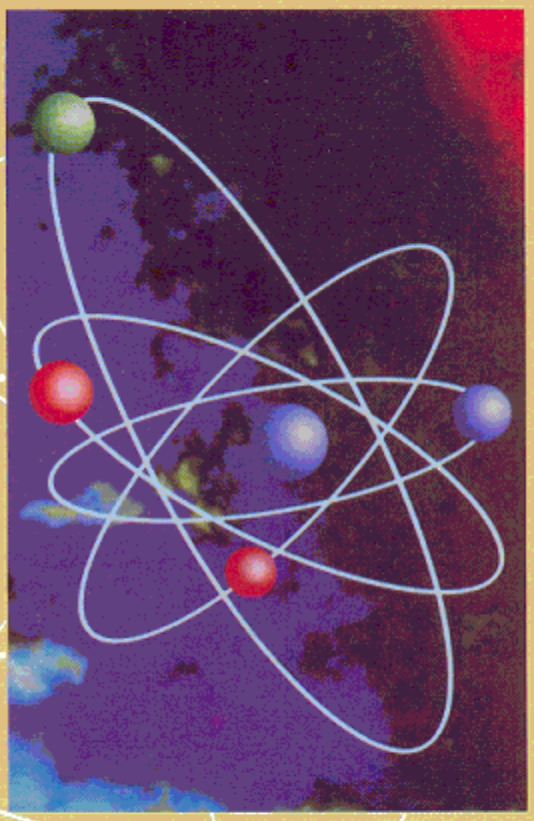
Annual Report
2005-2006



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GOVERNMENT OF INDIA

AERB

ATOMIC ENERGY
REGULATORY BOARD
MUMBAI

CHAPTER 1
GENERAL

1.1 COMPOSITION OF THE BOARD

1.	Shri. S. K. Sharma, AERB	...	Chairman
2.	Shri. S. K. Chande, AERB	...	Vice-Chairman
3.	Dr. M. V. S. Valiathan Honorary Advisor, Manipal Academy of Higher Education, Manipal (Up to July 28, 2005)	...	Member
	Dr. K. A. Dinshaw Director, Tata Memorial Centre, Mumbai (From July 29, 2005)	...	Member
4.	Dr. K. V. Raghavan Chairman, Recruitment & Assessment Centre, Defence Research & Development Organisation, Delhi	...	Member
5.	Prof. J. B. Joshi Professor and Director, University Institute of Chemical Technology (UICT) University of Mumbai, Mumbai	...	Member
6.	Dr. Om Pal Singh, AERB	...	Secretary

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 radiation and nuclear energy in India does not cause undue risk to health of people and the environment. Currently, the Board consists of Chairman, Vice-Chairman, three Members and Secretary.

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

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

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

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

GOVERNMENT OF INDIA

ANNUAL REPORT 2005-2006

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 Board's responsibility is to carry out the regulatory and safety functions envisaged under the relevant sections of the Atomic Energy Act. These functions include:

- Issuing authorisations for siting, construction, commissioning and operation of nuclear power facilities and radiation installations after appropriate safety reviews;
- Carrying out safety reviews of nuclear projects and radiation facilities under design, construction and operation;
- Ensuring compliance with the stipulated safety requirements by nuclear facilities and radiation installations;
- Conducting regulatory inspections of nuclear facilities 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 exercises as observer;
- 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 public informed of major issues of safety significance.

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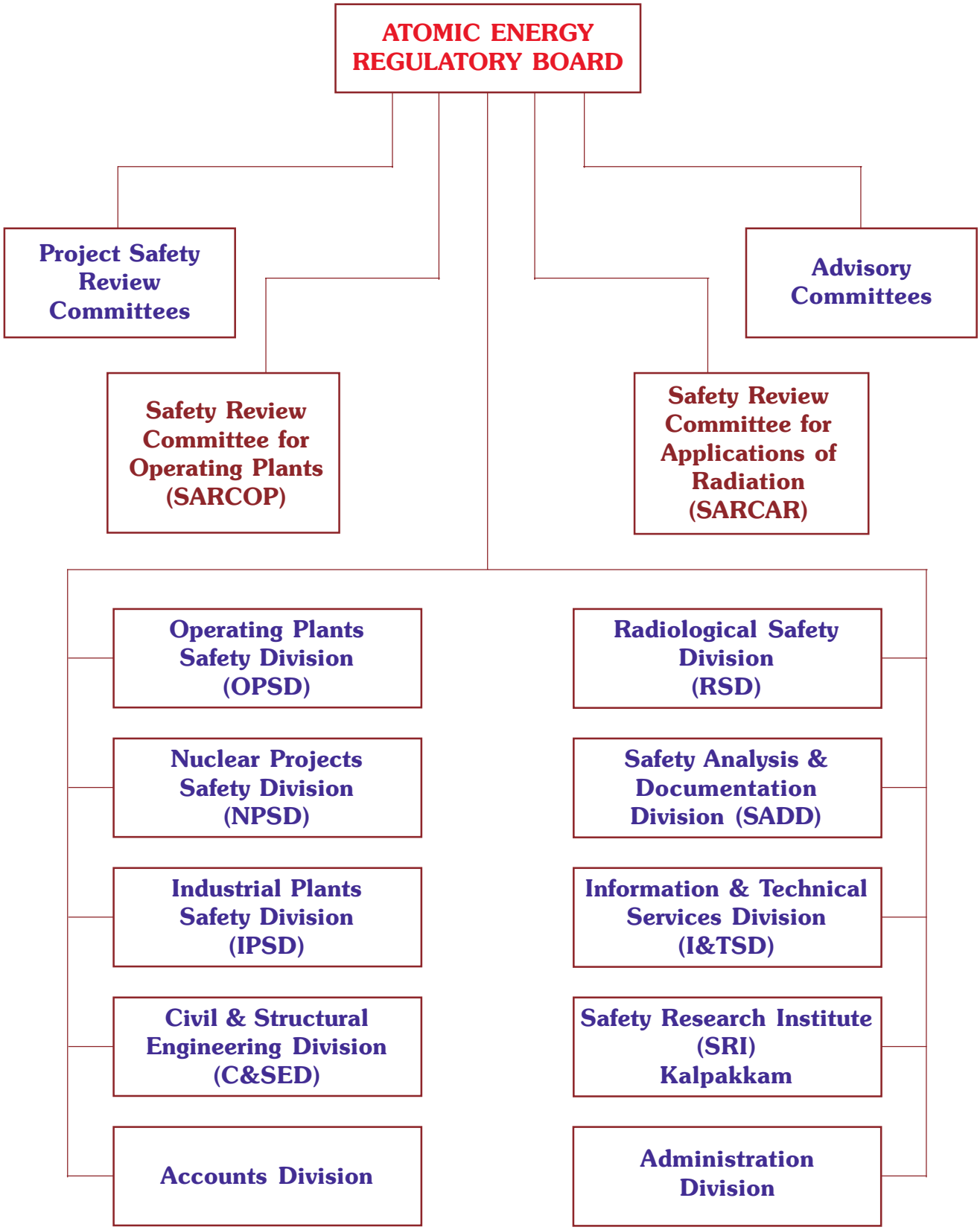


1.3 SUMMARY

A large number of nuclear and radiation facilities in operation and projects under construction in India are under the regulatory purview of AERB, which include 15 operating nuclear power Units and 8 nuclear power plants under construction. AERB carried out its charter of activities with the support of its secretariat and specialist committees under the guidance of the Board. The Board met four times during the year. The last meeting was held in March 2006 at the Kudankulam Nuclear Power Project site when Board members visited the power project and also the Manavalakurichi plant of Indian Rare Earths Limited. After the meeting on 14th Dec 2005, the members visited the Advanced Centre for Treatment, Research and Education in Cancer (ACTREC), Kharghar, Navi Mumbai.

AERB Board Meeting in Progress at Kudankulam Site (Sitting from L to R : Dr. K. V. Raghavan, Prof J. B. Joshi, Shri S. K. Chande, Shri S. K. Sharma, Dr. Om Pal Singh and Dr. K. Dinshaw)

Safety Review of Nuclear Projects

The multi-tier safety review of the Commissioning phase of the Tarapur Atomic Power Project (TAPP-3&4), having 2 PHWR units of 540 MWe each, continued during the year. In July 2005, AERB authorised operation of TAPP-4 upto 90% Full Power (FP) and authorisation was granted for fuel loading in TAPP-3 in March 2006. The safety review for other nuclear power projects under construction, viz., Kaiga Generating Station Units-3&4 (KGS-3&4), Rajasthan Atomic Power Project Units-5&6 (RAPP-5&6), Kudankulam Nuclear Power Project Units-1&2 (KK-NPP-1&2) and Prototype Fast Breeder Reactor (PFBR) continued during the year. AERB also took up safety review of the following new projects.

- Site Evaluation for locating two additional PHWR Units, each of 700 MWe at the Kakrapar site in Gujarat, i.e., Kakrapar Atomic Power Project-3&4 (KAPP-3&4).
- Demonstration Fast reactor fuel Reprocessing Plant (DFRP) at IGCAR located in the side of existing Kalpakkam Reprocessing Plant (KARP) premises.
- Safety review of Interim Fuel assembly Storage Building (IFSB) for PFBR.
- Pre-Licensing Design Safety Review of Advanced Heavy Water Reactor (AHWR).

TAPP-3&4

TAPP-4 attained first criticality on March 06, 2005. After successful completion of reactor physics related experiments, the Unit was synchronized to the grid on June 04, 2005. Based on the review of test results and commissioning data at 50% Full Power, AERB authorised the Unit to raise power upto 90% FP on July 06, 2005. For TAPP-3, authorisation for initial fuel loading was granted on March 20, 2006.

KGS-3&4 and RAPP-5&6

KGS-3&4 and RAPP-5&6 are repeat designs of KGS-1&2 and RAPS-3&4 respectively with minor differences in design and plant layout. The regulatory review focused on these differences. AERB issued authorisation for Erection of Major Equipment (EE) for RAPP-6 in July 2005. The authorisation for EE for KGS-3&4 and RAPP-5 had been granted in 2004.

KK-NPP-1&2

The important reviews conducted for KK-NPP-1&2 included seismic and environmental qualification of safety related equipment and components, validation and verification of thermal hydraulic codes used for accident analysis, reactor pressure vessel design and related topics and, the un-bonded pre-stressing system for primary containment that is being used for the first time in a Nuclear Power Plant.

PFBR

The partly constructed raft of PFBR project got affected because of flooding of the raft pit with sea water during the tsunami event of December 26, 2004. After review of the proposed corrective measures on the affected raft and design / layout changes, AERB granted permission for restart of the construction of NICB raft on April 25, 2005. Subsequently, AERB also granted authorisation for construction of NICB superstructure except for reactor vault and spent fuel storage bay. Safety review is in progress for clearance for start of construction of reactor vault.

KAPP-3&4

NPCIL has proposed to install two PHWR Units of 700 MWe each of new design at the Kakrapar site. Review of the Site Evaluation Report (SER) for this project is in progress.

DFRP

DFRP at Kalpakkam is for reprocessing spent fuel from Fast Breeder Test Reactor (FBTR) and PFBR. Civil construction of the project had been completed earlier together with the construction of KARP and installation of most of the equipment and piping had also been completed. A Project Design Safety Committee (PDSC) was constituted which has started the design safety review of DFRP.

IFSB

The facility is being designed by IGCAR for assembly and storage of mixed oxide fuel pins for the initial two core loadings in PFBR. PDSC constituted for the facility has started the design review.

AHWR

BARC has designed the AHWR with one of the objectives as developing fuel cycle technologies for thorium utilisation. There are several innovative features in the design including passive safety features. A Pre-Licensing Design Safety Committee has been constituted and review work has commenced to identify specific safety issues that need to be resolved through analysis and/or testing before initiating the formal licensing process.

Safety Review of Operating Nuclear Power Plants

All the Nuclear Power Plants (NPPs) and research reactors operated safely without any major incident during the year except that RAPS-1 continues to remain shutdown since October 2004. Techno-economic studies are in progress to decide on the future of this plant.

TAPS-1&2 were shutdown on October 1, 2005 for implementation of safety up-gradation and ageing management related actions. These actions had been identified earlier during 2000-2004 through detailed ageing studies and comprehensive safety review of these Units that are in operation since 1969. After completion of the identified actions, AERB granted permission in February 2006 for restart and renewed the authorisation for operation of these Units upto March 2011.

MAPS-1 was under shutdown since August 2003 for En-masse Coolant Channels Replacement (EMCCR) and safety upgradation activities. After extensive review of all aspects relating to coolant channel replacement and safety upgradations, AERB permitted restart of MAPS-1. The Unit was made critical on January 3, 2006 and was permitted to go to full power operation after review of its performance at various power levels. MAPS-2, which was started after EMCCR in July 2003, is performing well. AERB carried out an extensive periodic safety review of both the Units and authorised operation of the Units upto March 2011.

NAPS-1 was shutdown on November 1, 2005 for EMCCR. Detailed assessment of the health of coolant channels was performed in NAPS-2, which showed that operation of the Unit upto March 2007 is acceptable.

AERB had earlier granted interim authorisation for operation of RAPS-2 up to end of August 2005. Based on satisfactory resolution of all pending issues, AERB granted renewal of authorisation up to end May 2007 when the next Periodic Safety Review of the Unit will become due.

Regulatory Inspections of Nuclear Facilities

During the calendar year 2005, a total of 23 regulatory inspections were undertaken in the operating NPPs and research reactors, which included 5 special inspections. For the various projects under construction, 16 inspections were done. Special inspections dealing with civil engineering safety aspects and industrial safety aspects and to review commissioning activities of TAPP-3&4 were also performed.

