors, he is actively involved in the safety review of design of Kudankulam reactors.

He has carried out several assignments of the International Atomic Energy Agency (IAEA) by way of participating in Training Courses and Co-ordinated Research Programmes and developing safety documents for Research Reactors and Nuclear Power Plants. He was a member of IAEA's Nuclear Safety Standards Committee (NUSSC) from January 2002 to mid-2003 and is a member of newly constituted International Nuclear Safety Group (INSAG) from end of 2003.

9.1.9 Uranium Piece does not Pose any Security Threat or Health Hazard (February 5, 2005)

This is with reference to the news item titled "2 held with bomb-ready uranium" that has appeared in a section of the press on February 5, 2005. In this connection, AERB would like to clarify the situation.

Taking note of the media report about the recovery of a uranium bar that appeared in a Varanasi newspaper in mid-December, AERB contacted the Senior Superintendent of Police, Bareilly for details of the case. He was also requested to send the piece to Bhabha Atomic Research Centre (BARC) for testing. The report of the analysis carried out by BARC has confirmed that the piece is of depleted uranium. This material contains very low concentration of fissile uranium (about 0.21% of Uranium-235) and cannot be used for producing a bomb. As such the piece does not pose any security threat.

The piece also does not pose any significant radiation / health hazard as the radiation dose on the piece is negligible.

Such pieces of depleted uranium, being a heavy material, are generally used as shielding material in imported industrial radiography cameras, radiotherapy units used in hospitals or as counterweight in aircraft. There have been instances in the past when such pieces have been found in scrap yards.

The piece is now in the custody of AERB.

9.1.10 USNRC Delegation Visits Atomic Energy Regulatory Board of India (February 13, 2005)

A five member delegation of the United States Nuclear Regulatory Commission (USNRC) led by

Commissioner Jeffrey S. Merrifield visited the Indian Atomic Energy Regulatory Board (AERB) during 7 to 11 February, 2005 under the on-going nuclear safety co-operation between the two regulatory authorities. Extensive discussion in the form of a workshop was held during this visit on safety and regulatory matters related to the Nuclear Power Plants. The technical workshop was inaugurated by Commissioner Merrifield.

The nuclear safety co-operation was resumed in February 2003 when a USNRC delegation led by the-then NRC Chairman Dr. Richard A. Meserve visited India in February 2003. During the 2003 / 2004 period, four meetings, two in India and two in the US were held between the experts of the two regulatory bodies. The present workshop is the fifth discussion in the series where the topics of certification process and safety criteria for New Reactor Designs, Seismic Issues and revised requirements of Emergency Core Cooling Systems in nuclear power plants were discussed. In view of the recent tsunami event in India the two sides also discussed regulatory requirements related to tsunami and flooding hazard at nuclear plant sites. The Indian side also shared their experience of construction and commissioning of new reactors.

The discussions were found to be extremely useful by both sides and provided deeper insights into the regulatory process in the two countries. The US at present has 103 operating nuclear power reactors while India has 14 nuclear power plants in operation and 9 under construction.

The USNRC delegation visited the Dhruva reactor and some of the engineering R&D facilities at BARC and the Tarapur site where 2 Boiling Water Reactor Units of US design are operational and 2 Units of 540 MWe each of Pressurised Heavy Water Reactors (PHWR) Units of indigenous design are under construction. Commissioner Merrifield also visited the Kota site where 4 PHWR Units are operating and 2 are under construction.

The two sides also discussed the possibility of expanding the scope of the ongoing co-operation by including additional topics. The USNRC has offered to host one or two of AERB staff to provide exposure to the US regulatory process. As part of continuing co-operation programme, three more meetings during 2005-2006 are planned. The next meeting is scheduled to take place during August-September, 2005 in the US.

9.1.11 Workshop on Information Exchange on Nuclear Safety Between Rostekhnadzor of Russian Federation and Atomic Energy Regulatory Board (March 2, 2005)

A Workshop on Information Exchange on Nuclear Safety between Rostekhnadzor, the Regulatory Body of Russian Federation and Atomic Energy Regulatory Board (AERB) was held during February 21-24, 2005 at Mumbai. This was the first workshop organised under the Agreement for co-operation in the field of nuclear safety, between the two regulatory bodies, i.e. AERB and Rostekhnadzor (earlier known as Gosatomnadzor).

A ten member delegation from the Russian Federation led by Mr. A. Khamaza, Head of the International Relations of Rostekhnadzor visited AERB for this Workshop. The topics chosen for the technical presentations were related to the Kudankulam Nuclear Power Project which comprises of two VVER-1000 reactors of Russian Design that are presently under construction at Kudankulam in the State of Tamil Nadu.

A large number of technical presentations were made by the members of Russian delegation and the Indian team on the topics of design safety review, licensing process, aspects related to construction, commissioning and operation experience of the VVER type reactors. The presentations were followed by extensive discussions and were found to be extremely useful to both the sides. After the Workshop the Russian delegation visited the Kudankulam project site.

9.1.12 AERB Industrial Safety Awards (March 4, 2005)

The annual Industrial Safety Awards function of Atomic Energy Regulatory Board (AERB) was held on March 4, 2005. Shri S.K. Mukherjee, Executive Director (Safety, Health & Environment), HPCL presented the Safety Awards for 2004 to Narora Atomic Power Station, Heavy Water Plant, Tuticorin, Indian Rare Earths Ltd., Manavalakurichi and Kudunkulam Power Project for attaining high levels of Industrial safety.

On this occasion, Shri S.K.Sharma, Chairman, AERB released a compilation entitled "Industrial Safety Statistics of the Department of Atomic Energy (DAE) Units for the year 2004". The compilation contains data on the injury statistics amongst different Units of DAE. This data is analysed and compared with data from Units outside DAE. It is seen that Industrial Safety performance of DAE Units is substantially superior compared to other similar industries in the country.

CHAPTER 10
INTERNATIONAL COOPRATION

10.1 DEPUTATIONS ABROAD

Name of officer	Period of deputation	Venue	Purpose
Shri A.U. Sonawane	17.05.2004 to 20.05.2004	Vienna, Austria	IAEA Technical Meeting to Validate Regulatory Authority Information System Running Version
Shri S.K. Sharma	10.05.2004 to 12.05.2004	Vienna, Austria	IAEA Technical Meeting on Safety Management System Requirements; Resolution of Safety Standards Committees Comments
Shri S.K. Sharma	07.06.2004 to 11.06.2004	Vienna, Austria	IAEA Consultancy on Application of the Graded Approach to the Safety Requirements for Research Reactors
Prof.S.P. Sukhatme	07.06.2004 to 09.06.2004	Vienna, Austria	Meeting of the Commission on Safety Standards
Dr.P. Sasidhar	21.06.2004 to 25.06.2004	Budapest, Hungary	Consultants Meeting to Review the Preparation on Applications of Safety Assessment for Near Surface Radioactive Waste Disposal Facilities
Smt.M.V. Inamdar	23.08.2004 to 27.08.2004	Manila, Philippines	IAEA Regional Training Course on Occupational Radiation Protection
Shri B.K. Singh	16.08.2004 to 20.08.2004	Dhaka, Bangladesh	IAEA/RCA Regional Training Course on Radiation Protection in Radiography
Shri S.P. Agarwal	26.07.2004 to 30.07.2004	Vienna, Austria	Consultants Meeting on Denial of Shipment Of Radioactive Material
Shri R. Venkatraman	16.08.2004 to 20.08.2004	Haiyan, China	IAEA Expert Assignment Project on RAS-9-025-9009-01
Shri S.K. Chande	27.08.2004 to 06.09.2004	Washington, D.C., USA	Visit of Indian Delegation for Technical Discussion with USNRC
Shri R.I. Gujrathi	27.08.2004 to 06.09.2004	Washington D.C., USA	Visit of Indian Delegation for Technical Discussion with USNRC
Dr. S.K. Gupta	27.08.2004 to 06.09.2004	Washington D.C., USA	Visit of Indian Delegation for Technical Discussion with USNRC
Shri S.P. Agarwal	27.09.2004 to 01.10.2004	Vienna, Austria	Technical Meeting to Initiate Two Year Cycle of the Review and Revision if Necessary of the Regulation of Radioactive Material TS-R-1
Shri K.D. Pushpangadhan	27.09.2004 to 01.10.2004	Jakarta, Indonesia	IAEA Regional Training Course on Authorisation and Inspection of Radiation Sources in Nuclear Gauges and Well Logging