Safety Surveillance of Radiation Facilities

During the year 167 devices incorporating radioactive materials and radiation generating equipment were issued Type Approval Certificates and 597 Radiological Safety Officers (RSO) were authorised. Two Type-A transport packages designed by the Board of Radiation and Isotope Technology (BRIT) were registered with AERB and transport of 4 shipments was approved under special arrangement. Over 2000 licenses were issued for procurement and import of a variety of radiation sources. Regulatory inspections were conducted in 231 radiation facilities and 11 unusual occurrences related to loss of radiation sources and radiation injuries to personnel handling radiation equipment were investigated.

Recently it has been decided that State Governments would set up Directorates of Radiation Safety (DRS) for regulation of diagnostic X-ray Units in their respective States. The State of Kerala has already done this and 11 other States have recently come forward to set up DRS. A workshop was organised by AERB to apprise the State Government representatives on the need of DRS and the modalities of their coordination with AERB.

As a part of its safety promotional activities, AERB organised a number of training programmes for X-ray equipment service engineers, nuclear medicine technologists, medical physicists, radiological safety officers in radiation therapy facilities and radiotherapy technicians. A special course was conducted for qualifying persons as RSOs of gamma radiation processing facilities. A one-day radiation safety awareness programme for officials of Indian customs at Jawaharlal Nehru Port Trust, Nhava Sheva was also organised.

Uranium Mines and Mills

Authorisations were issued for development of the first stage for Bagjata uranium mine and to the Turamdih mine for Mining and Ore Transportation to Jaduguda mill.

Nuclear Fuel Complex

Authorisation was issued to Nuclear Fuel Complex, Hyderabad for start of construction of the new zirconium oxide and Sponge Project at Palayakayal.

RRCAT

Authorisation was issued for trial operation of DC Accelerator at 750 keV and 20 mA beam current using SF_6 or N_2 / CO_2 gas mixture and regular operation of the fifth beam line of Synchrotron Radiation Source in Indus-1 at the Raja Ramanna Centre for Advanced Technology (RRCAT), Indore.

Industrial and Fire Safety

There were 13 fatalities during the year due to industrial accidents at various construction sites. The accidents were investigated and remedial measures were recommended to the sites. Regulatory Inspections (RI) for industrial and fire safety were carried out at various project sites and at the operating facilities.

Safety Documents

Following new safety documents were published during the year.

1. Site Considerations of Nuclear Power Plants for Off-Site Emergency Preparedness (AERB/NPP/SG/S-8).
2. Safety Systems for Pressurised Heavy Water Reactors (AERB/NPP-PHWR/SG/D-10).
3. Radiation Protection Aspects in Design for Pressurised Heavy Water Reactor Based Nuclear Power Plants (AERB/NPP-PHWR/SG/D-12).
4. Establishing and Implementing Quality Assurance Programme for Nuclear Power Plants (AERB/NPP/SG/QA-6).
5. Guidelines for Pre-employment Medical Examination and fitness for Special Assignments (AERB/SG/IS-4).
6. Safety Guidelines on Accelerators (AERB/SG/IS-5).
7. Radiation Protection for Nuclear Facilities [AERB/NF/SM/O-2 (Rev. 4)].

With this the total number of safety documents published so far is 115 out of total 194 planned.

Safety Analysis

An IAEA document on Severe Accident Analysis of PHWR was developed together with specialists from Canada, Republic of Korea and the IAEA. Reliability evaluation of certain passive safety systems of AHWR was carried out. Safety analysis was carried out to estimate the integrity of 37-element fuel bundle of TAPP-3&4 under stratified flow conditions. A computer code for Fire Dynamics Simulation was commissioned. The Validation and Verification document on thermal hydraulics computer codes used in accident analysis of KK-NPP 1&2 was reviewed. A number of design basis and severe accident analyses were carried out for KK-NPP 1&2 using the computer codes available in AERB, for inter-comparison purpose.

Safety Research Institute, Kalpakkam

Studies in the area of nuclear, radiological and environmental safety were continued at the AERB's Safety Research Institute (SRI), Kalpakkam. Flexibility analysis of a segment of pipeline extending from steam generator to secondary sodium pump for PFBR was carried out. Shutdown neutron count rates for PFBR start-up using neutron source subassemblies were calculated. A collaborative project was initiated with BARC and NPCIL to develop in-house capabilities for core management for the Pressurised Water Reactor based NPPs.

Support for Safety Research and Related Activities

AERB promotes safety research in educational institutes and also provides financial support for conducting workshops/conferences on topics of AERB interest. During the year, 9 new research projects, which included studies on Soil-Structure Interaction, Simulation of Spontaneous Crack Growth in Nuclear Containment Vessel, Oceanic Dispersion of Radionuclides and Optical Gel-Dosimetry, were accorded to various researchers. Ten on-going research projects were renewed and 28 scientific conferences were financially supported.

Human Resource Development

An MoU was signed with IIT-Madras to establish AERB Graduate Fellowship Scheme (AGFS) on the lines of the existing MoU with IIT-Bombay. One student each at both the institutes was sponsored for doing M.Tech. During the year, 18 engineers and 2 supportive staff were inducted at different levels. Newly recruited engineers were given training in nuclear science and engineering and regulatory aspects. Five engineers were deputed to undergo training at Nuclear Training Centre at RAPS, Kota and for on-the-job training in one of the operating reactors. A refresher Course on 'Operational Reactor Physics' and 'Reactor Kinetics' was also conducted for AERB staff.

During the year, one officer obtained Ph. D. Degree in Reliability Analysis and another officer completed M.Tech in Structural Engineering. Four officers are registered for Ph. D. Degree with University of Mumbai and one officer registered for M.Tech with I.I.T Madras.

One officer was deputed for post-doctoral fellowship in the field of Radionuclide Migration Studies to Japan under the Japan society for promotion of science fellowship scheme and one officer was deputed to Italy to work with Prof. D' Auria in the University of Pisa in the field of Uncertainty Analysis of Thermal Hydraulics Safety Studies. Preparatory work for deputation of two officers to USNRC, Washington D.C in the field of Probabilistic Risk Assessment is completed and deputation is likely to start shortly.

Discussion Meetings

A discussion meeting was held in November 2005 on issues related to design, construction and operation of spent fuel storage pools where experts from NPCIL, BARC, IGCAR, AERB, Design consultants and Construction contractors participated.

The 22nd DAE occupational Health and Safety Professionals Meet was organised at Heavy Water Plant, Manuguru in November 2005 with 'Process Safety Management' as the theme of the meet.

SRI, in association with Institution of Engineers, Kalpakkam organised a two-day discussion meet on 'Low Level and Near Miss Events' in December 2005.

Public Information

Copies of AERB Annual Report were distributed to DAE Units, media and RSOs in radiation installations. Three AERB newsletters were issued. Senior officials of AERB interacted with media personnel for providing information on nuclear and radiological safety matters and 5 press releases were issued. Required measures were taken to implement the 'Right to Information Act' in AERB.

International Co-operation

Under the ongoing nuclear safety cooperation program with the United States Nuclear Regulatory Commission, discussion meetings were held in September 2005 at Washington D.C and March/April 2006 in Mumbai on topics of passive system reliability analysis, severe accident analysis and management, long term performance of concrete structures and verification and validation of digital system.

The cooperation agreement with DGSNR, the French regulatory body, was renewed for a further period of 5 years. A Technical Meeting was held under this cooperation agreement in October 2005 in Mumbai, which included discussions on the tsunami event in India, flooding event at an NPP in France, safety in transport of radioactive material and safety and leak tests of pre-stressed concrete containment.

An international workshop on 'External Flooding Hazard at NPP Sites' was organised in Kalpakkam during August/September 2005 jointly by IAEA, AERB and NPCIL. A total of 80 experts participated in the workshop, 44 from India; 4 from IAEA and 32 from 15 foreign countries.

An IAEA meeting of senior regulators of countries operating CANDU type reactors was organised by AERB in Mumbai. Senior officials of the regulatory bodies of Argentina, Canada, China, India, Korea, Pakistan and Romania attended the meeting.

Official Language Implementation

AERB officials presented scientific papers in Hindi at a National Seminar organised by Hindi Vigyan Sahitya Parishad. AERB also conducted several competitions in Hindi among its staff. AERB annual report and newsletters were published in both Hindi and English. Fifteen safety documents were translated in Hindi and published.

CHAPTER 2
SAFETY SURVEILLANCE OF NUCLEAR FACILITIES

2.1 NUCLEAR POWER PROJECTS

2.1.1 Project Safety Review

Presently a total of 7 nuclear power Units are under construction and one Unit is under commissioning stage in India. The Units under construction include: 4 Units each of 220 MWe capacity Pressurized Heavy Water Reactors (PHWR); 2 Units each of 1000 MWe capacity Pressurized Water Reactors (PWRs, VVER type) and 1 Unit of liquid sodium cooled Prototype Fast Breeder Reactor (PFBR) of 500 MWe capacity. One Unit of 540 MWe PHWR project, namely TAPP-3 is under commissioning stage. AERB has authorised the operation of TAPP-4 upto 90% FP and to load fuel in TAPP-3. All these projects are based on indigenous design except the twin-Unit project of Pressurised Water Reactors (VVER type), which is of Russian design. While the design of 540 MWe capacity Units is an "Evolved design" from the indigenously built 220 MWe capacity Units, design of PFBR is a totally new design. Though, design of VVER is proven in Russian Federation and some other countries, this is for the first time that reactors of this type are being constructed and reviewed in India. Safety review of these Units continued during the year.

Design of 700 MWe PHWR is being carried out by NPCIL and the design would utilise experience gained during design, construction, commissioning and safety review of 540 MWe PHWR Units at Tarapur. The proposed site for locating first two Units of this upgraded design is Kakrapar in south Gujarat. The NPCIL has submitted the Site Evaluation Report to AERB seeking clearance for this site and review of the same has been initiated.

An Advanced Heavy Water Reactor (AHWR) with an objective to develop the technology for utilisation of thorium in India is under design at BARC. The reactor will be operated by an agency other than BARC. The Pre-Licensing design safety review of AHWR is in progress.

The safety review of two nuclear fuel cycle facilities designed by IGCAR, a Demonstration Fast reactor fuel Reprocessing Plant (DFRP) and an Interim Fuel sub-assembly Storage Building (IFSB) for PFBR has been taken up. For each project, a separate Project Design Safety Committee (PDSC) has been constituted and the review process has been started.

AERB has been following the well established practice of multi-tier review mechanism for safety review of projects. The 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 includes specialist members from the Ministry of Environment and Forests, Central Boilers Board, Central Electricity Authority and Educational/Research Institutes and Members from BARC, NPCIL and AERB perform the second-tier review. The third-tier review is by the Atomic Energy Regulatory Board which reviews the projects at major consenting stages. The process of safety review is supplemented by Regulatory Inspections for verifying compliance of the requirements prescribed by the Safety Committees and those specified in various codes, guides and standards of AERB.

Table 2.1 lists the number of meetings held by various Safety Committees during the year.

Table-2.1: Safety Review Committee Meetings of Power Projects

Project Committee	Number of Meetings
ACPSR-LWR	10
ACPSR-PHWR	2
ACPSR-FBR	1
PDSC-KGS-3&4 and RAPP-5&6	5
PDSC-TAPP-3&4	48
PDSC-PFBR	6
PDSC-DFRP	4
PDSC-IFSB	1
CESC	16
PLDSC-AHWR	13

In addition, a number of meetings of KK Co-ordination Group, Specialists Groups, Task Forces and Working Groups constituted by PDSCs/CESC/ ACPSR/ AERB were held for in-depth review of specific aspects of the projects.

TAPP- 3&4

TAPP-4 attained first criticality on March 06, 2005. After successful completion of Phase-B physics experiments, the Unit was synchronized to power grid on June 04, 2005. Based on the review of test results and Phase-C commissioning data at 50 % Full Power (FP), AERB issued the authorisation to operate the Unit upto 90 % FP on July 06, 2005. The commissioning data and test results at 90 % FP are under review towards authorisation for continuous operation of the Unit at rated power.

TAPP-3: Testing of Fueling Machine on Rehearsal Facility

For TAPP-3, the primary containment Proof Test and Integrated Leakage Rate Test were completed in December 2005 and the test-results were satisfactory. As per the stipulation of AERB, the test to demonstrate the required interception by secondary containment would be repeated prior to first approach to criticality. Hot conditioning and light water commissioning of the Unit have also been completed after completion of major construction activities. Authorisation for initial fuel loading has been granted on March 20, 2006 and charging of fuel in the reactor is in progress. The first criticality of the Unit is expected in the second quarter of year-2006.

TAPP-3: Filling of SFSB after Major Modification.