Name of officer	Period of deputation	Venue	Purpose
Shri D.M. Rane	27.09.2004 to 01.10.2004	Jakarta, Indonesia	IAEA Regional Training Course on Authorisation and Inspection of Radiation Sources in Nuclear Gauges and Well Logging
Dr. Om Pal Singh	20.09.2004 to 24.09.2004	Ljubljana, Slovenia	IAEA Regional Workshop on Self Assessment of Regulatory Bodies
Shri S.K. Chande	24.09.2004 to 24.09.2004	Vienna, Austria	Joint Advisory Committee Meeting on the Incident Reporting System (IRS)
Shri S.K. Chande	27.09.2004 to 29.09.2004	Vienna, Austria	Joint/NEA Meeting of the IRS National Coordinators
Shri S.K. Chande	04.10.2004 to 08.10.2004	Nara (Osaka), Japan	6th International Conference on Nuclear Thermal Hydraulics Operations and Safety (NUTHOS-6)
Dr. S.K. Gupta	04.10.2004 to 08.10.2004	Nara (Osaka), Japan	6th International Conference on Nuclear Thermal Hydraulics Operations and Safety (NUTHOS-6)
Smt. Kanta Chhokra	04.10.2004 to 08.10.2004	Kuala-Lumpur, Malaysia	IAEA RTC on Prevention of Accidental Exposure In Radiotherapy
Dr. S.K. Gupta	11.10.2004 to 15.10.2004	Seoul, Korea	Consultants Service Meeting to Develop Analysis of Server Accident in PHWRS
Shri S.K. Chande	01.11.2004 to 05.11.2004	Bucharest, Romania	Annual Meeting of Sr. Regulators of Countries Operating CANDU Type Reactors
Shri R.K. Chugha	01.11.2004 to 05.11.2004	Vienna, Austria	Project Evaluation and Demonstration of Safety of Decommissioning of Nuclear Facilities
Shri P.K. Dash Sharma	11.11.2004 to 19.11.2004	Vienna, Austria	IAEA Consultants Meeting to Review Regulatory Authority Information Systems (RAIS 3.0)
Shri P.K. Ghosh	06.12.2004 to 10.12.2004	Vienna, Austria	IAEA Technical Meeting on Preparing Guidelines on Operational Safety Review Services for Fuel Cycle Facilities
Shri P.K. Ghosh	14.12.2004 to 16.12.2004	Vienna, Austria	IAEA Biennial Meeting of IAEA/NEA/FINAS National Coordinators to Exchange Information on Recent Events in Fuel Cycle Facilities
Shri S.N. Rao	13.12.2004 to 17.12.2004	Vienna, Austria	IAEA Technical Meeting on Use of External Operating Experience
Dr.P.C. Basu	14.02.2005 to 28.02.2005	Triestie, Italy Vienna, Austria	2nd Workshop on Earthquake Engineering for Nuclear Facilities, Uncertainties in Seismic Hazard Assessment and Consultant's Meeting to Organise Workshop on Flooding Hazards on NPP
Shri A.D. Roshan	14.02.2005 to 25.02.2005	Vienna, Austria	2nd Workshop on Earthquake Engineering for Nuclear Facilities, Uncertainties in Seismic Hazard Assessment

10.2 COLLABORATION WITH FOREIGN ORGANISATIONS AND REGULATORY BODIES OF OTHER COUNTRIES

10.2.1 AERB – USNRC Discussion Meetings / Workshops on Nuclear Safety

The fourth nuclear safety cooperation between AERB and USNRC was held in Washington in August–September 2004. Where, the topics covered were: Licensing of new designs of power plant, emergency preparedness issues, update on fire risks, PSA technology and its applications, operational safety issues, regulatory inspections methods and experience, licensing renewal and NDT and PHWR licensing issues and operating experience. The Indian Team also visited the Argonne National Laboratory. At the end of the 4th meeting it was agreed that the planned topics have been covered adequately over the course of the four meetings. It was also decided that the further co-operation can be in the area of New Reactor Designs, PRA methods and applications, severe accident analysis and management and proactive materials degradations programmes and the next meeting, to be held in India in February 2005, can be in the form of a workshop on the topics,

- New reactor designs such as technical basis for certification for a design, models/reviews, technology neutral network and
- Probabilistic risk assessment methods and applications (including seismic evaluations) / severe accident analysis and management (both operating and new designs).

A View of the AERB-USNRC Meeting in Progress. NRC Commissioner Mr. J. Merrifield and US Consulate General Mr. Angus Simmons Sitting Right of Shri S.K. Sharma Chairman, AERB.

The 5th meeting was held in AERB during February 7 – 11, 2005. The five-member USNRC delegation was led by Commissioner, Jeffrey S. Merrifield, who also inaugurated the workshop. The US-NRC delegation visited the BARC and the Tarapur site. Commissioner, Merrifield and his colleagues from US Embassy also visited Rawatbhata site. At the end of the workshop it was concluded that the technical discussions, have been very useful and have provided new insights into the various safety and regulatory issues. The experience of license renewal in the US provided some important inputs to Ageing management aspects of old reactors in India. Based on these discussions, AERB is considering integrating some of the elements of the risk informed approach to regulation in its regulatory process. The US NRC was benefited by the Indian experience of regulatory review, construction and operation of Heavy Water Reactors. In view of the mutual benefits that accrue from such technical exchanges, it was decided to continue the co-operation in future.

10.2.2 Workshop on Information Exchange on Nuclear Safety between Rostekhnadzor of Russian Federation and AERB

A Workshop on "Information Exchange on Nuclear Safety" between AERB and the Russian Regulatory Body, Rostekhnadzor was held during February 21-24, 2005 in Mumbai. For this workshop, a Ten-member ROSTEKHNADZOR delegation visited Mumbai and was led by Mr. A.A. Khamaza, Head of the International Relations of the organisation.

About 60 Indian participants from AERB, BARC and NPCIL participated in the Workshop and the Russian and Indian experts made a number of technical presentations. The presentations by Russian experts covered topics related to Quality Assurance; licensing of NPPs; verification and certification of computer codes used for the analysis; supervision during design, manufacture, installation and operation of equipment for NPPs and operating experience with VVER-1000 reactors. The Indian experts made presentations covering highlights of the review process and the salient findings pertaining to the review of systems, structures and components important to safety; Innovative Systems; and Verification & Validation of thermal hydraulics codes for KK-NPP. The discussions were found to be useful by both sides and provided insights into the regulatory review process in India and the Russian Federation.

At the end of the workshop, it was recommended to continue and expand on the co-operation between the two Regulatory Bodies with emphasis on exchange of information on Nuclear Safety including on advanced safety related topics related to VVER based Nuclear Power Plants.

The Russian delegation visited the Kudankulam Project site after the workshop.

A View of the AERB-ROSTEKHNADZOR Meeting in Progress. Mr. A.A. Khamaza, Leader of the Russian Delegation is seen to the Right of Shri S.K. Sharma Chairman, AERB.

10.2.3 IAEA Coordinated Research Program (CRP)

AERB is participating in the IAEA Coordinated Research Project (CRP) on the "Safety Significance of Near Field Earthquakes". The CRP aims at applying the recent engineering practices to evaluate seismic vulnerability of non-nuclear facilities in the seismic safety assessment of nuclear facilities with respect to the effects of near field earthquakes.

In the context of this CRP, work related to the non-linear analysis of concrete shear walls was carried out. Floor response spectrum and stress-resultants corresponding to different input time histories were generated. The report on the work conducted for the second year was submitted. Further non-linear analysis using input motions scaled to different levels of peak ground acceleration will be conducted as part of the third year work plan. Two different input time histories have been identified to carry out the study and about 12 different non-linear analyses have been conducted. This exercise turned out to be highly computationally intensive as each of the analysis required approximately 36 hours to complete. The results were processed to arrive at different parameters of interest.

CHAPTER 11
HUMAN RESOURCE DEVELOPMENT

11.1 GENERAL

As indicated before, AERB is involved in the challenging task of regulating the 14 operating plants, 2 research reactors, 9 nuclear power plants under construction at 5 different sites. These reactors are of different capacities (220 MWe to 1000 MWe) and different types (PHWR, LWR and FBR). Further, jurisdiction of AERB includes radiation safety in medicine, industry and research organisations. AERB also enforces safety provisions in plants like uranium mines and mills and nuclear fuel fabrication and heavy water plants. Recently, Pre-Licensing Design Safety Appraisal of Advanced Heavy Water Reactors (AHWR), which is a next generation plant with a number of novel features to enhance the safety, has also been entrusted to AERB. Review of PHWR design of higher capacity (700 MWe) is to be taken up. Considering the present and future activities, the requirement of additional manpower was assessed and 67 new posts were sanctioned. Work on filling up these posts has been initiated.

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 post graduates through AERB sponsored schemes in I.I.T., Bombay and Madras.

11.2 AERB TRAINING PROGRAMME

The newly inducted manpower is trained through various schemes. Initial familiarisation training is given in-house where apart from providing the exposure to basics of Nuclear Science and Engineering, a good deal of exposure is given to AERB activities. Regulatory aspects of review and authorization and inspections and enforcement are also dealt within detail. After this, the staff is trained in NPCIL's Nuclear Training Centre (NTC) and through on the job training (OJT) at NPPs.

During the year under review, 20 engineers and 3 supportive staff were added at various levels. Two engineers were sponsored for M. Tech in Energy System Engineering, 5 were trained in NTC and 3 in OJT of NPCIL. A detailed programme is in place for training a set of 21 engineers in AERB training course, 7 in NTC and 6 in OJT of NPCIL during the year 2005-2006. Before inducting the M.Tech sponsored students in AERB, these personnel go through the BARC Orientation Course in Engineering for Post graduates (OCEP).

11.3 AERB EXPANSION PROJECT

To provide office space for the additional staff being inducted, construction of AERB Annex building adjacent to the existing Niyamak Bhavan as part of 10th plan "AERB expansion project" was started in Dec 2004. The dismantling work of the existing structures for clearing the site for the Annex building was completed by October 2004.

11.4 WORKSHOPS/SEMINARS PROGRAMME

The following workshops and seminars were organised on topics of interest to AERB.