Some of the important observations during commissioning phase of TAPP-4 are as follows:

- Results of low power Phase-B experiments of TAPP-4 were satisfactory.
- Performance of Shutdown System No.1 (SDS-1) was as per the design intents. Provision for on-line testing of partial drop of shut off rod (clutch release test) was tested and results were satisfactory.
- During initial commissioning period, fluctuation of level in the Zone Control Compartment-1 (ZCC-1) of the Liquid Zone Control System (LZCS) was observed due to helium leakage from threaded joint of ZCC-1 assembly. The threaded joints of all the ZCC assemblies were suitably modified.
- Some of the important events since first synchronisation of TAPP-4 (during Commissioning Phase-C at 50 % & 90 % FP) and the corrective measures taken to preclude their recurrence are given below.
  - While the Unit was operating at 90 % FP and surveillance testing of SDS-2 instrumented channels was in progress, both the shutdown systems got actuated. Creeping of gadolinium into moderator and malfunction of instrumentation were analysed to be the causes for the event. Suitable modifications were incorporated to eliminate the problem.
  - There were a few occasions, when the Output Processor Node (OPN) / Input Processor Node (IPN) of Reactor Regulating System (RRS) halted or failed resulting in reactor trips. Appropriate design changes are being incorporated to eliminate the problem.
  - One of the Atmospheric Steam Discharge Valves (ASDVs) was found to be opening (~ 35% open) unwarrantedly. Investigation revealed considerable voltage drop across solenoid valves for Primary Heat Transport (PHT) crash cool down circuit. Suitable modification has been incorporated to overcome the problem.
  - There were a few reactor trips on 'Steam Generator Feed Water Line Low Pressure'. This was occurring due to mal-operation of speed control function of main boiler feed pumps. Modification in the logic was incorporated to eliminate the problem.
  - Failure of pipelines had occurred on two occasions at down-stream side of different Condenser Steam

Dump Valves (CSDVs). The problem was solved by replacing all the four lines of CSDVs by pipelines of appropriate design.

- High conductivity was observed in the feed water in condenser hot well. The problem was due to ingress of sump water through a passing valve into the system and the same was corrected.
- Condenser cooling water flow was observed to be less than required during lowest low tide level periods. De-silting of sea-water 'intake canal' was carried out to solve the problem.
- Fuel Handling System was commissioned and about 30 channels equivalent refueling operation was rehearsed on Rehearsal and Emergency Storage Facility. Also 5 channels equivalent fuel transfer operation were carried out. Required design modifications were done based on the experience gained during commissioning of the system.
- Ground water seepage in Spent Fuel Transport Duct was observed. Grouting was done to rectify the leaks.
- In the original design, there is provision of two diesel driven fire-water pumps. This was not considered adequate by AERB, as it was not meeting requirement of having an active stand-by during maintenance outage of one pump. An additional (third pump) diesel driven fire-water pump is being provided.
- Neutron field of 0.02 - 0.03 mGy/h has been observed in Horizontal Flux Unit area. Corrective measures are being worked out.
- In the light of the tsunami event of December 26, 2004, NPCIL was asked to carry out reassessment of maximum seawater tide level upto which essential safety functions of the Units can be maintained.

- Water accumulation in the leakage collection modules and dampness on the floor and walls of spent fuel storage bays of TAPP-3&4 were noticed. The source of ground water seepage was traced to gaps around rock-anchors and corrosion of Stainless Steel (SS) pipes of leakage collection modules. A backup Carbon Steel (CS) liner has been incorporated to protect the SS liner from corrosion due to chloride laden sub-soil seepage water.
- During hot conditioning, the problem of steam back flow from ASDV exhaust was observed. The designs of ASDV piping and its support system were modified to preclude the possibility of steam back flow. The support system of the modified pipeline was further changed based on review findings.

KGS-3&4 and RAPP-5&6

KGS-3&4 and RAPP-5&6 are "Repeat Designs" of KGS-1&2 and RAPS-3&4 respectively with minor differences in design and plant layout. The regulatory review process continued with emphasis on these differences and feedback from the operating plants. AERB issued the authorisation for Erection of Major Equipment (EE) for RAPP-6 in July 2005. The authorisations for EE for KGS-3&4 and RAPP-5 had been granted earlier in 2004.

KGS-3: PHT Feeder Tubes Installation in Progress

For all these 4 Units, civil construction of major buildings & structures and erection of equipment, piping, panels etc are in progress.

Some of the important observations made during design safety review are given below:

- Proposal from NPCIL for increasing 'Hot Creep Gap' in coolant channels of the Units upto 60 mm, with a view to achieving reduction in the frequency of gap adjustments, is under review.

- The experts committee, which reviewed the seismic qualification report, noted that the stresses as brought out in the analysis for seismic response of Calandria - End Shield integral assembly of KGS-1&2 (also applicable for KGS-3&4/RAPP-5&6) are found to meet the stipulated requirements of ASME Section-III, subsection-NB.
- NPCIL has agreed, as per AERB stipulation, for upgradation of Equipment Decontamination Facility to handle equipment with surface dose rate upto 50 mSv/h, as against 10 mSv/h envisaged in the earlier design.
- It was noted, during regulatory inspections, that dimensional mismatch between foundation and equipment base-plate has occurred for few equipment (e.g., Active Process Water Cooling System pumps and pedestal of HP Heater 6 at KGS-3 and PHT Storage Tank, Vapour Suppression Pool Re-circulation Pump and End-shield Cooling Pumps of RAPP-5). The site has been asked to prepare a complete list of such equipment for measurement of vibrations of piping and equipment during commissioning phase. Designers were asked to re-look into the stress analysis carried out earlier, in view of changes in the support design.
- NPCIL was asked to ensure proper maintenance of water chemistry in the vapour suppression pool to minimise the corrosion effect on the down-comers in the system. This is based on the operational experience from NAPS/KAPS.
- Geometric imperfections were noticed on the outer surface profile of inner containment dome of KGS-3. Based on the review by AERB, corrective measures were incorporated for the subsequent dome construction. Safety of as-built dome was found satisfactory under all applicable design load combinations.

KK- NPP-1&2

For KK-NPP consisting of two Russian design VVER reactors, each of 1000 MWe capacity, Co-ordination Group (KK-CG) along with the Specialist Groups (SGs) carries out the first level of review. The ACPSR-LWR, at the second level, reviews the recommendations of KK-CG/SGs along with the relevant documents. The review process is currently focused on the next stage of regulatory consent, i.e., Clearance for Erection of Major Equipment (EE).

The 88th Board meeting was held at KK-NPP site. The members were apprised of the status of the construction of the Units. The members visited the power project and witnessed the construction work in progress. A visit was also made to the IREL plant at Manavalakurichi.

AERB Board Members with Site Officials at KK-NPP Site

The review of specific topics like Reactor Pressure Vessel Design and related aspects, Water Chemistry and Materials has been completed. Specialist Group on PSA has been reviewing the PSA Level - 1 Report. Most of the issues that were brought out during the review of PSAR (Rev.1) have been satisfactorily addressed in PSAR (Rev.-2). Actions have been initiated towards resolution of the balance issues, as relevant to EE.

Some of the salient observations/recommendations are the following.

- The design requirements as given in PSAR packages on seismic and environmental qualification of safety related equipments and components have been reviewed.
- The Validation and Verification (V&V) document for thermal hydraulic codes for accident analysis was reviewed and found acceptable. The methodology for review of V&V of Computer Based systems is under formulation.
- Unbonded cables are being used for the first time for internal pre-stressing of the containment. A mock up using modified scheme for threading of cables in the horizontal duct has been conducted satisfactorily.
- The plant is provided with a special cooling system, which caters to the heat load of spent fuel pond and core residual heat removal following reactor shut down. The consequences of sharing a normal process function and safety performance under different off-normal conditions were reviewed. This design practice followed in Russian plants was accepted subject to certain stipulations.

- System for hydrogen management under severe accident conditions is a passive system and uses catalytic re-combiners. NPCIL has been asked to provide a scheme for periodic in-service tests to confirm the functionality of these re-combiners throughout the life-time of the plant.
- AERB has taken steps to develop in-house expertise for safety review of core management schemes and related aspects during operating phase of the plant.
- Various safety related aspects namely, thermal hydraulics, stress analysis and fatigue, material properties, quality assurance during manufacturing, surveillance programme for the pressure vessel material and in-service inspection were reviewed in detail for reactor pressure vessel.
- Out of the 1 mSv/year permitted public dose for a given site, KK NPP has been assigned a limit of 0.20 mSv/year, out of which 0.16 mSv/year and 0.04 mSv/year will be for air and liquid route respectively.

PFBR

Authorisation for First Pour of Concrete for the raft of Nuclear Island Connected Building (NICB) was issued on December 15, 2004 and the construction of raft was progressing well till the site got affected due to the tsunami event on December 26, 2004. Considering this, further construction of the raft was stopped. Site submitted reports on the incident addressing the impact assessment, proposed action plan for corrective measures and proposed improvements/changes, in the design/layout etc. These reports were reviewed by AERB and based on this review, AERB granted permission for restart of construction of NICB Raft on April 25, 2005.

PFBR: Mock-up for Construction of Reactor Vault

Subsequently, based on the application from BHAVINI and conduct of safety review, clearance for construction of superstructure for the eight buildings on NICB common raft, viz., Radioactive Waste building (RWB), Fuel Building (FB) excluding Spent Subassembly Storage Bay (SSSB), Steam Generator Buildings-1&2 (SGB -1&2), Reactor Containment Building (RCB) excluding Reactor Vault (RV), Electrical Buildings-1 & 2 (EB-1&2) and Control Building (CB) was granted on December 14, 2005. Also, clearance for construction of stack monitoring room and its associated tunnels and foundations for fuel oil storage tanks was issued. Safety review of PFBR is in progress with focus on next sub-stage of authorisation, that is, construction of reactor vault.

Some of the important observations/recommendations during the review include the following:

- Detailed review of the Plant Layout in particular from operation and maintenance considerations was carried out.
- In-depth safety review was carried out prior to re-construction of raft of Nuclear Island Connected Buildings over the partly constructed damaged raft due to tsunami.
- Mock-up test is planned and is being done in stages and the test results are being reviewed progressively by AERB.
- Detailed review of design and structural analysis of various safety significant buildings and structures was performed and modifications/changes were recommended to enhance safety.
- It was noted that the neutronic status of the core might remain un-monitored for certain periods during/after fuel loading operations with the present arrangement of Instrumented Central Sub-Assembly. This aspect is being reviewed further.
- A passive system, namely Safety Grade Decay Heat Removal (SGDHR) based on natural convection cooling is provided to reject decay heat of the core to outside atmosphere under station blackout condition. The system aspects namely, need for on-line purification system, establishment of SGDHRs capacity through

thermal hydraulic studies, experimental backup to confirm the design intent of SGDHR, structural integrity assessment of Decay Heat Exchanger under Core Disruptive Accident pressure loading, etc. are under detailed review.

- Fuel Sub-Assembly design has been modified and graphite is removed as top axial shield and is replaced with B_4C and SS, to avoid possible sodium-graphite reaction in the presence of oxygen.
- Specialist Group consisting of experts has carried out in-detail design safety review of Inclined Fuel Transfer Machine (IFTM) and has made many important recommendations for safety improvements.
- Aspects related to cable layout within the plant were reviewed in detail to assess compliance with safety requirements.
- AERB is currently checking the conformity of PFBR design with IAEA code NS-R-1, 2000 requirements.
- It was noted that there are a number of safety significant major equipment, which are required to be installed/ erected in parallel with civil construction. Installation of first of such equipment, Safety Vessel (SV), is expected to be started in about 6 months from the start of construction of reactor vault. Installation of SV would be considered as the beginning of third sub-stage of construction authorisation requiring Regulatory Consent.

KAPP-3&4

NPCIL, based on its experience with 540 MWe PHWR Units built at Tarapur, proposes to build two upgraded Units of 700 MWe at Kakrapar in Gujarat. AERB has initiated the review of the Site Evaluation Report submitted by NPCIL for approval of the site.

DFRP

IGCAR is setting up a Demonstration Fast reactor fuel Reprocessing Plant (DFRP) at Kalpakkam to process the carbide fuels from FBTR and fuel assemblies of PFBR in future. The DFRP would be forerunner of the FBR fuel reprocessing plant proposed to be set up at Kalpakkam and would utilise the experience gained from Lead Mini Cell operation. The DFRP is located adjacent to the Kalpakkam Reprocessing Plant (KARP), a BARC facility and shares with it certain safety related systems, facilities and buildings.

A Project Design Safety Committee (PDSC-DFRP) is currently reviewing aspects such as, plant design safety criteria, operating experience of Lead Mini Cell and issues related to sharing of certain facilities with KARP. AERB is also reviewing an application for construction of the Head End Facilities of DFRP.

IFSB

IGCAR has proposed to construct an Interim Fuel Storage Building (IFSB) for PFBR. The facility is being designed for making fuel assemblies for initial two core loadings. The IFSB will be constructed within FBTR complex. A Project Design Safety Committee for IFSB has been constituted recently and the review process has been initiated.

Some of the salient observations/ recommendations during the review process are the following:

- Provision of appropriate shielding to take care of the gamma radiations from build up of Americium-241.
- Analysis of accidental dropping of fuel Sub-Assembly as a Design Basis Event.

2.1.2 Authorisations / Permissions Issued for Nuclear Projects

TAPP-3

- Authorisation for Hot Conditioning and Light Water Commissioning
- Permission for Draining Light Water from PHT and Moderator Systems
- Authorisation for Initial Fuel Loading in the Core

TAPP-4

- Authorisation for synchronization of the Unit and operation upto 50% FP
- Authorisation for operation upto 90% FP

RAPP-6

- Authorisation for Erection of Major Equipment

PFBR

- Authorisation for Re-construction of Nuclear Island Connected Buildings (NICB) raft.
- Permission for Construction of Perimeter Wall around NICB and certain Safety Related Buildings/Structures.
- Clearance for Construction of Superstructure for the eight buildings on common NICB raft (except RV and SSSB)

2.1.3 AHWR

Advanced Heavy Water Reactor (AHWR) is a vertical, pressure tube type, heavy water moderated, boiling light-water-cooled reactor relying on natural circulation for core cooling in all operating and shutdown conditions. The AHWR has a unique design and is developed by BARC as a next generation nuclear power plant incorporating a number of novel features to enhance the safety of the reactor. AHWR also aims at extensive utilisation of thorium to facilitate development and deployment of technologies relevant for the third stage of the Indian nuclear power programme.