11.4.1 Workshop on AERB Design Safety Codes and Guides for Nuclear Power Plants

A workshop on "AERB Design Safety Codes and Guides for Nuclear Power Plants" was conducted in AERB auditorium during 28-29 June 2004. About sixty technical staff attended the workshop from AERB, NPCIL-Head quarters, NPP sites, BARC and IGCAR.

The Workshop was divided into six sessions. The

Inaugural Session of the Workshop in Progress. On the Dias, from left, are : Shri P. Hajra, Head SADD AERB, Shri S.K. Sharma, Vice Chairman, AERB, Prof. S.P. Sukhatme, Chairman, AERB and Shri S. B. Bhoje former Director, IGCAR Kalpakkam.

senior faculty of AERB, NPCIL and BARC made presentations on fifteen published design documents and one manual, which is under publication. The need for improvements and modifications to be done in the documents in keeping with the latest development on the subject was highlighted during the discussion. The feedback will be used in the revision of the documents.

11.4.2 Seminar on Innovative Designs of Nuclear Power Plants of the Next Decade

India has an ambitious program of building 20000 MWe nuclear power by the year 2020. The new NPP to be built in the next decade will be off different designs and will have to meet significantly higher standard of safety and performance. To initiate discussions on these issues, a one-day seminar was organised on 26th July 2004 on the Innovative Designs of NPP of the next decade. AERB, NPCIL and IGCAR experts made presentations on PHWR and FBR of next decade. The discussions in the seminar have been extremely useful in getting an overall view of the proposed new designs.

11.4.3 Workshop for Management Module on "Communication Skills"

A two-day course on 'Management Module' on the topic 'Communication Skills' was conducted in AERB Auditorium on 8th and 9th November 2004. The faculty from South Indian Education Society (SIES) Institute of Management, Mumbai, conducted the courses.

A total of 29 participants from various divisions of AERB attended the course. The course mainly covered various topics for effective communication in group discussions, presentations, meetings, trainings, and report writings etc., which are useful for carrying out the regulatory functions.

CHAPTER 12
SAFETY PROMOTIONAL ACTIVITIES

12.1 SAFETY RESEARCH PROGRAMME

One of the objectives of the AERB is to promote safety research useful in regulatory process. For this, a Committee for Safety Research Programmes (CSRP) has been constituted to frame rules, regulations and guidelines and evaluates, recommend and monitor the research projects. The committee also recommends financial assistance to universities, research organisations and professional associations for holding symposia and conferences of interest to AERB after scrutinising applications from the organisations. Financial support to 24 such seminars etc., was provided during the year.

The CSRP met twice and deliberated on the new project proposals, renewal of on-going research projects and grants for seminars. A total of ten new project proposals were reviewed. The committee deliberated on the proposals along with the comments/views/suggestions from the relevant referees and experts. The committee approved the following proposals.

Sr. No.	Project No.	Project Title	Principal Investigator
1.	31/02	Developing Tissue Equivalent TLD materials for Personnel Monitoring	Dr. S. K. Omanwar Amravati University, Amravati.
2.	31/03	Investigation on the Role of Computerized Radiography with Photostimulable Phosphor for Portal Imaging and QA in Radiation Therapy	Dr. B. Paul Ravindran CMCH, Vellore.
3.	31/06	Melt Jet Fragmentation as a Prediction to a Steam Explosion under Core Meltdown	Dr. Balachandra Puranik Dept. of Mechanical. Engineering IIT-Bombay.
4.	31/10	Development of Novel Polymeric Nuclear Track detectors	Dr. V. S. Nadkarni Goa University, Goa.
5.	31/13	Phytoextraction of Caesium-137 from Contaminated Soil	Dr. S. Meena TNAU, Coimbatore.

Interaction Meeting with IIT-Bombay, Mumbai

An interaction meeting with the faculty and some post-graduate students of IIT-Bombay, Mumbai was held on August 25, 2004. A team of total five members from AERB and NPCIL visited IIT-Bombay and made presentations on different topics regarding safety, research and regulatory activities. As a result of the meeting, nine research proposals were submitted to AERB, which were reviewed internally and in CSRP. Ultimately one project was awarded and three of the projects are under revisions and will be evaluated again.

Interaction Meeting with IIT-Madras and Anna University, Chennai

A team of three members from AERB, Mumbai and two members from IGCAR, Kalpakkam visited IIT-Madras and Anna University in Chennai. The meeting between Faculty of IIT-Madras and members of AERB team was held on 31st January 2005. Dean of IC&SR, IIT-Madras and other faculty members of IIT-Madras were present in the meeting. The interaction meeting between AERB team and Anna University faculty was held on 1st February 2005. Presentations were made by the AERB team members on different topics related to nuclear safety activities and the areas in which research project works can be carried out. Discussions were made on topics of interest to AERB in various fields of science and technology. The team also visited

the various R&D facilities of IIT-Madras and Anna University. The interaction is still continuing. Two proposals from IIT-Madras and one proposal from Anna University have been received and are being evaluated internally.

Appraisal of Report on CSRP Activities

A report, giving the details on the major highlights and achievements for the previous four years up to the year 2004-05 has been prepared. It has been brought out in the report that the role of AERB coordinators should be from the inception and formulation stages of the project proposals to ensure clarity. The coordinators should establish closer interaction with Principal Investigators and monitor the progress of the projects to ensure deliverables to AERB. The overall funding has been more on radiation safety research project and less emphasis on nuclear safety related projects as shown in the bar diagram given in Fig.12.1. The funding of the R&D projects may be more evenly distributed between nuclear safety and radiation safety projects.

12.2 INDUSTRIAL SAFETY AWARDS

The annual Industrial Safety Awards function was held at the AERB on March 4, 2005. Shri S.K.Mukherjee, Executive Director, Health, Safety & Environment, HPCL presented the Safety Awards for 2004 to Narora Atomic Power Station, Heavy Water Plant-Tuticorin, Indian Rare Earths Ltd., Manavalakurichi and Kudunkulam Power Project for attaining high levels of Industrial safety.

12.3 FIRE SAFETY AWARD

The Fire Safety Award is decided by taking into account the safety record on fire incidents and fire potential at the site. The award is based on the highest value of Preventive Efforts and Fire Hazard Index (PEFHI) score amongst all DAE Units. Heavy Water Plant, Kota has been selected as the winner for the year 2004.

12.4 INDUSTRIAL SAFETY STATISTICS OF DAE UNITS

The data related to injuries at various DAE Units

Fig 12.1A: Distribution of AERB Funding for Safety Research (%)

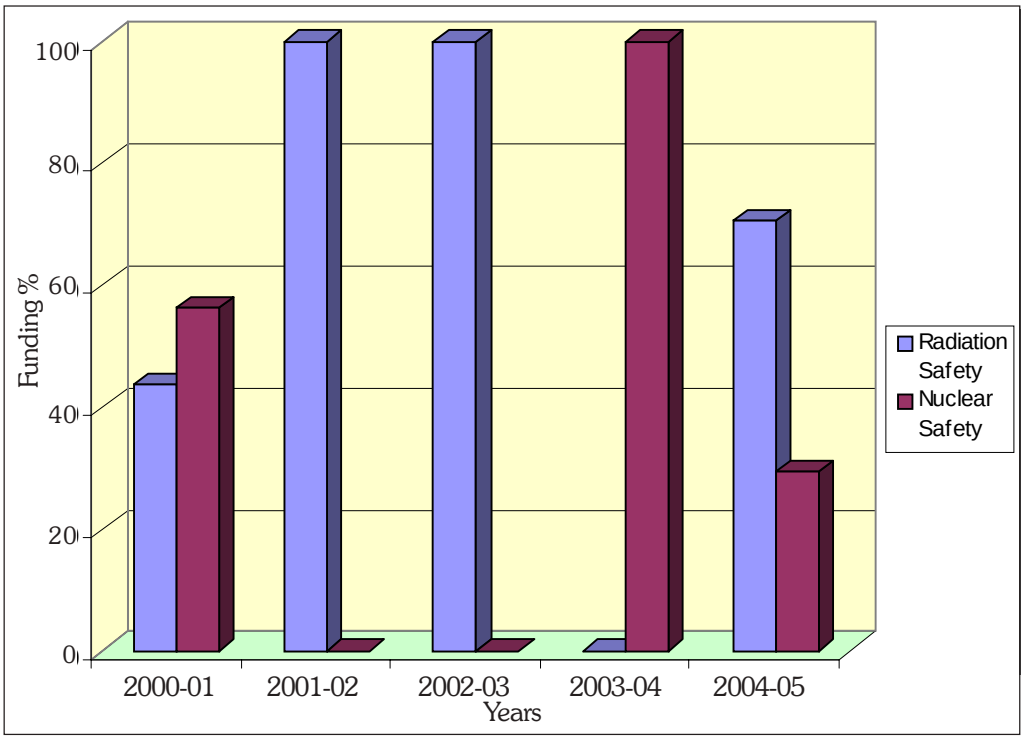
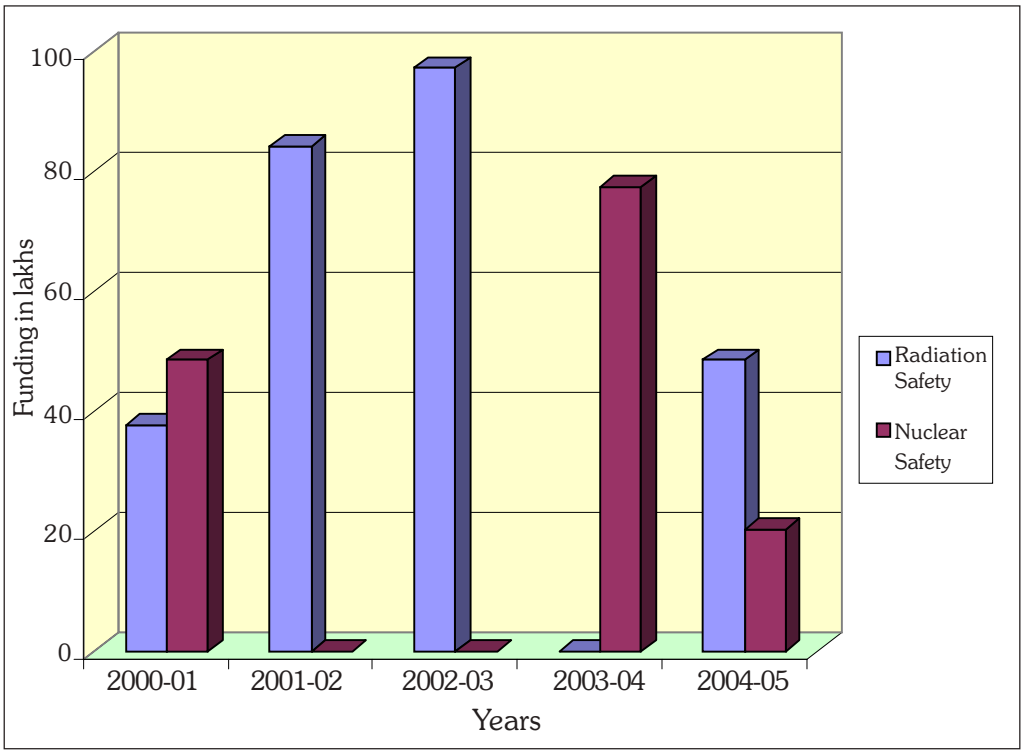


Fig:12.1B: Distribution of AERB Funding for Safety Research (absolute)



were compiled and a document entitled "Industrial Safety Statistics of DAE Units for year 2004" was released on March 4, 2005 during the Industrial Safety Awards presentation function. The data is analysed and presented in tabular and graphical forms. The analysis of the causes of the incidents and suggestions of requisite preventive measures to reduce the accidents is also incorporated in the document. The injury statistics, frequency rate (number of lost time injuries per million man-hours worked), severity rate (number of man-days lost per million man-hours worked), injury index (product of Frequency rate and Severity rate divided by thousand) and incidence rate (number of lost time injuries per thousand persons employed) of each Unit were compared with those of previous years (since 1999). The comparisons of various Units of the same group with respect to the above-mentioned parameters are drawn for various groups. Classification of various types of employees (Regular, Contractor & Casual) is also presented for the individual Units in a group. Analysis of number of injuries and man-days lost is made based on agency of injury, type of injury, unsafe act causing the injury and unsafe condition causing the injury, nature of injury and location of injury. Similar comparisons were drawn between different groups of DAE Units with respect to all the above parameters. In addition trends of "unsafe acts" and "unsafe conditions" causing the injuries have been analysed for individual groups and total DAE Units from the years 2001 to 2004. Some of the results of the study for the data obtained are represented in the figures 12.2 to figures 12.5.

Chairman, AERB Shri S.K. Sharma is with Shri S.K. Mukherjee, Executive Director (HSE), HPCL (Chief Guest), Shri P.K. Ghosh and Shri V.V. Pande on the Dais at the Occasion of Industrial Safety Award Function.

Fig. 12.2 : Reportables Injuries (DAE Units, 2004)

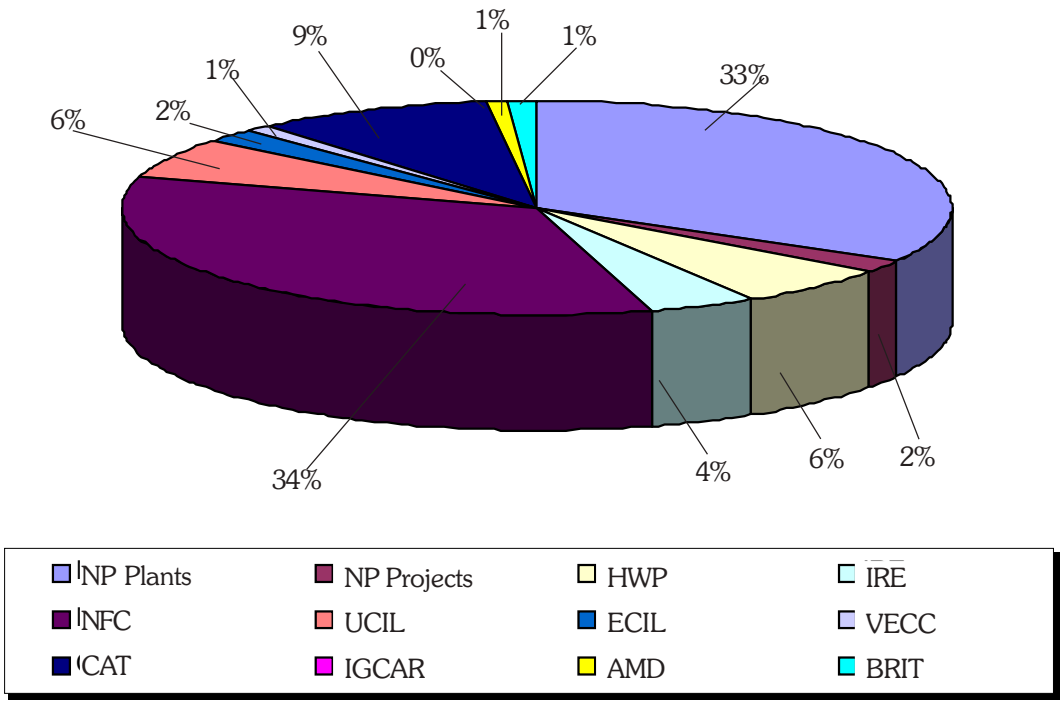


Fig. 12.3 : Severity Rate of Injuries (DAE Units, 2004)

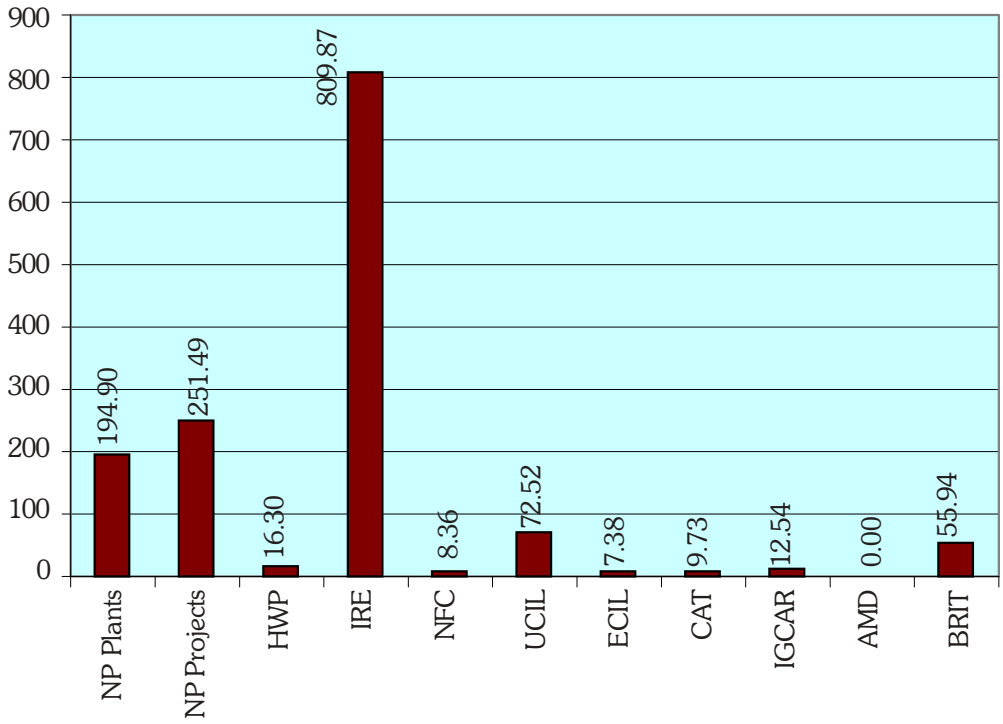


Fig. 12.4: Frequency Rate of Injuries (DAE Units, 2004)