A Pre-Licensing Design Safety Committee for Advanced Heavy Water Reactor (PLDSC-AHWR) was constituted to carry out pre-licensing design safety review and to identify specific areas in the design that need to be qualified by testing and/or analysis before initiating the formal licensing process.

The mandate of the Committee's work includes checking conformity of the design with AERB Codes and Guides and applicable international safety documents, adequacy of design provision for operational transients and accident scenarios, international consensus on the criteria for advanced new generation reactors, adequacy of R&D programmes to support design and operability etc.

The Committee and its sub-committees made good progress in the safety review process. An interim report has been brought out on the status of the Pre-licensing Safety Review.

Some of the issues that were discussed during the review are given below.

- Parallel channel instability and associated neutronic thermal hydraulic issues.
- Two-phase natural circulation at normal full power operation.
- Startup, shutdown, low power operations and a few operational transients.
- Nuclear data for thorium and validation of computer codes.
- Cooling of Reactor under all conditions and coolability criteria.
- Demonstration and validation of unique and novel systems like all passive systems, advanced accumulator, direct ECCS injection to fuel, use of Th-Pu and Th-U MOX, use of Dysprosium, long vertical fuel assembly and fuel handling system.
- Performance of reactivity mechanisms and other safety devices located below deck plate and expected to operate at 280°C.
- Reliability of Annulus Gas Monitoring System.
- Review of the use of best estimate codes.
- Issues arising out of delayed attainment of equilibrium core.
- Failure Mode & Effect Analysis for each system and demonstration of safety.
- Integrity, efficiency and capability of setting up a satisfactory Emergency Core Cooling System recirculation flow through Gravity Driven Water Pool (GDWP).
- Demonstration of the capability of GDWP in carrying out its multiple functions, especially those that may require simultaneous functioning.
- Location of equipment inside containment as against present practice of locating most of them outside.

2.1.4 Regulatory Inspections of Projects

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

Table-2.2 : Regulatory Inspections of Nuclear Power Projects

Site	No. of Inspections
TAPP - 3 & 4	3
KK - NPP -1 & 2	3
KGS - 3 & 4	3
RAPP - 5 & 6	3
PFBR	1
DFRP	1

In addition to these planned inspections, teams of AERB representatives visited TAPP-3&4 to observe certain important commissioning tests or to assess the preparedness of site prior to granting of authorisations for the next phase of commissioning activity. Inspections of certain Project Sites were carried out, as necessary, exclusively by experts in civil engineering / industrial safety fields.

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

TAPP-3&4

- The plant has lowered the trip level for PHT Storage Tank Level for actuation of Shutdown System No. 1. The justification of the change is being reviewed.
- In the supplementary control room, deficiencies such as reading of certain safety related parameter not matching with those appearing in Main Control Room (MCR), Computer based Operator Information System (COIS) screen frozen, unavailability of SDS-1 rod position, logbook not updated, etc were noticed. Site was directed to correct the deficiencies.
- Fire barrier is to be provided for the control cables at the entry point of the Supplementary Control Room.
- Design provision is to be made to alert operator, in case of failure of a Self-Powered Neutron Detector.
- It was observed that 'Reactor Setback' function was not taking place on RTD fault condition. This aspect is under safety review.

KGS-3&4

- The minimum radial clearance between the guide tube of reactivity mechanism and calandria tubes, which can be tolerated considering the postulated severe conditions and the margins available with the actual measured dimensions is to be assessed.
- Earthing levers of all 220 kV Switchyard Feeders/ Equipment were tied with a rope to avoid the accidental closing of earth-switch following the misalignment of the balancing weight attached to the lever while the feeder/equipment is in charged condition. It was recommended to incorporate necessary modification/ replacement of the 220 kV earth-switches (in KGS-1&2 switchyard) to eliminate tying with a rope.
- The plant is to ensure that site internal audit committees do the internal audit of the contractors as per schedule.
- The procedure for identification and preservation of Calandria Tube and Pressure Tube off-cut samples is to be prepared and made available for reference in future.
- In KGS-3, three Inconel bellows installed inside Calandria Vault (CV) between CV-floor EPs and lower standpipe of Secondary Shutdown System (SSS) were replaced because of helium leakage detected during the test after carrying out site welds. The site was recommended to review the causes of failure of the bellows and to qualify the bellows of similar design including those already installed in SSS.
- During installation of diffuser sleeve at adjuster rod assembly locations in KGS-3, it was noted that 20 mm dia holes in diffuser sleeves were blocked, as they were not projecting inside the calandria as per original design. Additional 20 mm dia holes have been drilled to resolve the problem. The modified design is being reviewed further.
- The appropriateness of extension of Class-II power supply from safe shutdown earthquake qualified control building to non-seismic switchyard building is to be confirmed.

RAPP-5&6

- A root cause analysis in the context of an observation of linear surface defects (~ 2 mm deep) on calandria of RAPP-5 is to be carried out.
- It was observed that 3 out of 30 SS bellows and 10 out of 30 inconnel bellows did not qualify in hydro and helium tests. However, site confirmed that only qualified bellows are being used.
- Test results of total 16 Drive Mechanisms for Primary Shutdown System Rods and Shim Rods for RAPP-5 showed that rod drive-out time for 3 mechanisms were in the range of 140-150 s. These values should have been more than 150 seconds. It was recommended that these drives should be qualified as per the design intent.
- Out of total 306 channels, for 118 Pressure Tubes, Design Concession Request (DCRs) have been raised which were related to minor deviations with respect to chemical impurity specification of ingot and wall

thickness. Identification of the long-term impact of the chemical impurities and maintenance of uniform CT-PT gap were recommended.

- It was also recommended to augment the Fire Fighting Water provisions in phase with the construction of Reactor building.

KK-NPP-1&2

- It was noted that the location of Spent Fuel Building (SFB) is coming under Low Trajectory Turbine Missile (LTTM) zone of Turbine Building 1. The designers were asked to ensure adequate design provisions in SFB to avoid penetration of turbine missile.
- Certain deviations were observed in the "Loading curve of the DG sets" as given in its Equipment History Documents vis-à-vis the one in safety report. This aspect would be reviewed further.
- In the Reactor Building of KK-NPP-1&2, MS bars were found welded directly as barricade members at some locations on the upper portion of SS lined wall of reactor vessel inspection well. It was also noticed that at some locations, the EPs were dis-bonded from concrete. Site was asked to rectify the situation and asked the contractor to prevent recurrence of such instances.
- During the fabrication of Sprinkler System Piping, ferrite content of 9.5 % (normal range: 2 to 8 %) was observed. The plant was asked to ensure control over the ferrite content in welding.

PFBR

BHAVINI was asked to:

- submit QC procedures and QA procedures for actual concreting, radiometry, etc. to achieve the required bulk shielding in roof slab based on the review of the mock-up results,
- submit a procedure for handling of shell segments of safety vessel and main vessel of large dimensions (~13 m diameter and height) in the Site Assembly Shop (SAS),
- prepare and get approved the Job Hazard Analysis (JHA) reports for fabrication activities at SAS related to handling of major components like Safety Vessel, Main Vessel, Core-catcher, Roof Slab, etc and
- revise the Emergency Manual to update the display of guidelines for individuals during site/plant emergency and to impart training to all the contract labourers and BHAVINI staff.

DFRP

- The designers were asked to prepare Quality Assurance Manual for the on-going civil works.
- In the basement floor of chopper cell, dampness around grout holes were observed. IGCAR was asked to conduct a survey of all the basement areas for identification of possible seepage, leakage and damp patches and take necessary rectification measures before steel liners are installed on these floors.
- Certain deficiencies with respect to layout and routing of safety and non-safety related cables were noted. The site was asked to take corrective measures.

2.1.5 Industrial Safety

Regulatory Inspections on fire and industrial safety aspects were carried out in KGS-3&4, TAPP- 3&4, KK-NPP -1 & 2 and RAPP-5&6. In each case, a detailed inspection report was sent to the concerned Unit with the major shortcomings highlighted. The project authorities were asked to ensure among other things, the following.

- Strengthening of industrial safety organisation.
- Implementation of all safety precautions during blasting operations.
- Display of neutralisation procedures for handling chlorine leakages.
- Working platform of minimum 1 m width and provision of safety nets at openings when working at height.
- Preparation of Job Hazard Analysis (JHA) report for all major construction activities.
- Availability of ammonia detection system in the ammonia condenser area.

2.1.6 Special Regulatory Inspections

Following a fatal accident, AERB had directed suspension of all jobs involving work at heights at all NPCIL

project sites by a notification until a detailed report on measures taken to improve safety of work practices while working at height was submitted to AERB. Special regulatory inspections were carried out at all the nuclear projects to verify the improvement in the industrial safety status after which the restriction was lifted.

2.2 NUCLEAR POWER PLANTS AND RESEARCH REACTORS

The Operating Plants Safety Division of AERB carries out the safety review and monitoring of operating NPP and research reactors. The Safety Review Committee for Operating Plants (SARCOP), the apex committee for overseeing safety of operating plants, held 18 meetings during the calendar year 2005.

The Unit safety committees established under SARCOP have met a number of times to review safety related issues. The information on number of meetings conducted by various Unit safety committees during 2005 is given in Table 2.3.

Table 2.3: Meetings of Safety Committees

Name of the safety committee	No. of meetings
SARCOP	18
TAPS Safety Committee	6
RAPS - MAPS Safety Committee	12
NAPS - KAPS Safety Committee	7
KGS - RAPS - 3 & 4 Safety Committee	8
IGCAR Safety Committee	3
CESCOP	3

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

2.2.1 TAPS-1&2

TAPS-1&2 were operational upto a power level of 160 MWe. The Units remained shutdown between October 1, 2005 and February 14, 2006 for implementation of safety upgradation and ageing management related inspections for which simultaneous shutdown of both Units was necessary. Other safety upgradation jobs had been completed during operation of the Units and during their normal refueling outages.

Upgradation of TAPS-1&2:

TAPS-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 of the review were given in the AERB annual report for the year 2003-2004. Based on these reviews, a number of safety upgradations were identified towards meeting the current 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 Control Rod Drive (CRD) 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. The review also identified the components/ equipment requiring inspection for assessment of health from ageing considerations. Both Units of TAPS were shutdown on October 1, 2005, for carrying out the identified upgradation jobs.

After extensive review of all aspects relating to safety upgradations, health assessment of equipments, compliance with all the regulatory requirements/stipulations and satisfactory progress made towards resolution of the identified issues, AERB permitted restart of TAPS-1&2 and renewed the authorisation for operation of Units upto March 2011, when Application for Renewal of Authorisation (ARA) and Periodic Safety Review (PSR) of the Units will become due for submission.

Seismic Re-evaluation of TAPS-1&2

TAPS-1&2 Units were designed for seismic loading using equivalent static analysis method, which was the state of the art at the time of their design in mid 1960's. Considering the developments in seismic analysis and design, a need was felt for seismic re-evaluation of TAPS-1&2. The review basis ground motion parameters for re-evaluation were considered same as that of the design basis parameters for the new TAPP-3&4 Units, located nearby. IAEA safety series 28, "Seismic Evaluation of Existing Nuclear Power Plants" was used by AERB as the review basis. AERB also conducted

a site visit to verify the implementation of the retrofitting approaches adopted by NPCIL.

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

RAPS-1, continued to remain shutdown since October 2004. RAPS-2, RAPS-3&4 operated normally during the year.

RAPS-1

RAPS-1 continues to remain shutdown since October 2004. In May 2005, NPCIL submitted a proposal seeking permission for disabling of high-pressure ECCS and Small Leak Handling System (SLHS) and for de-linking the same from RAPS-2. These systems are shared between the two Units and were introduced as part of the safety upgradations.

A techno-economic review of the status of RAPS-1 and ageing related issues indicated that RAPS-1 would remain shut down for many more years. Under these circumstances NPCIL intends to utilise the system hardware such as valves removed from ECCS of RAPS-1, for retrofitting in MAPS-1, which would help in completing the upgradation jobs in time. This proposal was supplemented with additional steps such as (a) assessment of safety implications of disabling the systems, (b) provision for alternate measure to achieve decay heat removal in case of loss of coolant, (c) relocation of moderator heavy water from the reactor to outside storage tank to rule out any possibility of inadvertent reactor criticality, and (d) substitution of heavy water in the PHT system with light water.

After a detailed review, which showed that there would not be any unacceptable safety implications, AERB agreed for the disabling of ECCS of RAPS-1 and removal of the system hardware for reuse in MAPS-1.

RAPS-2

As brought out in the previous annual report, AERB reviewed the ARA of RAPS-2 in August 2004. Though, the overall safety performance of the Unit was found 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 requirement of a 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 and considering that there is nothing of immediate safety concern, the authorisation for operation of RAPS-2 was renewed by AERB upto end of August 2005.

Subsequently, NPCIL carried out detailed assessments and worked out action plans to address all the identified issues. After detailed review, based on the satisfactory progress made towards resolution of the issues, AERB granted the renewal of authorisation for operation of RAPS-2 upto May 31, 2007 when its next PSR will become due.

2.2.3 MAPS-1&2

MAPS-2 operated normally during the year. MAPS-1 was under shutdown from August 10, 2003 to January 3, 2006, for EMCCR and safety upgradation activities. The old Zircaloy-2 coolant channels with two loose fit garter spring spacers were replaced by coolant channels made of Zirconium-2.5% Niobium alloy with four tight-fit garter springs. The new coolant channels are expected to have a much longer life span as compared to the earlier Zircalloy channels, owing to lower hydrogen pick up during operation and reduced possibility of movement of garter springs from their design locations.