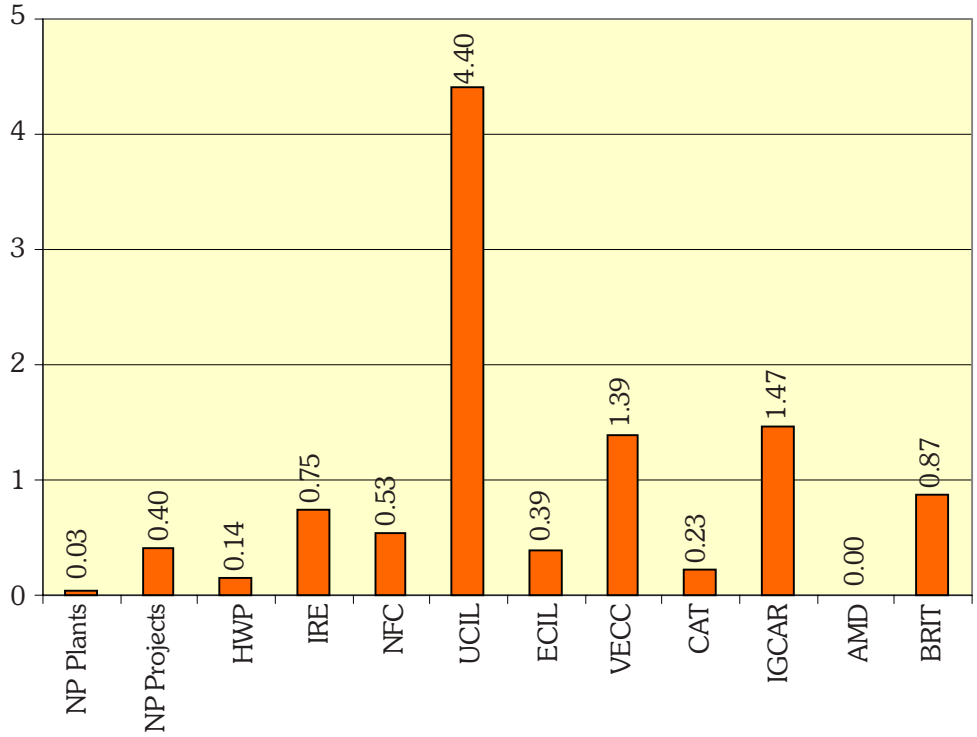
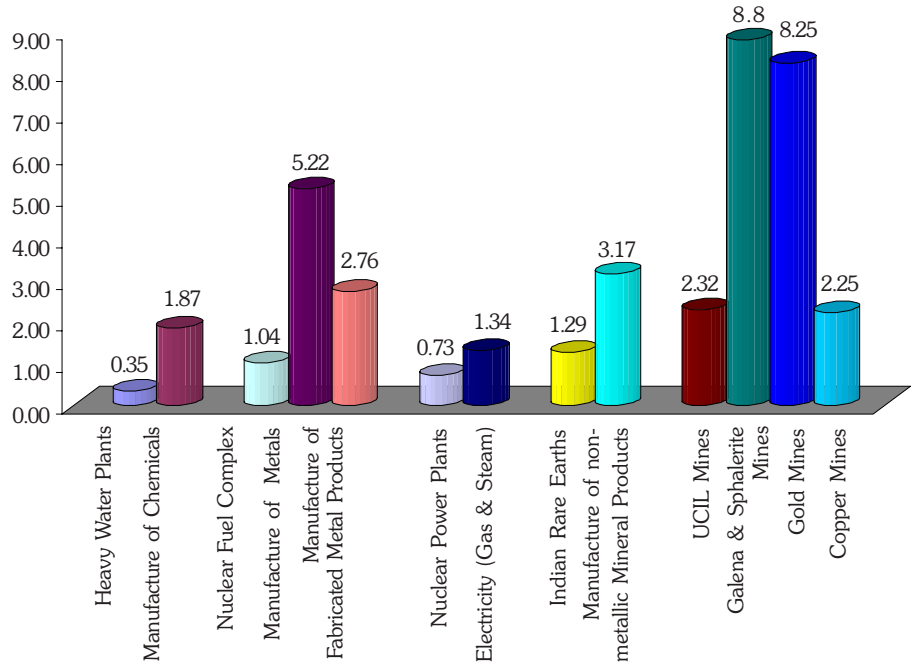


Fig.12.5: Comparison of Incidence Rates
(DAE & Non-DAE Units in INDIA, 2004)



The incidence rate for the *mines* is combined *fatal+serious accident* incidence rate. A serious injury is taken as one which involves *permanent loss or injury to sight or hearing or fracture of any limb*

12.5 ANNUAL DAE SAFETY & OCCUPATIONAL HEALTH PROFESSIONALS MEET

The 21st DAE Safety and Occupational Health Professionals' Meet was held at Variable Energy Cyclotron Centre, Kolkata during November 22 – 24, 2004. The theme of the meet was "Electrical Safety" and "Physical Hazards". Around 110 safety and occupational health professionals participated in the Meet and discussed on various safety related issues. Chairman, Central Electricity Authority delivered the endowment lecture. Chairman, AEC, presented AERB's Fire Safety Award and Green Site Award to the winning sites. "Comparison of plants occupational health and safety aspects with those envisaged in IS18001 by NPCIL, IREL, ECIL, HWB, NFC and BARC" , "Fatal accident cases during the past year", "Modern Techniques of Accident Investigation" were some of the significant discussions topics covered during the meet. A poster session on "Safety in Handling of Cryogenic Materials" and "Health Effects of Radio Frequency" was also arranged.

12.6 SUPPORTIVE WORK FOR BUREAU OF INDIAN STANDARDS (BIS) SAFETY DOCUMENTS

- The document IS: 4155:1966 "Glossary of Terms Relating to Chemical and Radiation Hazards and Hazardous Chemicals" was reviewed and comments were sent to BIS, New Delhi.
- Comments received on different Indian Standards related to Code of Safety on some Hazardous Chemicals were reviewed, and comments were sent to BIS, New Delhi.
- Draft BIS standard on "Safety Work Permit for Process Industries" was submitted for review and comments.

12.7 BEACH SAND MINERALS INDUSTRIES

A discussion meeting on the Beach Sands Minerals Policy was held in Mumbai during January 6-8, 2005, participated by various government and private sector stakeholders. Some regulatory issues related to radiological safety of processing of these minerals were raised in this meeting. To carry out a detailed examination of these issues towards developing appropriate regulatory guidelines on the subject, a Committee has been constituted by Chairman, AERB to examine the radiological safety issues involved in mining and milling of beach sands.

Four factories of mineral separation of M/S V. V. Minerals were inspected under the Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules, 1984 and the Radiation (Protection) Rules, 2004, by an inspection team of AERB.

12.8 IAEA SAFETY DOCUMENTS

The following draft IAEA safety documents were received by AERB as the nodal agency at the Member States comments stage.

1. DS332 – Release of Sites from Regulatory control upon termination of Practices
2. DS333 – Decommissioning of Nuclear Facilities

These draft documents were reviewed by experts in AERB, NPCIL and IGCAR. All comments were compiled and sent to IAEA.

CHAPTER 13
OFFICIAL LANGUAGE IMPLEMENTATION

In the year 2004-2005, the Official Language Implementation Committee (OLIC) of AERB accelerated the process of enhancing the use of Rajbhasha, Hindi in AERB through various means. A system of internal audit was also instituted to explore all possibilities for use of Hindi in various Divisions of AERB.

During the year, 10 "HINDI COMPETITIONS" were organised from 2nd to 11th August 2004. On this occasion, a total of 10 Hindi competitions were organised for AERB staff & Officers. These include Quiz, Hindi Typing, Noting/ Drafting, Scientific & Technical Translation, Debate, Essay, Memory Test, Hindi Slogan, Cross word puzzle and Elocution competitions. Prize distribution function for the previous year's competitions was organised in May 2004.

AERB staff also participated and won prizes in Hindi Competitions organised from 08 to 13 September 2004 jointly by AERB, HWB, DCSEM and DPS located in Anushaktinagar, Mumbai. A joint Hindi prize distribution program was conducted on 14th Sept.2004 at AERB Auditorium.

Hindi workshops were organised from August 30, 2004 to September 01, 2004 & September 02-03, 2004 for non-gazetted and gazetted administrative officials respectively by the Official Language Implementation Joint Co-ordination Committee of Anushakti Nagar based four organisations. Four employees from AERB participated in the above Hindi workshops. Representation of AERB was made in Town Official Language Implementation Committee (TOLIC) meetings conducted under the chairmanship of General Manager, Western Railway, Mumbai.

The Incentive Schemes for promoting the use of Hindi in Official work were also implemented and employees participated in these schemes. Scientific articles were presented in Hindi by the scientist in seminars held at RAPP-Kota and Banaras Hindu University.

During the year, one employee imparted Translation Training Course conducted by Central Translation Bureau, Mumbai. One employee was nominated for Prabodh Hindi Training under Hindi Teaching Scheme from Central Hindi Training Institute, Delhi through Correspondence Course. Two employees were nominated for Hindi Typing Training from Central Hindi Training Institute, Delhi through Correspondence Course.

AERB Annual Report, Newsletter and Brochure have been published in both Hindi and English, and these are circulated to DAE Units and various organisations of Government of India.

Four AERB Codes of Practice safety documents were translated in Hindi. Work on translation of eight other safety documents in Hindi is in progress.

Chairman, Shri S.P. Sukhatme and then Vice-Chairman, Shri S.K. Sharma along with Shri S.P. Agarwal, Chairman, OLIC and Shri N.S. Nair AO-III on the Dais at the Occasion of Hindi Prize Distribution

APPENDIX-A

A.1 PARTICIPATION OF AERB STAFF IN TRAINING COURSES / WORKSHOPS.

- S.C. Utkarsh , Workshop on "Application of Two-Phase flow and heat transfer to Indian Nuclear Reactors", at Safety Research Institute, Kalpakkam September13-15, 2004.
- S.C. Utkarsh, Industrial Training Program on "Application of Finite Element Technique in Industrial Problems", organized by Indian Nuclear Society at AERB, Mumbai held during October 25-29, 2004
- I.A.Patwegar, Fredric Lall, S.T.Swamy and Asokan Pillai: attended a course on "Communication Skills" held at AERB, during November 8-9, 2004, conducted by experts from NITIE, Powai, Mumbai
- S. Bhattacharya, workshop on "Environmental Legislation and Management", January 21-22, 2005.
- P.K. Ghosh and J. Prasad "Lead Auditors course on Occupational Health & Safety Management Systems (OH&SMS 18001)" January 24-29,2005.The training programme was conducted by M/s. EQMS India Private Limited at NPCIL.
- K. Ramprasad, "Lead Assessor Course for ISO 9001:2000" March 14-18, 2005 organised by National Centre for Quality Management, Mumbai.
- V.V. Pande, R. Bhattacharya and S. Bhattacharya attended one-day workshop on "Introduction to Occupational Health and Safety Management System based on requirements of OHSAS (ISO 18001)", on March 17,2005 organised by National Centre for Quality Management, Mumbai.
- Ajai S. Pisharady attended workshop conducted by IIT Chennai on Fracture mechanics of concrete structures during 1-3 December 2004 at Chennai.
- Ajai S. Pisharady attended the national workshop on advances in materials and mechanics of concrete structures (NWAMMCS) conducted by IIT Chennai during 02-03 July 2004 at Chennai.
- Ajai S. Pisharady attended the training programme for DAE Officers on Application of GIS and remote sensing in engineering conducted by RRSSC, Nagpur during 28 August – 01 September 2004 at Nagpur.
- Prabir C. Basu, S.K. Gupta and Ajai S. Pisharady attended National Conference on Ageing Management of SSC, organized by NPCIL at BARC TSH, Mumbai.
- A.D. Roshan attended 3rd international symposium on "New Technologies For Urban Safety Of Mega Cities In Asia" during 18-19 October, 2004 held at Agra, India.
- A.D. Roshan attended a five-day industrial training course on corrosion and condition monitoring organized by Indian nuclear society during 1-5 November 2004 at Mumbai.
- P. Shylamoni attended a five-day course on application of finite element technique in industrial problems organized by Indian nuclear society during 25-29 October 2004 at Mumbai.
- L.R. Bishnoi attended a five-day course on Pressure Vessel and Piping Design organized by Indian nuclear society during 29 November – 3 December 2004 at Mumbai.
- L.R. Bishnoi, P. Shylamoni, and Ajai S. Pisharady attended the workshop on "Information Exchange on Nuclear Safety" between AERB and ROSTEKNADZOR of Russian Federation held at AERB, Niyamak Bhavan, Anushaktinagar, Mumbai during 21 to 15, February 2005.
- During the workshop a presentation on "Highlights of Regulatory Review of Structures, Systems and Components of KK-NPP" was also made by Shri L. R. Bishnoi.
- Sourav Acharya attended the seminar on 'Tsunami and its mitigation' conducted by Indian society for earthquake technology on 5th March, 2005.
- Prabir C. Basu, L.R. Bishnoi, P. Shylamoni, A.D. Roshan, Ajai S. Pisharady and Sourav Acharya attended the presentation on "Russian Method of Design of Reinforced Concrete Slab & Wall" made by Prof Santhakumar, IIT Chennai held at NUB, Anushaktinagar on 31st March, 2005.
- Prabir C. Basu attended a National Workshop on Building Codes at Ahmedabad on July 09, 2004 conducted by The Gujarat State Disaster Management Authority, Gandhinagar.

- Prabir C. Basu and S.K. Gupta acted as Member of the Technical Committee for National Conference on Ageing Management of Structures, Systems and Components (NCAM-2004) during 23-25 August 2004.
- Prabir C. Basu attended a Seminar and delivered a lecture on High Volume Fly Ash Concrete Technology held on 15th October 2004 organised by Confederation of Indian Industry, New Delhi.
- Prabir C. Basu attended Annual Seminar on December 22, 2004 at STAADPro on 22.12.2004, organised by Research Engineers.
- Prabir C. Basu acted as a Faculty in the Training Programme conducted by the Associated Cement Companies Ltd., Mumbai on 28th December 2004.
- Prabir C. Basu attended Seminar and delivered a lecture on "Safety of Nuclear Installations against Tsunami" jointly organised by ICI Mumbai Chapter on 12th March 2005.
- R. Venkataraman "Life extension and Safety Upgradation in Indian NPPs-A Regulatory Perspective" presented in the International Conference on Topical Issues in Nuclear Installation Safety, Quinshan, China from 18th -22nd October 2004.
- S.N. Rao, "Operating Experience Feed back of Indian NPPs- A regulatory Approach" presented in the Technical meeting on "Use of External Operating experience" Vienna, December 13-17, 2004.
- R.K. Chugha " Evaluation and Demonstration of Safety of Decommissioning of Nuclear Facilites" presented in Technical Meeting on " Decommissioning Aspects of Nuclear Power Plants" Vienna 1-5 November 2004.
- R.S. Rao attended Advanced Nuclear Reactor Technology, June 2004, Royal Institute of Technology, Stockholm, Sweden.
- R.S. Rao attended Training Course on ASTEC, June 21-25, Aixen Province, Aix, France.
- R.S. Rao attended AERB-ROSTECHNADZOR, workshop on regulatory aspects, Feb 21-24, 2005, AERB.
- S.K. Dubey attended Workshop on Application of two phase flow and Heat transfer to Indian Nuclear reactors, September 13-15, 2004, Kalpakkam.
- S.K. Dubey attended Annual conference of Indian Nuclear Society On "Nuclear Technology and societal needs" November15-17, 2004, Mumbai.
- S.K. Dubey attended AERB-ROSTECHNADZOR, workshop on regulatory aspects Feb 21-24 2005, AERB, Mumbai.
- D.B. Nagrale attended one day seminar on "Energy Day", 26Feb 2005, IIT- Bombay, Mumbai.
- S.K. Pradhan attended one day seminar on "Energy Day", 26Feb 2005, IIT- Bombay, Mumbai.
- S.K. Tripathi attended course on "Structural Integrity Assessment Methods", May 14- June 30, 2004, BARC Training School, Mumbai.
- S.K. Tripathi attended 5 days course on " Finite Element Techniques for Industrial Problem", Oct 25-29, 2004, Indian Nuclear Society, Mumbai.
- S.K. Tripathi attended 5 days workshop on " Pressure Vessel and Piping Design", Nov 29-Dec 03, 2004, Indian Nuclear Society, Mumbai.
- U.K. Paul attended " Theme Meeting on High Burn Up issues in Nuclear Fuels", March 16, 2005, Central Complex, BARC, Mumbai.
- U.K. Paul attended "AERB-USNRC workshop on Nuclear Safety", Feb 11, 2005,AERB, Mumbai.
- Y.K. Shah attended "Indian Nuclear Society Annual Conference (INSAC-2004)", Nov 15-17, 2004.
- Y.K. Shah attended "National Conference on Ageing Management (NCAM-2004)" Dec 15-17, 2004 Mumbai.

A.2 PUBLICATIONS

- Prabir C. Basu, A. D. Roshan, Ajai S. Pisharady "Quantitiative Approach For Seismic Retrofitting Of Structures Using Pushover Analysis", 3rd international symposium on "New Technologies For Urban Safety Of Mega Cities In Asia" Agra, India, October 18-19, 2004.
- Shri L.R. Bishnoi, Dr. Prabir C. Basu, "Siting of Nuclear Installations", Nuclear India, Vol.38, Jan-Feb 2005, No.1, pp. 8-10.
- Utkarsh.S.C, 'Analysis of Large and Small Break LOCA experiments with RELAP-5 MOD 3.2' proceedings of 12th International Conference on Nuclear Engineering (ICONE-12) April 25-29, 2004, Arlington, Virginia, USA.
- Utkarsh.S.C, 'Natural Convection Heat Transfer in a

stratified pool with volumetric heat generation" proceedings of NUTHOS-6 International Conference held during October 4-8, 2004, at Nara, Japan.