A number of other safety related upgradation jobs were also carried out in MAPS-1 during this shut down, as was done in the case of MAPS-2 earlier. Some of the important safety related modifications carried out include the following.

- Retrofitting of high pressure Emergency Core Cooling System
- Incorporation of Supplementary Control Room
- Upgradation of fire detection and fire protection systems
- Segregation of control and power supply cables of safety related systems.

Taking advantage of this long shutdown, all the old steam generators of the Unit were also replaced. In addition, newly designed moderator inlet spargers were installed to restore original moderator flow configuration.

The Safety Analysis Report was revised subsequent to the safety upgradation of MAPS-2. This revision also took account of various modifications/ upgradations carried out since initial commissioning of the Unit. With identical upgradations implemented in MAPS-1, the same safety analysis will now be applicable to both Units.

After extensive review of all the aspects relating to coolant channel replacement, safety upgradations, quality assurance aspects and compliance with all the regulatory requirements/stipulations, AERB permitted restart of MAPS-1. The Unit was made critical on January 3, 2006. Clearance was accorded in stages for Phase-B experiments, operation upto 75% FP and subsequently upto 90 % FP. Based on the review and satisfactory operation of the Unit at 90% FP by SARCOP, both the Units were permitted for operation till December 2010 by the Board of AERB when their next PSR becomes due.

AERB Representatives with MAPS Staff after MAPS-1 Criticality following EMCCR

2.2.4 NAPS-1&2

Both Units of NAPS operated normally during the year. NAPS-1 remains shutdown from November 1, 2005 for EMCCR.

Life Management of Coolant Channels in NAPS Units

An extensive campaign of in-service inspection and life assessment of coolant channels was carried out in NAPS-1 during July-September 2004. Based on the results of these assessments, NPCIL proposed to operate NAPS-1 till July 2005 and to take up a long shutdown of this Unit for EMCCR. Subsequently, in July 2005, NPCIL requested AERB to extend the permission for operation of the Unit till end of October 2005 citing logistical constraints and unavailability of requisite hardware for beginning the EMCCR activities. After an extensive safety review of the proposal which indicated no undue reduction in the safety margins, AERB accepted the NCPIL request for extension of operation of NAPS-1 up to end of October 2005. Subsequently, NAPS-1 was shutdown on November 1, 2005 for EMCCR.

Similar to NAPS-1, the campaign for life assessment of coolant channels was performed in NAPS-2 in May 2005. Results of this campaign indicated that the coolant channels would meet the acceptance criteria for operation of the Unit up to 11.5 'Hot Operating Years' (HOYs). NAPS-2 is likely to reach this by March 2007.

2.2.5 KAPS-1&2

Both the Units of KAPS operated normally during the year.

In KAPS-2, a steam generator feed water (10 % line) rupture incident occurred on 9th February 2006. Unit Safety Committee and SARCOP conducted a comprehensive review of the incident. The incident was attributed to accelerated flow assisted corrosion (FAC) due to excess feed water flow velocity in this line. A detailed examination/inspection of all vulnerable lines/areas were undertaken for KAPS-1&2. Required repairs/replacements were carried out and after detailed QA checks, Unit-2 was permitted to restart. The implications of this failure for all operating Units were also assessed and comprehensive in-service inspections have been planned for all operating Units in a phased manner.

2.2.6 KGS-1&2

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

2.2.7 Indira Gandhi Centre for Atomic Research

Fast Breeder Test Reactor (FBTR)

FBTR was operational up to a power level of 15.7 MWth.

Burn-up limit for FBTR fuel

The fuel used in FBTR consists of a mixture of plutonium carbide and uranium carbide. Since the international experience on the performance of this fuel is limited, its burn up limit is being increased in steps after careful review of the fuel performance at each stage. Post Irradiation Examination (PIE) of the irradiated fuel sub-assemblies is also carried out to study the in-reactor behavior of the fuel and to ascertain the permissible safe life of this fuel.

Presently the peak burn-up for FBTR has reached a record level of 147600 MWd/t (Megawatt-day per ton) without any fuel failure.

Kamini

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

2.2.8 Regulatory Inspections

Regulatory Inspection of Operating Nuclear Power Plants and Research Facilities is carried out periodically to:

- check for any radiological and industrial unsafe conditions,
- confirm the plant operation is as per the approved Technical Specifications and AERB/ SARCOP directives,
- confirm compliance with the maintenance, in service inspection and quality assurance programmes,
- confirm proper maintenance of records/ documentation,
- check that observations/deficiencies brought out in previous regulatory inspection 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 and it is under the process of publication after completion of review by ACCGORN. Routine Regulatory Inspections were carried out once in six- months for nuclear power plants and once in a year for research facilities. In addition, Special Inspections were carried out during up-gradation and EMCCR work or for any other specific safety requirement.

During the calendar year 2005, a total of 22 inspections were undertaken in the operating NPPs and research facilities, of which 17 were routine pre-planned inspections as per the regulatory inspection programme. The remaining 5 were special inspections. Four special inspections were carried out at TAPS-1&2 to assess the up-gradation work. One special inspection was carried out at MAPS-1 to review the completeness of EMCCR and safety upgradation work. Inspection of Fast Reactor Technology Group (FRTG) and Radio Chemistry laboratory (RCL) of IGCAR facilities was also included as a part of regular inspection from 2005.

The observations during the inspections are categorised 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	Shortcomings identified in the design of Safety, Safety related and Safety support systems, based on operating experience including generic deficiencies.
Category: IV	Procedural inadequacies.
Category: V	Observations on housekeeping and departure from good practices.

Category wise distribution of observations in different plants is given in Table 2.4.

Table 2.4: Categorisation 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	4	0	3	7	31	4
MAPS - 1 & 2	1	1	0	2	4	17	0
RAPS - 1 & 2	2	0	0	6	8	45	7
NAPS - 1 & 2	2	0	0	8	7	35	9
KAPS - 1 & 2	2	0	0	11	12	52	3
KGS - 1 & 2	2	0	0	3	8	36	8
RAPS - 3 & 4	2	0	0	3	5	28	12
RAPPCOF	1	0	0	0	0	0	0
FBTR &KAMINI	1	0	0	4	4	19	3
Fast Reactor Technology Group (FRTG)	1	0	0	0	0	6	0
Radiochemistry Laboratory (RCL)	1	0	0	0	2	12	1
TOTAL	17	5	0	40	57	281	47

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

TAPS-1&2

- Control rod drive pump recirculation line was having a recurring problem of a leak at a flange joint. Station replaced the flange joint with a welded cap to increase the availability of the safety related pump.
- The Technical Specification document was issued in 1991 and many revisions were subsequently added to it. Station was asked to revise the entire Technical Specifications document to take into account the changes made in systems due to upgradations, etc. AERB completed the review of the revised Technical Specifications.
- Special inspections were carried out to check the implementation of safety upgradation jobs.

MAPS-1&2

- Fire protection system for Diesel Generator was kept in manual mode. Also surveillance tests were not carried out for logic checks of fire protection system. Station was informed to institute a system for conducting surveillance tests and keep fire protection system in auto mode.
- A special inspection was carried out to check preparedness prior to authorisation for startup after completion of EMCCR. Station has completed the action plan required to address the observations and recommendations of the special inspection prior to start-up. AERB inspection team was present to witness the First Approach to Criticality of MAPS-1 after EMCCR.

RAPS-1&2

- During the plant condition when reactor power is below 2 % FP and hot pressurisation scheme is normalised, design deficiency in Reactor Protection System logic was noticed, where there is a requirement of manual action to trip the reactor under certain conditions. Station was informed to put up a proposal to SARCOP to institute necessary changes in logic so as to avoid recurrence of such an event and also to report it as a Significant Event Report (SER).
- Reactor building main airlock seals were replaced for both the Units. However, after replacement of the seals, air leak test as required under station policy was not done. Station was asked to conduct leak rate test of the main air locks, which was complied with.

NAPS-1&2

- Inadequacy in submission of bioassay samples for internal dose estimations was observed. The station was asked to ensure implementation of prescribed monitoring procedures.
- It was observed that station was not having level-III qualified person for ISI work. The station was asked to comply with the regulatory requirements with respect to test and inspections of NPPs.

KAPS-1&2

- An increase in trend for radioactivity due to Cs^{137}, Cs^{134} and Co^{60} in the silt weeds of Moticher pond was found at the effluent discharge point. Station was asked to take corrective steps to avoid further accumulation of activity and to treat the active liquid waste by ion-exchange method. Station has implemented the corrective measures and the radioactivity trend is under observation.

KGS-1&2

- Failure of lip seal weld in PHT system valve was observed in Unit-2. Station was asked to conduct a detailed review of all the valves and carry out required modifications.

RAPS-3&4

- It was observed that the 50 MVA transformer feeding the switchyard from 132 KV grid was kept de-energised and a decision was taken to charge it only when required. NPCIL was asked to verify its effect on system reliability. NPCIL carried out the reliability analysis, which showed that there is no impact on safety of keeping the transformer in de-energised condition. RAPS-3&4 Safety Committee agreed to the revision of safety analysis report and to permit keeping the transformer in de-energised condition. NPCIL has been asked to carryout a similar reliability analysis for RAPS-1&2 also.

2.2.9 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.

Table 2.5: Licensing of Operating Personnel

Plants	No. of Candidates cleared for the Positions					Licensing Committee Meetings
	SCE	ASCE	ASCE(F)	CE	CE(F)	
TAPS - 1 & 2	7	-	-	6	-	2
RAPS - 1 & 2	3	3	1	11	5	2
MAPS - 1 & 2	2	1	1	3	4	2
NAPS - 1 & 2	6	2	1	4	-	2
KAPS - 1 & 2	7	9	2	11	3	2
KGS - 1 & 2	4	5	2	12	3	2
RAPS - 3 & 4	1	4	2	6	3	2
TAPS - 3 & 4	8	10	5	21	9	3
Total	38	34	14	74	27	17

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

2.2.10 Significant Events

It is obligatory for all operating NPPs to report promptly to AERB, certain events that occur 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 categorisation depends on the safety significance and importance to operational safety experience feedback. Based on the reporting criteria, NPPs submit 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 rates events at seven levels (1 to 7) depending on their safety significance. The accident at Chernobyl nuclear power plant in the former USSR (now in Ukraine) was rated at level 7 on INES. The incident involved core melt down with the consequences of large-scale off-site radioactivity release having widespread environmental and human health effects. Events rated at level 4 and above are termed as accidents. Events rated at level 1, 2 and 3 are called incidents (an event at level 1 is an anomaly). Events at level 0 or below the scale are called deviations. The IAEA-INES scale is shown in Fig.2.1.

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	

The number of SERs for each year from 2001-2002 to 2005 and their ratings on INES are given in Table 2.6. In the year 2005, a total of 28 significant events were reported from the operating NPPs. In the year 2004, the number of significant events was 44. The classification of SERs for the year 2005 on INES scale is given in Table 2.7.

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

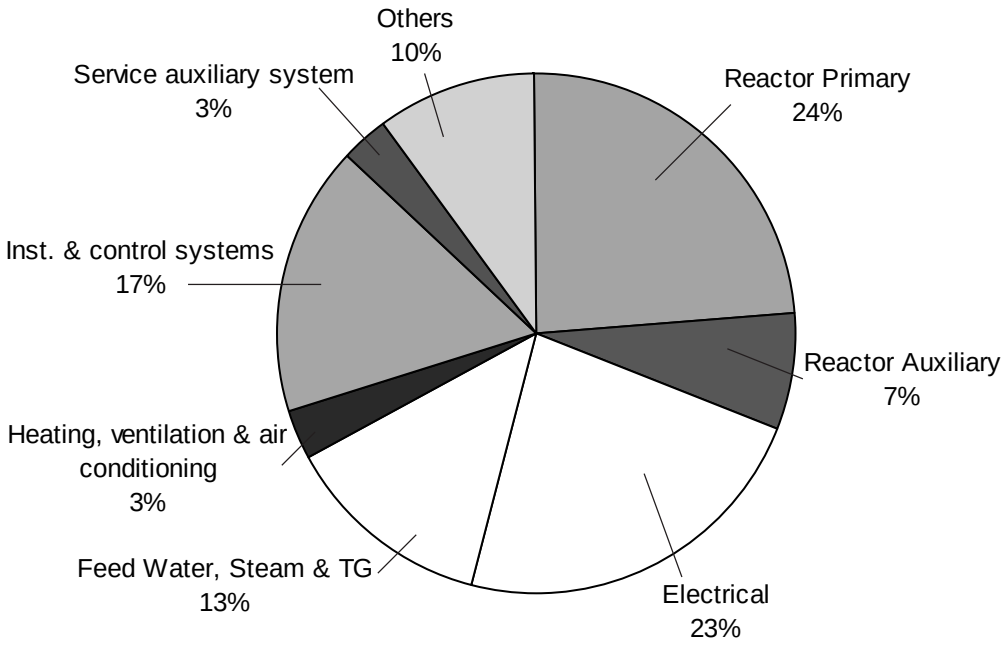
INES Levels	2001-2002	2002-2003	April-Dec. 2003	2004	2005
Out of Scale	0	0	0	0	0
0	43	26	21	39	26
1	2	5	10	4	2
2	0	1	0	1	0
3	0	0	0	0	0
>3	0	0	0	0	0
Total	**45**	**32**	**31**	**44**	**28**

Table-2.7 : Classification of SERs in Individual NPPs (2005)

Plant Name	Out of Scale	International Nuclear Event Scale					
		0	**1**	**2**	**3**	**> 3**	**Total**
TAPS - 1 & 2	-	0	0	0	0	0	0
RAPS - 1 & 2	-	6	0	0	0	0	6
MAPS - 1 & 2	-	6	2	0	0	0	8
NAPS - 1 & 2	-	5	0	0	0	0	5
KAPS - 1 & 2	-	3	0	0	0	0	3
KGS - 1 & 2	-	2	0	0	0	0	2
RAPS - 3 & 4	-	4	0	0	0	0	4
Total	-	**26**	**2**	**0**	**0**	**0**	**28**

Two events were rated at level 1 on INES. The system wise classification of SERs in NPPs is given in Fig.2.2. Both the events rated at level 1 on INES occurred at MAPS-1 and were rated at this level because of exposure of temporary workers beyond their annual radiation exposure limit (dose constraint) of 15 mSv.

Figure 2.2 : System Wise Classification of SERs in NPPs (Year 2005)



There were 26 events rated at level 0 on INES. Out of these, there were three events, one each at RAPS–3, KAPS-1 and MAPS-2 that involved deviation from Technical Specifications requirements and are briefly described below.

At RAPS-3, during surveillance testing, one of the redundant ECCS valves was found to be not operating. The deficiency was rectified during Unit operation and the valve was tested successfully. As the Unit operated for some duration with a deficient ECCS valve, it is considered a violation of Technical Specifications requirement.

In an event at KAPS-1, a blockage occurred in the riding line connecting calandria vault expansion tank to calandria. As the expansion tank level is monitored to assess calandria vault water level, the water level in the calandria vault could not be monitored due to the blockage and it dropped below the Technical Specifications limit during the period.

During reactor operation at MAPS-2, one of the redundant isolation dampers provided in reactor containment ventilation exhaust duct got closed (in fail safe direction) due to failure of its solenoid valve. For the sake of ventilation in reactor containment, the closed damper was kept open manually and was not available on 'AUTO' for the duration till the solenoid valve was replaced. These dampers are supposed to close automatically in case of Loss of Coolant Accident on containment isolation signal.

2.2.11 Industrial Safety

Regulatory Inspections on fire and industrial safety aspects were carried out in NAPS-1&2, RAPS-1&2, RAPP-3&4, KAPS-1&2, KGS-1&2, TAPS-1&2 and RAPP Cobalt facility. The major recommendations after these inspections include following:

- Chlorine detectors should be installed in the chlorine tonner handling area.
- Fire organisation should be as per the requirement of Standard for Fire Protection Systems of Nuclear Facilities, "AERB/S/IRSD-1".
- Illumination levels in the plant areas should be improved to the levels specified in Rule 11 (1) of Atomic Energy (Factories) Rules, 1996.

- Hydro testing of fire extinguishers should be completed.
- Job Hazard Analysis should be carried out for all hazardous jobs.
- Sectional level safety committee should meet once in a month.
- Procedure for investigation of occupational illness shall be prepared as per Rule 89(5) of Atomic Energy (Factories) Rules, 1996.

2.3 FUEL CYCLE FACILITIES

Review and monitoring of safety status of fuel cycle facilities and other nuclear facilities is carried out by Industrial Plants Safety Division (IPSD) of AERB. A three-tier review process is followed for granting consent for major stages for hazardous facilities of nuclear fuel cycle. For less hazardous facilities, a two-tier review process is adopted with first review being conducted by the Unit safety committee of the facility. Highlights on safety status and reviews carried out with respect to these facilities are given below.

2.3.1 Nuclear Fuel Complex (NFC)

All the plants of NFC, Hyderabad operated normally during the year with a satisfactory record of radiological and industrial safety. The Safety Committee of Nuclear Fuel Complex, Hyderabad (NFCSC), SARCOP and ACPSR-FCF reviewed proposals from NFC during the year. The following proposals were accepted after ensuring satisfactory compliance to the safety requirements.

- Proposal for processing of depleted uranium (0.3% U^{235}) in enriched uranium oxide plant powder and pelletising was approved.
- The Design Basis Reports (DBRs) pertaining to New Zirconium Oxide Sponge Project, which is being set up at Palayakayal near Tuticorin in Tamilnadu was reviewed by the sub-committee constituted by NFCSC. The committee reviewed the comments given by the sub-committee on the DBRs and the application seeking authorisation for construction of the facility. After further review by ACPSR-FCF and AERB Board, Chairman, AERB issued authorisation for construction of New Zirconium Oxide Sponge Project, Palayakayal.
- NFCSC discussed the various safety aspects regarding the rehabilitation work, which is being carried out in Zirconium Sponge Plant (ZSP) building at NFC. The committee asked NFC to apply for grant of commissioning clearance after feedback from trial production of five batches.
- NFC/NPCIL completed the rehabilitation of the old ZSP at NFC, Hyderabad. The reports addressing the rehabilitation undertaken and the confirmatory investigation were reviewed by CESCOP. The Committee made certain observations on the report and recommended NFC to submit the plan for future monitoring along with the results of next round of Non Destructive Testing.

2.3.2 Heavy Water Plants (HWP)

The HWPs at Thal, Tuticorin, Baroda, Hazira, Kota, Manuguru and solvent facilities at Talcher operated normally during the year. The Safety Committee of Heavy Water Operating Plant (SCHWOP) and SARCOP reviewed the safety status of the plants and certain proposals. Highlights of these reviews are as follows:

- HWP, Manuguru proposes to establish a facility to produce sodium metal and elemental Boron-10 required for PFBR. SCHWOP discussed the DBR, Environment Management Plan, Safety Report and HAZOP study report submitted by HWP, Manuguru for establishing Boric Acid Enrichment Plant (BEP) and noted that the plant does not handle any flammable chemicals and will be located at a safe distance from the existing H_2S based Heavy Water Plant. SCHWOP stipulated that before seeking operational clearance, HWP, Manuguru should submit revised Safety Report, Technical Specifications, Commissioning Test Report documents and addendum to the licensing document to cover licensing of BEP operating personnel.
- HWP, Manuguru submitted the DBR and Safety Report for seeking consent for establishing Sodium Metal production based on fused sodium chloride electrolysis at their site. SCHWOP agreed in principle that the plant can be set up at HWP, Manuguru and recommended that a detailed engineering report should be submitted for review before seeking construction clearance.
- HWB is developing a solvent extraction based technology for uranium recovery from phosphoric acid. HWP, Talcher submitted DBR, Safety Report and Effluent Management Report for grant of clearance for setting up of a Solvent Extraction Test Facility. The proposal along with the recommendations of SCHWOP is under review by SARCOP.

- HWP, Baroda has made an application to AERB for authorisation for regular operation of the plant. SCHWOP after discussion on the operational experience during and after commissioning and the structured ageing management plan had recommended for grant of regular operation. SARCOP is further reviewing the application.
- HWP, Talcher had submitted Safety Report for grant of clearance for setting up of packing evaluation test loop for Boron Enrichment at HWP, Talcher and its commissioning. The operation is intended for 3 to 6 months. SCHWOP recommended clearance of the proposal with certain stipulations.
- In- Service Inspection Plan of Main & Mini Cracker Units of Ammonia based Heavy Water Plants was approved by SCHWOP.
- The earthen bund of the Ash Pond-1 of HWP, Manuguru breached in January 2004. HWB undertook failure analysis of the ash pond dyke and proposed a methodology for repair of the breached portion of the dyke. The report on the analysis and proposals for repair of the breached portion were reviewed by CESCOP and SARCOP. Based on the review, SARCOP granted clearance to undertake the repair. HWP was asked to undertake a study to establish stability of the existing ash pond bunds and implement a maintenance program for the ash pond bunds. The plant was also asked to study the liquefaction potential and slope stability under seismic loading.

2.3.3 Indian Rare Earths Limited (IREL)

The IREL plants at Chavara, Manavalakurichi, OSCOM and Udyogamandal were operating normal during the year. The Safety Committee for IRE plants (IRESC) and SARCOP reviewed the safety status of the plants and proposals for certain new activities. Important permissions/ clearances issued for IREL plants are as follows:

- Interim clearances were issued in the year 2004 for retrieval and processing of 300 tons of thorium concentrate and subsequently for retrieval and processing of additional 1000 tons of thorium concentrate stored in the silos at IRE, Udyogamandal, for recovery of uranium (Project THRUST - Thorium Retrieval, Uranium recovery and Storage). IRE completed the processing of 1000 tons of thorium concentrate and sought permission for regular operation of THRUST Project. Clearance for continuous retrieval and processing of the thorium concentrate contained in the silos 1, 2 & 3 was issued after extensive reviews and implementation of a number of modifications in the plant systems as stipulated by AERB.
- The Safety Evaluation Report for processing of Columbite – Tantalite sludge (CTS) to produce Ammonium Diuranate in the Uranium Refining Plant of IRE, Udyogamandal was reviewed and the Safety Committee recommended processing of CTS with some stipulations.
- IREL, OSCOM has proposed for setting up 10,000 TPA of monazite processing plant at IREL, OSCOM. A sub-committee has been constituted to study the revised Site Evaluation Report.
- Safety committee discussed on the processing of uranium ore obtained from Metallurgical Products India Ltd. at IREL Udyogamandal and recommended the proposal of processing of 7.5 tons of ore with some stipulations.

2.3.4 Uranium Corporation of India Limited (UCIL)

The UCIL mines at Jaduguda, Bhatin, Narwapahar, Turamdih and Banduhurang and Jaduguda mill were operating normal. Following were the documents/reports reviewed and recommendations made by UCIL Safety Committee and ACPSR-FCF.

- Safety Report on "Authorisation of Stage-3 of Turamdih Mines i.e., "Mining and Ore Transportation to Jaduguda Mill" was discussed and USC recommended Stage 3 of Turamdih mine with some stipulations. The proposal was further discussed in SARCOP and Board meetings. Subsequently, authorisation was issued for Turamdih mine for 'Mining and Ore Transportation to Jaduguda mill' at a maximum rate of 550 TPD with certain stipulations.
- Safety Committee reviewed the Environmental Impact Assessment (EIA) report, Safety Report, ventilation and radiological assessment of the proposal for authorisation for the development of Bagjata mine. These reports were further deliberated in the meetings of ACPSR-FCF, which recommended to AERB the authorisation of the 'Development Stage' of Bagjata Mine with certain stipulations. Subsequently, authorisation for development of the first stage for Bagjata Mine, UCIL was issued.

- Safety Committee discussed the Safety Report for pilot plant study of leachability of Tummalapalle Uranium ore. Susequently, approval was given to pilot plant study on Tummalapalle Uranium Ore at 'Technology Demonstration Pilot Plant', Jaduguda with certain stipulations.
- AERB had granted construction clearance for Turamdih mill during October 2003 with a stipulation that Tailings Pond should be put in operation before commissioning of the mill. Subsequently, UCIL submitted application for authorisation of Tailings Pond and Dam construction along with the DBR for Waste Water Treatment Plant and Tailings Dam. After detailed review in USC and ACPSR-FCF, the proposal was discussed and approved in the Board of AERB.

2.3.5 Licensing of Plant Personnel

The committee for licensing of operating personnel for HWP met at HWP-Kota, Hazira and Tuticorin and authorised / re-authorised 37 operation personnel.

2.3.6 Regulatory Inspections

Regulatory inspections on industrial safety aspects were carried out during the year in HWP-Baroda, Talcher, Thal, Hazira, Manuguru, Tuticorin, NFC- Hyderabad, IRE Research Centre-Kollam, IRE Ltd.- Udyogamandal, OSCOM, Chavara and Manavalakurichi, UCIL-Jaduguda, Turamdih, Bagjata Mines, & Jaduguda Mill, Board of Radiation and Isotope Technology-ISOMED, Electronics Corporation of India Ltd-Hyderabad, Demonstration Fuel Reprocessing Plant, IGCAR, Raja Ramanna Centre for Advance Technology-Indore and Variable Energy Cyclotron Centre-Kolkata.

Detailed inspection reports were sent to the concerned Units highlighting the observed deficiencies. Some of the major recommendations made to HWPs, NFC, IREL are as follows.

Heavy Water Plants

- Load testing of monorails should be done according to Rule 35 of Atomic Energy (Factories) Rules; 1996.
- Pending recommendations of HAZOP study conducted at HWP-Thal should be reassessed and actions should be taken for implementation.
- A detailed review of surveillance of high pressure/high temperature piping should be carried out and report submitted.
- All critical safety valves should be periodically tested as per the frequency specified in the Technical Specifications.
- Hydro tests of the portable fire extinguishers should be done as specified in the "Standard for Fire Protection Systems of Nuclear Facilities".
- Periodic inspection of spring hangers and other piping supports should be continued.
- Production of Heavy Water in excess of the licensed capacity should be put up to SCHWOP to discuss safety implications, if any.
- CESCOP recommendations regarding ash pond for restriction of cattle/animal movement inside ash pond should be adhered to.
- In - Service Inspection of glass-lined reactors/vessels (HWP-Talcher) should be done as per the approved procedure.

Nuclear Fuel Complex

- Interlocks on the machine should not be bypassed. Interlocks provided for the furnaces in ZFP should be made functional.
- Integrity of HDPE lining of solar evaporation ponds should be checked.
- Safety precautions prescribed by AERB for working at height shall be strictly followed.
- HAZOP study of NUOFP (O) should be completed at the earliest.
- Fire hydrant ring main pressure should be maintained as per the requirements of "Standard of Fire Protection Systems for Nuclear Facilities".
- The Limiting Condition for Operations (LCO) and Limiting Safety System Settings (LSSS) mentioned in the Technical Specifications should be adhered to in NUOFP (O).
- Structural stability of the Old Hafnium building should be assessed before commissioning of the jaw crushers operation.
- Emergency Preparedness Plan for entire NFC should be updated.