- C. Senthil Kumar, A. John Arul, Om Pal Singh and K. Surya Prakash Rao, "Reliability Analysis of Shutdown System" Annal A, Nucleus Energy, 32, 63-87, 2005.
- R.P.Gupta, "Nabhikiya Urja Evam Paryavaran Sanrakshan ke Niyamak Pahaloo" Vaigyanik sangoshthee "URJA-2004: Ikkisaveen Sadi ki Chunautiyan evam Paryavaran Mulyankan" December 08-09, 2004, at BHU Varanasi (Hindi).
- R.P.Gupta, "Paramanu Bijaligharon ki Prachalan Sanraksha-Samiksha mein Aayu-Prabandhan ka Mahatva" 6th Vaigyanik sangoshthee June 23-24, 2004 at Rawatbhata (Hindi).
- Prabir C. Basu "Service Life Prediction of Concrete Structures" during the National conference on ageing management of structures, systems and components 15-17 December 2004 BARC, Mumbai.
- Om Pal Singh and S.K. Chande, "An Appraisal of the Effectiveness of the Regulation of Atomic Energy Regulatory Board India" IAEA Regional Workshop Technical Meeting on Self-Assessment of Regulatory Bodies, Ljubljana, Slovenia, September 20-24, 2004.
- P.K Ghosh, S.Bhattacharya, V.P. Gholap and L.N. Valiveti, "Accident Investigation using ASSET Methodology" 21st DAE Safety and Occupational Health Professional meet, Nov.22, 2004.
- R.S.Rao et al , KOZLODOUY-5 VVER –1000/V320 plant safety evaluation report, "Severe Accident Risk Assessment and Severe Accident Management", May 2004.
- R.S.Rao et al, "Analysis of the fuel heat up and coolability in the spent fuel pool of the Gosgen plant after the loss of water supply (LOWS) accident", to Center for Nuclear safety , Bratislava, Slovakia, June 2004.
- S.K.Gupta et al., "Modeling of Pressure Tube Ballooning deformation during high temperature transient", NUTHOS-6, Nara, Japan, Oct 4-8, 2004.
- S.K.Gupta et al, "Hydrogen Generation aspects during accidents in PHWRs", NUTHOS-6, Nara, Japan, Oct 4-8, 2004.
- S.K.Gupta et al, "Thermal Hydraulic Aspects of Steam Drum Level control philosophy for the Natural Circulation based Heavy Water Reactor", NUTHOS-6, Nara, Japan, Oct 4-8, 2004.
- S.K.Gupta et al., "Thermal Hydraulic Aspects of uncertainty in Power measurements of Nuclear reactors", NUTHOS-6, Nara, Japan, Oct 4-8, 2004.
- S.K. Gupta presented "Thermal and Mechanical Characterstics leading to Fuel Bundle and Fuel Channel and Fuel Integrity Criteria during Accidents", workshop on Application of two Phase Flow and Heat Transfer in Indian Nuclear Reactors 13-15 Sep 2004, SRI, Kalpakkam.

A.3 AERB Colloquia

- Shri S. Sankar, Director, Reactor Group delivered a talk on "Life Management of Research Reactor-CIRUS" on May 03, 2004.
- Dr. Om Pal Singh, Director, ITSD delivered a talk on "Safety Design aspects of FBRP" on May 28, 2004.
- Shri M.V. Ramamurthy, Sr. Vice-President (Shipping), Reliance Industries Limited delivered a talk on "Safety in Maritime Transportation of Hazardous Material" on October 04, 2004 at AERB Auditorium.
- Dr. R. Srivenkatesan, Head, RPDD, BARC delivered a talk on "Physics of Thorium Cycle and Advanced Heavy Water Reactor (AHWR)" on December 13, 2004 at AERB Auditorium.
- Prof. S.P. Shah, Director, ACBM, USA delivered a talk on "Health Monitoring of Concrete Structure" on January 17, 2005 at AERB Auditorium.
- Prof. Bal Raj Sehgal, Royal Institute of Technology, Sweden delivered a talk on "In Vessel Coolability and Vessel Failure During a Severe Accident" on January 18, 2005 at AERB Auditorium.
- Dr. Peter Ormai, Chief Engineer of PURAM, Hungary delivered a talk on "Overview of Radioactive Waste Management Practices in Hungary with Particular Reference to Upgrading of Safety in a Near Surface Repository in Hungary" on January 18, 2005 at AERB Auditorium.
- Dr. Peter Ormai delivered a talk on "Regulatory Approaches in Radioactive Waste Management" on January 19, 2005 at AERB Auditorium.

CHAPTER 14
AERB PERSONNEL
(31.03.04)

Sr. No.	Name	Designation/ Grade
1	Sharma S.K	Chairman
2	Chande S.K.	Vice-Chairman
3	Gupta S.K. (Dr.)	OS
4	Basu P.C. (Dr.)	H
5	Gujarathi R.I.	H
6	Ghosh P.K.	H
7	Singh Om Pal (Dr.)	H
8	Warrier S.K.	H
9	Venkataraman R.	"
10	Sukeshwala S.A.	"
11	Nandakumar A. (Dr.)	"
12	Chugha R.K.	SO (G)
13	Pande V.V.	"
14	Prasad J.	"
15	Ramakrishna A.	"
16	Rao S.N.	"
17	Agarwal S.P.	"
18	Bhattacharya R.	"
19	Fredric Lall	"
20	Krishnamurthy P.R.	"
21	Chauhan B.S.	"
22	Shah Y.K.	"
23	Srivasista K.	"
24	Patwegar I.A.(Dr.)	"
25	Subbaiah K.V.	"
26	Bhattacharya S. (Smt.)	SO (F)
27	Kanta Chokra (Smt.)	"
28	Ashraf S.A.H.	SO (F)
29	Bishnoi L.R.	"
30	Khan S.A.	"
31	Shirva V.K.	"
32	Swamy S.T.	"
33	Ramprasad K.	"
34	Sasidhar P. (Dr.)	"
35	Paul U.K.	"
36	Janakiraman G.	"
37	George Thomas	"
38	Padmanabhan T.S.	"
39	Arun Kumar	"
40	Harikumar S.	"
41	Sonawane A.U.	SO (E)
42	Garg A.P.	"
43	Nagalakshmi B (Smt.)	"
44	Nehru R.M.	"
45	Deepak Ojha	"
46	Koley J.	"
47	Pushpangadhan K.D.	"
48	Gupta R.P.	"
49	Upadhayay K.C.	"
50	Natarajan G.	"
51	Dash Sharma P.K.	"
52	Senthil Kumar.C	"
53	Asokan Pillai N.G.	"
54	Parmar R.U.	"

Sr. No.	Name	Designation/ Grade
55	Mahale L.B.	SO (E)
56	Titto E.R.	"
57	Raut V.V.	"
58	Kulkarni H.K.	"
59	Bhave S.R.	"
60	Sekhar Bhattacharya	"
61	Animesh Biswas	"
62	Shylamoni P. (Smt.)	SO (D)
63	Iyer V.S.	"
64	Roshan A.D.	"
65	Singh R.K.	"
66	Vijayan. P (Dr.)	"
67	Valivetti L.N.	"
68	Rao R.S.	"
69	Solanki R.B.	"
70	Utkarsh S.C.	"
71	Bhattacharya D.	"
72	Suneet K.	"
73	Vivek	"
74	Virdhi P.S.	"
75	Pisharady A.S.	"
76	Dubey S.K	"
77	Srikrushna Kumar Pradhan	"
78	Tripathi S.K	"
79	Mahendra Prasad	"
80	Jagannath Mishra	"
81	Dhanesh B. Nagrale	"
82	Pachpor P.M.	"
83	Umesh S. Awasthi	"
84	Ashok Hanimanal	SO (D)
85	Animesh Pal	"
86	Sourav Acharya	"
87	Gurumurthy	"
88	Anuradha Vangala (Smt.)	SO(C)
89	Inamdar M.V. (Smt.)	"
90	Sunil Sunny C.	"
91	Amit Sen	"
92	Pimpale D.V.	"
93	Pradhan S.K.	"
94	Sahani G.	"
95	Gholap V.P.	"
96	Singh B.K.	"
97	Kodolkar S.M.	"
98	Rane D.M.	"
99	Senthil Kumar. M	"
100	Kulkarni Arti. R (Kum)	"
101	Patnaik Dipali (Smt.)	"
102	Patil Pravin	"
103	Dhotre V.R.	"
104	Chodankar N.M.	"
105	Soumen Sinha	"
106	Kum Sonal Surana	"
107	Kum Singh Ritu Suryaprakash	"
108	S.G. Krishna	"
109	Sivaraman. G	"
110	Gopal Krushna Panda	"
111	Chaturvedi R.K.	"
112	Alok Pandey	"

Sr. No.	Name	Designation/ Grade
113	Kadambini Devi (Kum)	SO(C)
114	Kavi Upreti	SO (SB)
115	Ingavale B (Smt.)	"
116	Soumya George (Kum.)	SA (B)
117	Jayalakshmi D (Kum.)	SA (B)
118	Bokade Dipika P (Smt.)	"
119	Bapat A.P.	T'man F
120	Bhoite S.S.	Asstt. Foreman
121	Salgaonkar R.D.	T'man D
122	Kajania B.D.	T'man B
123	Puran Singh	"
124	Nair N.S.	AO-III
125	M.K. Damodaran	PPS
126	Palamattam R.J.	Sr.P.S.
127	Nalini Venugopalan (Smt.)	P.S (NS)
128	Vijayan C.K.	AO-II
129	Kuriakose V.P.	"
130	Narsingh Ram	AD (OL)
131	Sumambika Panicker (Smt.)	Asstt.
132	Chandrasekhar P. (Smt.)	Steno I
133	Sheela K. Menon (Smt.)	"
134	Mallika Nair (Smt.)	Steno II
135	Narayanan P.	"
136	Radha Raghavan (Smt.)	"
137	Latha Mohandas (Smt.)	"
138	Sathe M.S.	PRA
139	Shukla M.K.	JR. H.T.
140	Neena J. (Smt.)	Steno III
141	Moopnar. G.M	"
142	Shelar P.A. (Smt.)	UDC
143	Koli R.R.	"
144	More J.K.	LDC
145	Shettigar S.M. (Smt.)	"
146	Vaibhavi R. Dalvi (Smt.)	"
147	Parab Priya P (Smt.)	"
148	Naktode J.S.	Hindi Typist
149	Prabhuzantye S.S.	DCA
150	Samuel P (Smt.)	AO
151	Nair S.M (Smt.)	AAO
152	Javed Jafri	A.A.
153	Prakash K.V.	UDC
154	Harinarayanan P. (Smt.)	UDC
155	Satwilkar V.V.	UDC
156	Randhe V.R.	Driver (OG)
157	Shaikh F.A .A. A	Driver (OG)
158	Leo Babu Joseph	Helper A (T)
159	Kamble N.G.	Driver
160	Patil P.S.	Driver
161	Karande S.A.	Driver
162	Kanse S.S.	Driver

Personnel who retired on superannuation from AERB.