Indian Rare Earths Limited Plants

- Augmentation of ventilation in Uranium Recovery Plant and Material Processing Plant in IREL, Udyogamandal should be taken up.
- Administrative control should be strengthened for entry and exit in silo area / retrieval area/ slurry and dissolution area in IREL, Udyogamandal.
- Solid waste kept in between the silo and trenches should be shifted to the disposal yard in IREL, Udyogamandal.
- Burner management system in dryers of Mineral Separation Plant in IREL, OSCOM should be implemented.
- Authorised electrical operator should be appointed for handling electrical substation at Indian Rare Earths Research Centre, Kollam.
- Ventilation in the monazite section and high-tension section should be improved to reduce air activity.
- Sand sealing should be provided in the monazite trenches area to avoid monazite coming out of the storage bay in IREL, Chavara.
- Fire detectors should be provided in the vulnerable areas.
- Permanent identification marking for all monazite trenches should be done in IREL, Chavara.
- Mechanisation of product draw system in the Thorium plant and Thorium Oxalate feeding system should be done in IREL, OSCOM.

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 new projects like Turamdih, Banduhurang & Bagjata Mines and Turamdih Mill.
- UCIL should appoint safety officers, one for all mines and one for Jaduguda Mill.

2.3.7 Siting Committee for Fast Reactor Fuel Cycle Facility, IGCAR

The Siting Committee for Fast Reactor Fuel Cycle Facility at IGCAR met once during this period to review the site evaluation report for the facility. The working groups constituted by the committee met many times during the year for in-depth review of the documents, which included ground motion parameters, flood level, design basis wind speed, geotechnical parameters, site meteorological data and hydro-geological investigations.

2.4 OTHER NUCLEAR FACILITIES

2.4.1 Variable Energy Cyclotron Centre

The cyclotron was operated regularly during the year. Erection of equipment in the super conducting building is under progress.

Following are the highlights of VECC & RRCAT Safety Committee deliberations pertaining to VECC.

- Safety Assessment Document on Radioactive Ion Beam Facility at VECC was reviewed and the safety committee agreed to the proposal with certain stipulations.
- A DAE Medical Cyclotron Project is being constructed at Kolkata. The facility will be set up by VECC and BRIT will implement the processing facility for cyclotron-based radioisotopes for producing radiopharmaceuticals. The Preliminary Safety Report for Accelerator Driven System (ADS) Target Facility in the project was reviewed by the safety committee.

2.4.2 Raja Ramanna Centre for Advanced Technology

Indus-1 and DC accelerators, laser units and the LINAC in IMA building radiation facilities at RRCAT, Indore were operating normal. Commissioning trials were being carried out at Indus-2 accelerator. VECC - CAT Safety Committee discussed the following issues pertaining to RRCAT:

- Proposal for regular operation of the fifth beam line was discussed and based on the recommendations of the safety committee, AERB granted license for regular operation of the fifth beam.
- Radiation Processing Facility, Agricultural Radiation Processing Facility (ARPF) and Industrial Radiation Processing Facility (IRPF) are being set up at RRCAT.

Safety Committee deliberated on the revised shielding calculation of ARPF and IRPF.

- Permission for commissioning of Stage-2 of Indus-2, i.e., extracting 700 MeV beam from Indus-1 Booster Synchrotron and transferring it to Transport Line – 3 up to beam dump of Indus-2 was granted.
- Safety status of Indus-2 for Stage-3 operation (i.e. injection of the beam into Indus-2 ring and subsequent storage up to 10 mA current and acceleration to 2 GeV energy) was discussed by the safety committee. The proposal was further discussed in SARCOP meeting and finally authorisation was granted for Stage-3 operation of the Accelerator.
- AERB granted authorisation for trial operation of DC accelerator at 750 keV and 20 mA beam current at RRCAT, Indore using SF_6 and nitrogen/carbon-dioxide gas mixture.

Regulatory Inspection of Indus-1 and Indus-2 was carried out. The centre was asked to prepare documents such as Operation Manual, Emergency Operating Procedure, Technical Specifications and Access Control Report for Indus Accelerator complex. The centre was also advised with respect to manpower requirements and Instruments for Health Physics Unit as specified by the VCSC.

2.4.3 Electronics Corporation of India Limited

Regulatory Inspection of ECIL, Hyderabad was carried out and the major recommendations are the following.

- Clearance should be obtained from AERB for LINAC accelerator facility.
- Audiometry examination of employees should be done periodically.
- Structural integrity of the oxidation pond should be ascertained.
- Additional safety officer should be appointed.
- Job Hazard Analysis for all critical job activities should be carried out.

2.5 ENFORCEMENT OF THE FACTORIES ACT, 1948

2.5.1 Licenses Issued/Renewed

Under the Factories Act 1948, licenses valid for a period of five years were issued/ renewed to the following DAE units

Fresh License

- Heavy Water Plant, Talcher for the production of Di-Ethyl Hexyl Phosphoric Acid and Tri- Butyl Phosphate.

Renewal of License

- Electronics Corporation of India Ltd.
- Jaduguda Mill of Uranium Corporation of India Ltd.
- Indian Rare Earths Limited, Chavara
- Heavy Water Plant, Tuticorin
- Heavy Water Plant, Kota

2.5.2 Approvals Granted

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

1) Three persons of RAPP-5&6.
2) Four persons of KAPS.
3) One person of KGS.
4) Nine persons from KK-NPP -1&2.
5) Three persons of HWP-Tuticorin.
6) Eight persons of HWP-Manuguru.
7) One person of HWP-Hazira.
8) Two persons of IREL – Manavalakurichi.
9) Nine persons of RRCAT, Indore.

CHAPTER 3
SAFETY SURVEILLANCE OF RADIATION FACILITIES

3.1 SAFETY REVIEW OF RADIATION EQUIPMENT AND APPROVAL OF SAFETY PERSONNEL

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

Number of various radiation installations and radiation devices, which are regulated by AERB as on March 31, 2006, is given in Table 3.1.

Table-3.1: Radiation Installations Regulated by AERB

S.No.	Type of Application	No. of institutes	No. of Devices in Use	
1	Diagnostic X-ray	~ 40,000	~ 50,000	
2	Radiotherapy	218		
	Teletherapy		Telecobalt	271
			Telecesium	4
			Accelerators	78
			Gamma Knife	3
	Brachytherapy		Ir-192 wire (manual)	23
			HDR	76
			LDR	31
			Manual (Intracavitary)	87
			Manual (Interstitial)	34
			Opthalmic (^{90}Sr)	20
			Opthalmic (^{125}I)	1
			Opthalmic (^{106}Ru)	1
3	Nuclear Medicine		Not applicable	
	● RIA Centres	450		
	● Diagnostic & low dose therapy	106		
	● Diagnostic low & high dose therapy	25		
4	Research	500	Not applicable	
5	Industrial radiography	461		
	● Radiography cameras		1196	
	● X-ray units		213	
	● Accelerators		11	
6	Gamma Irradiators	10	10	
7	Nucleonic Gauges	1386	~ 7500	
8	Consumer Products			
	● Gas Mantle	65		
	● Lamp starters	20		
	● Smoke Detectors	95	Not applicable+	
	● ECD	365	370	

3.1.1 Type Approvals

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

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

Sr. No.	Type of Equipment	Number of Approvals
1	Medical diagnostic X-ray Units	48
2	Radiotherapy Simulators	5
3	Computed Tomography (CT) Units	16
4	Telegamma Therapy Units	1
5	Gamma Knife Units	2
6	Medical Linear Accelerators	18
7	Remote Controlled after-loading Brachytherapy Units	9
8	Gamma Chambers	4
9	Nucleonic Gauging Devices	57
10	Baggage Inspecton Systems	7

3.1.2 Approval of Radiological Safety Officers

During the year 2005-06, approval certificates were issued to 597 Radiological Safety Officers. Details of the approval are given in Table 3.3.

Table-3.3: Approval Certificates Issued for RSOs

Sr. No.	RSO Level	Number Approved
1	RSO Level-III (Medical)	102
2	RSO Level-III (Industrial radiography)	22
3	RSO Level-II (Industrial radiography)	306
4	RSO Level-II (Nuclear medicine diagnosis)	23
5	RSO Level-I (Nucleonic gauges)	117
6	RSO Level-I (Research applications)	27

3.1.3 Approval of Packages for Transport of Radioactive Material

As per AERB regulations, Type A packages, which are permitted to transport radioactive material of activity not exceeding the specified limits, need to be registered with AERB. All Type B packages are subjected to a stringent approval procedure and are required to fulfill the regulatory standards. Two type approval certificates for Type A packages were issued by AERB during the year.

3.2 LICENSING / AUTHORISATION AND REGULATORY INSPECTIONS

3.2.1 Licensing / Authorisation

Licenses for operation were issued to two 11 MeV self-shielded Medical Cyclotrons and three high capacity gamma radiation processing plants.

AERB issued 225 regulatory licenses as Certificate of Registration to diagnostic X-ray installations upon confirming that the applicable regulatory requirements are duly satisfied. Details of Licences / NOCs issued by AERB during the year 2005 are given in Table 3.4.

Table-3.4: Licences / NOC Issued

A. Procurement of Sources

Sr. No.	Type of application	Licenses/NOCs/Registrations issued	
		Local	Import
1	**Radiotherapy**		
	● Telecobalt	19	8
	● Telecaesium		0
	● Accelerators		17
	● Gamma Knife		0
	Brachytherapy		
	● HDR		93
	● LDR		-
	● Manual (Intracavity & Interstitial)		-
	● Opthalmic Sr-90		-
	● Opthalmic I-125		-
	● Opthalmic Ru-106		-
2	**Nuclear Medicine**		
	RIA facilities	10	183
	Diagnostic	89	165
	Therapeutic Research	153	180
3	Industrial Gamma Radiography Exposure Devices	605	8
4	Gamma Irradiators	3	0
5	Nucleonic Gauges	88	177
6	Diagnostic X-ray	225 (Registered)	0
7	**Consumer Products**		
	● Gas Mantle	33	13
	● Lamp starters	9	0
	● Electron capture devices		83
	● Smoke detectors	97	21

B. Number of Authorisations for Export and Disposal of Sources

Export		Disposal of sources	
By BRIT & IRE	**By user**	**At BRIT**	**At WMD, BARC + CWMF Kalpakkam**
15	97 (Disused Sources)	313	1474(ICSD) + 471

3.2.2 Shipments Approved

Consignments, which do not meet all the applicable requirements of the transport regulations due to specific reasons, may be permitted to be transported under special arrangements, which include provision of compensatory operational controls. During the year 2005, four shipments were approved to be transported under special arrangements.

3.2.3 Regulatory Inspections

Particulars relating to regulatory inspections carried out during the year are given in Table 3.5. In such inspections, some times one finds non-compliance with regulatory requirements.

The non-compliance with regulatory provisions observed during inspection are reviewed in the AERB Standing Committee for Investigation of Unusual Occurrences in Radiation Facilities (SCURF). The enforcement actions recommended by SCURF include issuance of warning letters, suspension of radiation practices, withdrawal of certificates of radiation workers and revocation of license issued to operate radiation installations in Radiation Facilities, SCURF meets at least once in two months.

Table-3.5: Regulatory Inspections

Sr. No.	Type of Application	No. of Institutes existing	No. of Inspections Carried out
1	Diagnostic X-ray	~ 40,000	208
2	Radiotherapy	218	23
3	Nuclear Medicine Diagnostic (including 22 CA thyrid treatment centres)	131	40
4	Research	500	6
5	Industrial Radiography	461	126
6	Gamma Irradiators	10	11
7	Nucleonic Gauges	1386	11
8	Consumer Products ● Gas Mantle ● Fluorescent Lamp starters ● Smoke Detectors ● ECD	 65 20 95 365	 22 3

3.3 RADIOLOGICAL SAFETY SURVEILLANCE

3.3.1 Radiation Diagnostic and Therapy Facilities

On the basis of pre-commissioning safety evaluation, AERB issued authorisations for the commissioning of 27 Teletherapy Units which include 4 Telecobalt Units & 23 Medical Linear Accelerators and 14 remote after-loading Brachytherapy Units and for the decommissioning of 5 Teletherapy Units during the year. Permissions were accorded for re-starting 7 Telecobalt Units after source replacement and 7 new radiotherapy centres. Forty nuclear medicine facilities and six research institutions, where unsealed radioactive materials are used for diagnostic and therapy purposes, were inspected. AERB reviewed annual safety status reports received from the licensees and inspected 208 medical X-ray diagnostic installations. Deviations and violations of regulatory requirements were taken up with the users. In some cases, AERB initiated appropriate regulatory actions such as suspension of license.

3.3.2 High Intensity Gamma Irradiation Facilities

Inspections were carried out for the following eight operating gamma irradiation facilities:

- Panoramic Batch Irradiation Technology (PANBIT), Thiruvananthapuram, Kerala.
- Radiation Vulcanisation of Natural Rubber Latex (RVNRL), Kottayam, Kerala.
- Radiation Sterilisation and Hygenisation of Medical Products (RASHMI), Bangalore.

- Shriram Applied Radiation Centre (SARC), Delhi.
- Radiation Processing Facility, BRIT, Vashi, Navi Mumbai.
- Isotope in Medicine (ISOMED), BRIT, Mumbai.
- VIKIRAN, M/s. Organic Green Foods Limited, Kolkata.
- RAVI, Defence Lab., Jodhpur.

Pre-commissioning inspection of the following gamma radiation processing facilities was carried out:

- M/s. Vardaan Agrotech, Sonepet.
- M/s A. V. Processor, Ambernath.
- M/s Universal Medical Pvt. Ltd., Baroda.