S.No.	Name	Designation	Date of retirement
1.	Smt. S. Lakshmanan	PPS	30.04.2004
2.	Shri C.P. Raghavendran	SO (F)	30.06.2004
3.	Shri S.K. Sharma	DS (VC)	31.07.2004
4.	Shri D.K. Dave	H+	30.09.2004
5.	Smt. R.N. Vadiwala	SA (E)	31.10.2004
6.	Shri R.P. Singh	SO (G)	31.12.2004
7.	Prof. S.P. Sukhatme	Chairman	14.01.2005
8.	Shri P. Hajra	SO (H)	28.02.2005

Personnel who joined AERB.

S.No.	Name	Designation	Date of **Joining**
1.	Shri Pravin Patil	SO (C)	01-04-2004
2.	Shri F.A.A.A. Shaik	Driver	07-04-2004
3.	Dr. S.K. Gupta	OS	01-07-2004
4.	Shri S.S. Prabhuzantye	DCA	18-08-2004
5.	Kum. Sonal Surana	SO (C)	01-09-2004
6.	Kum. Ritu Singh	SO (C)	01-09-2004
7.	Shri Soumen Sinha	SO (C)	01-09-2004
8.	Shri S. Ganga Krishna	SO (C)	01-09-2004
9.	Shri M.K. Damodaran	PPS	10-09-2004
10.	Shri D.B. Nagarale	SO (D)	05-01-2005
11.	Shri S. Bhattacharya	SO (E)	12-01-2005
12.	Shri G.K. Panda	SO (C)	12-01-2005
13.	Shri S.K. Sharma	Chairman	14-01-2005
14.	Shri R.K. Chaturvedi	SO (C)	19-01-2005
15.	Shri Umesh Awasthi	SO (D)	20-01-2005
16.	Shri Ashok D. Hanimanal	SO (D)	24-01-2005
17.	Shri P.M. Pachpore	SO (D)	25-01-2005
18.	Shri A.P. Garg	SO (F)	27-01-2005
19.	Shri Alok Pandey	SO (C)	27-01-2005
20.	Kum. Kadambini Devi	SO (C)	04-02-2005
21.	Shri Animesh Biswas	SO (E)	08-02-2005
22.	Shri Animesh Pal	SO (D)	21-02-2005
23.	Shri Sourav Acharya	SO (D)	01-03-2005

ANNEXURE
LIST OF ABBREVIATIONS

ACCGORN	:	Advisory Committee on Preparation of Code and Guides on Governmental Organization for Regulation of Nuclear and Radiation Facilities
ACCGASSO	:	Advisory Committee for Codes, Guides & Associated Manuals for Safety in Operation of NPPs
ACCGQA	:	Advisory Committee for Codes, Guides & Associated Manuals for Safety in operation of NPPs
ACNS	:	Advisory Committee on Nuclear Safety
ACPSR	:	Advisory Committee for Project Safety Review
ACOH	:	Advisory Committee on Occupational Health
AFR	:	Away From Reactor
AHX	:	Air Heat Exchanger
AHWR	:	Advanced Heavy Water Reactor
AMD	:	Atomic Minerals Division
ASME	:	American Society of Mechanical Engineers
BARC	:	Bhabha Atomic Research Centre
BDE	:	Backward Difference Formula
BHAVINI	:	Bhartiya Nabhkiya Vidyut Nigam
BRIT	:	Board of Radiation and Isotope Technology
BSA	:	Blanket Sub Assembly
CAT	:	Centre for Advanced Technology
CCF	:	Common Cause Factor
CCWF	:	Condenser Cooling Water Pump
CDA	:	Core Disruptive Accident
CDF	:	Cumulative Damage Frequency
CEP	:	Condensate Extraction Pump
CESC	:	Civil Engineering Safety Committee
CESCOP	:	Civil Engineering Safety Committee for Operating Plants
CFFP	:	Ceramic Fuel Fabrication Plant
CSIR	:	Council for Scientific and Industrial Research
CT	:	Computed Tomography
CWMP	:	Central Waste Management Facility
DAE	:	Department of Atomic Energy
DBR	:	Design Basis Report
DBFL	:	Design Basis Flood Load
DEM	:	Digital Elevation Model
DHDP	:	Decay Heat Drain Pump
DHX	:	Decay Heat Exchanger
DRDO	:	Defence Research and Development Organisation
ECCS	:	Emergency Core Cooling System
ECIL	:	Electronics Corporation of India Ltd
ECL	:	Environmental Chemistry Lab
ECSQ	:	Expert Committee for Seismic Qualification
EE	:	Equipment Erection
EFPY	:	Effective Full-Power Years
EIA	:	Environmental Impact Assessment
ERS	:	Event Reporting System
FBR	:	Fast Breeder Reactor
FBTR	:	Fast Breeder Test Reactor
FEA	:	Finite Element Analysis
FMEA	:	Failure Mode Effect Analysis
FRERP	:	Fast Breeder Fuel Processing Plant
GAN	:	GOSATOMNADZOR
GIS	:	Geographic Information System
HWB	:	Heavy Water Board
HWP	:	Heavy Water Plant
IAEA	:	International Atomic Energy Agency
I &C	:	Instrumentation & Control
ICRP	:	International Commission on Radiological Protection
IGCAR	:	Indira Gandhi Centre for Atomic Research
INES	:	International Nuclear Event Scale
IREL	:	Indian Rare Earths Limited
IRMRA	:	Indian Rubber Manufacturers Research Association
IRS	:	Incident Reporting System
ISI	:	In-Service Inspection
ISRO	:	Indian Space Research Organisation
IV &V	:	Independent Verification & Validation
KAPS	:	Kakrapar Atomic Power Station
KGS	:	Kaiga Generating Station
K-NPP	:	Kudankulam Nuclear Power Project
LBB	:	Leak Before Break
LWR	:	Light Water Reactor
LMC	:	Lead Mini Cell
LOCA	:	Loss of Coolant Accident

MAPS	:	Madras Atomic Power Station
MCNP	:	Monte Carlo N-Particle
MSL	:	Mean Sea Level
MOU	:	Memorandum of Understanding
NAPS	:	Narora Atomic Power Station
NICB	:	Nuclear Island Connected Building
NFC	:	Nuclear Fuel Complex
NOC	:	No-Objection Certificate
NORM	:	Naturally Occurring Radioactive Material
NPCIL	:	Nuclear Power Corporation of India Limited
NPP	:	Nuclear Power Project
NUOFP	:	New Uranium Oxide Fabrication Plant
OBE	:	Operating Basis Earthquake
OGDHRS	:	Operational Grade Decay Heat Removal System
OSCOM	:	Orissa Sand Complex
ONERS	:	On-Line Emergency Response System
PDSC	:	Project Design Safety Committee
PHT	:	Primary Heat Transport
PHWR	:	Pressurised Heavy Water Reactor
PSAR	:	Preliminary Safety Analysis Report
PSS	:	Primary Shutdown System
QA	:	Quality Assurance
RAPP	:	Rajasthan Atomic Power Project
RAPPCOF	:	Rajasthan Atomic Power Project Cobalt Facility
RAPS	:	Rajasthan Atomic Power Station
RCB	:	Reactor Containment Building
RPAD	:	Radiological Physics & Advisory Division
RPN	:	Risk Priority Number
RRSSC	:	Regional Remote Sensing Service Centre
RS	:	Remote Sensing
RPV	:	Reactor Pressure Vessel
RSO	:	Radiological Safety Officer
SARCAR	:	Safety Review Committee for Applications of Radiation
SARCOP	:	Safety Review Committee for Operating Plants
SAC	:	Space Application Center
SC	:	Safety Committee
SC	:	Secondary Containment
SCHWOP	:	Safety Committee for Heavy Water Operating Plants
SPND	:	Self Powered Neutron Detector
SER	:	Significant Event Report
SFSB	:	Spent Fuel Storage Bay
SGDHRS	:	Safety Grade Decay Heat Removal System
SGTF	:	Steam Generator Test Facility
SRI	:	Safety Research Institute
SS	:	Stainless Steel
SSE	:	Safe Shutdown Earthquake
SSSF	:	Solid Storage Surveillance Facility
SW	:	Steam Water
TAPS	:	Tarapur Atomic Power Station
TAPP	:	Tarapur Atomic Power Project
Type B (U)	:	Type B (Unilateral)
UCIL	:	Uranium Corporation India Limited
VECC	:	Variable Electron Cyclotron Centre
VVER	:	Water Water Energy Reactor
USNRC	:	United States Nuclear Regulatory Commission
WIP	:	Waste Immobilisation Plant
ZSP	:	Zirconium Sponge Plant
ZCC	:	Zone Control Compartment

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