The mandatory quarterly safety status reports were received from all the gamma radiation-processing facilities. The occupational exposures in gamma irradiation facilities in the last five years did not exceed 2 mSv/y, which is well below the prescribed dose limit of 20 mSv/y. Three proposals for the loading of 4 PBq of Cobalt-60 sources from such facilities were reviewed and clearances were issued. The source loading operations were safely completed in three gamma irradiation facilities.

3.3.3 Industrial Radiography

There are 461 industrial radiography institutions in India. The total number of industrial gamma radiography exposure devices, which are in use in India, is 1420. Since radiography work is permitted at authorised sites only, users seek AERB's permission if movement of radiographic devices from an approved site / storage location is required. During the year, a large number of such source movements were approved by AERB. Eighty-two industrial radiography sites and installations were inspected. Monthly safety status reports were received from all users and reviewed in AERB.

3.3.4 Nucleonic Gauging

The application of nucleonic gauges for level monitoring, thickness gauging, density measurement and moisture detection in many industries such as steel, paper, plastic, textile, cement, power, coal and oil exploration recorded a notable increase. AERB inspected over 100 installations in 11 institutions. Six-monthly safety status reports from these installations were reviewed. A database of the radioactive materials used in nucleonic gauging was compiled.

3.3.5 Manufacture of Consumer Products

Consumer products like ionisation chamber smoke detectors, fluorescent lamp starters and thorium gas mantles use very small quantities of radioactive materials and are manufactured by authorised persons in approved installations. Twenty-five such installations were inspected and it was found that the practices followed were in conformity with the regulatory requirements.

3.3.6 Transport of Radioactive Materials

Twelve authorisations for transport of radioactive material were issued, while 11 regulatory inspections of packages were carried out during the year. Representatives of AERB witnessed the testing of Type B packages, one each of BRIT and NPCIL. AERB regularly communicates with other government authorities for the safe transport of radioactive material in and out of the country. The concerned nodal agencies are Director General of Civil Aviation (DGCA), New Delhi, Port Trusts, Indian Railways, Airport Authority and Customs. AERB sent 4 recommendations to port authorities for prompt clearance of the radioactive consignments arrived at Indian ports and 3 recommendations to DGCA for air freighting of radioactive material.

3.3.7 Disposal of Radioactive Materials

The users send decayed radioactive materials from medical, industrial and research institutions for safe disposal to the original supplier or to one of the approved radioactive waste disposal facilities in India. The number of authorisations issued for disposal during the year is as follows.

Export to original supplier	35
Transfer to domestic supplier	78
Consignments transported for disposal	86

Before the authorisation for disposal of the material is issued, safety assessments of the disused sources are done by physical inspection, correspondence with the waste generator and the authorised waste management agency. One hundred twenty numbers of such assessments were done during this year.

3.4 UNUSUAL OCCURRENCES

All unusual occurrences at radiation investigations were investigated and appropriate enforcement actions commensurate with the nature of the occurrence were implemented. Particulars regarding unusual occurrences during 2005 are given in Table 3.6.

Table 3.6: Unusual Occurrences during 2005

	No. of Institutions	Type of Violations/ Cause of Occurrence
Industrial Radiography	7	● Radiography work at unauthorised sites. ● Unauthorised source movements. ● Trainee radiographers operating devices. ● Radiography work without Thermo Luminiscence Detector (TLD).
Nuclear Medicine Centres	3	● Misplacement of radioactive package at the airport. ● Non-claiming the radioactive package from the airport. ● Discharging patients treated with nuclear medicine therapy doses without measuring the radiation exposure emitted by the patient
Radiation Therapy Installations	1	● Stuck up of source in ALCYON-II telecobalt Unit

3.4.1 Loss of Exposure Devices

Two exposure devices model Techops-660 containing Ir-192 sources with activities 279 kBq and 555 MBq respectively were lost from one of the user's premises in May 2005. Representatives from AERB visited the site for investigation and searched for the devices. Police authorities also investigated the case in depth but the exposure devices could not be traced. However, due to low activity of decayed sources, these sources do not have potential to cause any significant harm to the public.

Authorisations to carry out radiography work at the above site by the user institution as well as radiography agencies working at the sites were suspended temporarily due to observation of irregularities regarding safety and security of radiography sources and permission to resume work was given after implementation of satisfactory steps to prevent recurrence.

3.4.2. Theft of Pigtail of Exposure Device

In August 2005, an Industrial Radiography Agency of Mumbai reported that source pigtail with source (Ir-192, 1.87 TBq) of exposure device model Spec-2T was stolen from their approved site in Navi Mumbai. The radiography agency also lodged a complaint with the Police.

Representatives from AERB visited the site for investigation and to search for the source pigtail. It was found that a person working for another radiography agency stole the source and threw it into the Vashi creek. Extensive search operations in the Vashi creek were carried out but the source could not be located. Probably the source pigtail would have drifted into the sea due to heavy water currents. It was concluded that water shield above the source would provide enough protection to prevent any harm to the public.

Licenses of both radiography agencies involved in the incident were suspended. A complaint was lodged with the police against the person who had stolen the source pigtail for appropriate legal action.

3.4.3. Overexposure of a Trainee Radiographer

In July 2005, a trainee radiographer of a radiography agency reported to AERB with radiation injury to his fingers. His Chromosome Aberration test revealed that he received 160 mSv of radiation dose. AERB investigated the incident. It was found that the radiographer had operated a 1.48 TBq Ir-192 radiography source in August 2004, which caused the overexposure. The radiography agency failed to inform AERB about the incident and hence a show cause notice was issued to the agency. The agency subsequently submitted detailed explanation. Regulatory actions were enforced against the agency to avoid recurrence.

3.4.4 Radioactive Source in Shipping Container

AERB received a message from Customs authorities of JNPT about the possibility of a shipping container having radioactive material along with steel scrap. This was based

on an alert received by them from US Customs. AERB/ BARC team visited JNPT port and after thorough search recovered a low activity (1.11 TBq) Am-Be neutron source from one container.

3.4.5 Fire Incident

Three transport containers carrying radiation sources Am-241 (592 GBq), Cs-137 (59.2 GBq) and Am-241 (18.5 GBq) used in well-logging operation by an oil exploration company were engulfed in fire that took place at one of the oil well drilling rigs operating in Rajahmundry site, A.P. on 09-09-05.

Inspection of the damaged transport containers was carried out and the oil exploration company was directed by AERB to send all the three containers back to their original supplier (USA) for disposal of sources in suitable transport containers with adequate shielding.

3.4.6 Disposal of Radioactive Contaminated Steel Products

Two cases of steel consumer products exported by two Indian firms to US were reported to be contaminated with cobalt–60 radioactivity. A thorough search was made and contaminated steel was detected at the manufacturer's premises and steel mills. All the contaminated steel was identified and sent to BARC for safe disposal. During investigations, it was observed that the steel was made from melt of imported steel scrap. The manufacturers were advised to monitor any steel products for radiation before they are exported.

3.4.7 Other Unusual Occurrences

Some other unusual occurrences during the period are as given below.

- In November 2005, a radiography service reported to AERB that source pigtail with source (Ir-192, 296 GBq) was detached while carrying out radiography work at TAPS -1&2. The certified radiographer handled the incident and reconnected the pigtail with the male coupler and received whole body dose of 0.9 mGy during the operation. Representative from AERB visited the site to investigate the probable cause of the incident. The pigtail got detached due to the sharp bending of the guide tube.
- A 18.5 GBq Mo-99 column generator booked to Chennai by air was not received at Chennai Airport. The consignment was traced after four days at Chennai airport along with normal cargo items.
- A radioactive package containing 6.539 GBq Y-90 source consigned to one of the hospitals in Mumbai was received at Mumbai airport and was lying unclaimed since December 2004. On investigation, it was seen that the package had arrived by mistake due to communication gap between the supplier and the consignor. But the supplier from Australia had agreed to take back the consignment. During the interim period, the package was wrongly handed over to a waste management agency in Mumbai along with other waste by the Air carrier during clean-up operation of their warehouse. The said waste management agency, on realising that the material is radioactive, handed over the package to AERB. The air carrier was advised appropriately to avoid such mistakes in future.

3.5 OTHER ACTIVITIES

3.5.1 Handling of Naturally Occurring Radioactive Materials

An industrial firm at Baddi, Himachal Pradesh proposes to chemically process 70 tons per annum of imported Columbite and Tantalite ore concentrate for the extraction of Niobium and Tantalum metal. The ore contains naturally occurring radioactive materials. The proposal was evaluated by the "Safety Committee on Naturally Occurring Radioactive Material (SCNORM)", which also conducted a precommissioning inspection of the plant. The company was advised to comply with the recommendations of the committee. This is the second such industry in the country.

3.5.2 Accreditation of Laboratories

A performance assessment of the low level counting laboratory at Sriram Institute of Industrial research, New Delhi was made for accreditation of the lab for the purpose.

3.5.3 Commissioning of Container Scanner at JNPT

JNPT, Nhava Sheva has installed one 9 MV LINAC machine, for scanning of containers arriving at the port. AERB accorded approval for the commissioning of the Unit after inspection and review.

3.5.4 Clean-up Operation at Rajasthan University

Department of Physics, Rajasthan University sent a proposal to clean up a room, which was used for handling

open isotopes for experimental purposes twenty years ago. A team of officers from AERB, RAPP and AMD, Jaipur carried out the clean up job.

Department of Zoology was also using a radiography exposure device (very old model) for irradiation experiments. However, the device was not used for the past 13 years. The camera was sealed and the in-charge of the facility was advised to arrange for the safe disposal of the device along with the decayed source.

3.5.5 Training Activities

Members of RSD, AERB served as faculty for courses in BARC training school, the Diploma in Radiological Physics conducted by BARC and other courses.

Various medical institutes in the country are conducting training programmes for radiography and radiotherapy technicians. AERB, in consultation with experts from BARC and based on the advice provided by SARCAR, evolved a comprehensive course content for the radiological safety components of these programmes.

Training programmes were conducted for X-ray service engineers, nuclear medicine technologists, medical physicist cum RSO in radiation therapy facilities, technicians for radiotherapy and radiography facilities and for qualifying as RSOs of gamma radiation processing facilities. With this effort, the volume of trained manpower for radiological safety function would increase and will contribute to further improved radiological safety status in radiation facilities.

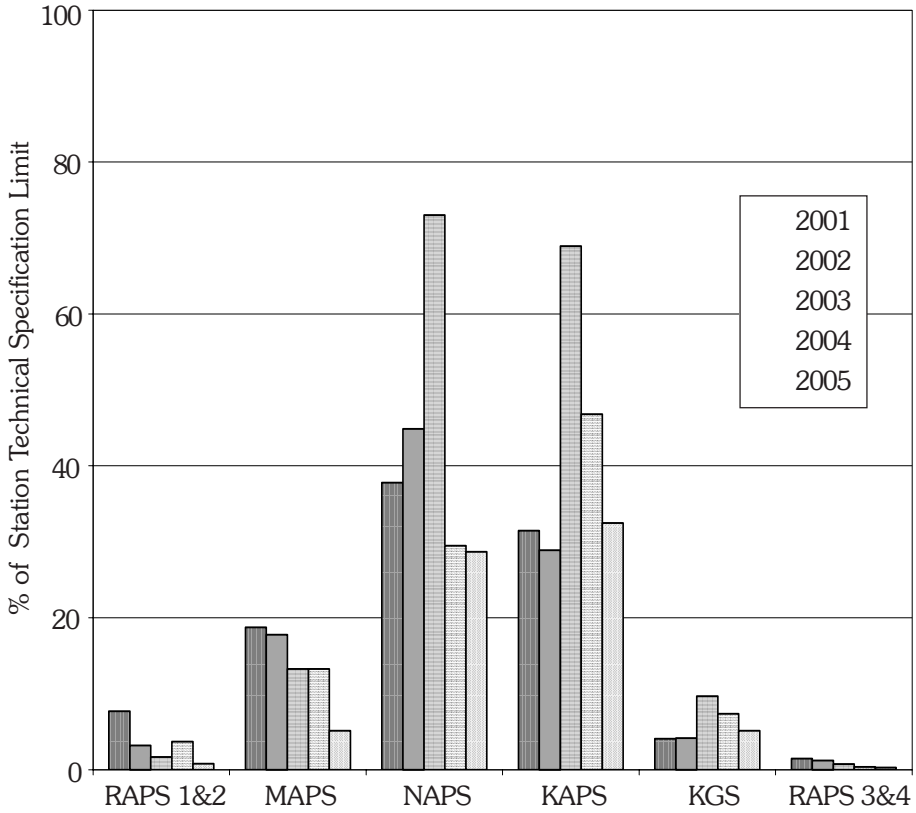
A one-day radiation safety awareness programme for Indian Customs at Jawaharlal Nehru Customs House, Nhava Sheva, was arranged. The programme was arranged for the personnel involved with the operating container scanner installed at JNPT.

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 at all the operating nuclear power plants at sites. The liquid and gaseous waste discharged to the environment during the year 2005 from the operating Units was only a small fraction of the prescribed Technical Specification limits. Figs. 4.1a - 4.1e show the liquid and gaseous discharges from the plants for the years 2001,2002,2003,2004 and 2005 as % of permissible limits as per Technical Specifications. Figs. 4.2a and 4.2b show the committed dose to the members of the public due to the release of radioactive effluents from the plants. Radiation dose to members of the public near the operating plants is estimated based on measurements of radionuclide concentration in items of diet, i.e., vegetables, cereals, milk, meat, fish, etc and through intake of air and water. It is seen that in all the sites the effective dose to public is far less than the AERB yearly dose limit of 1 mSv.

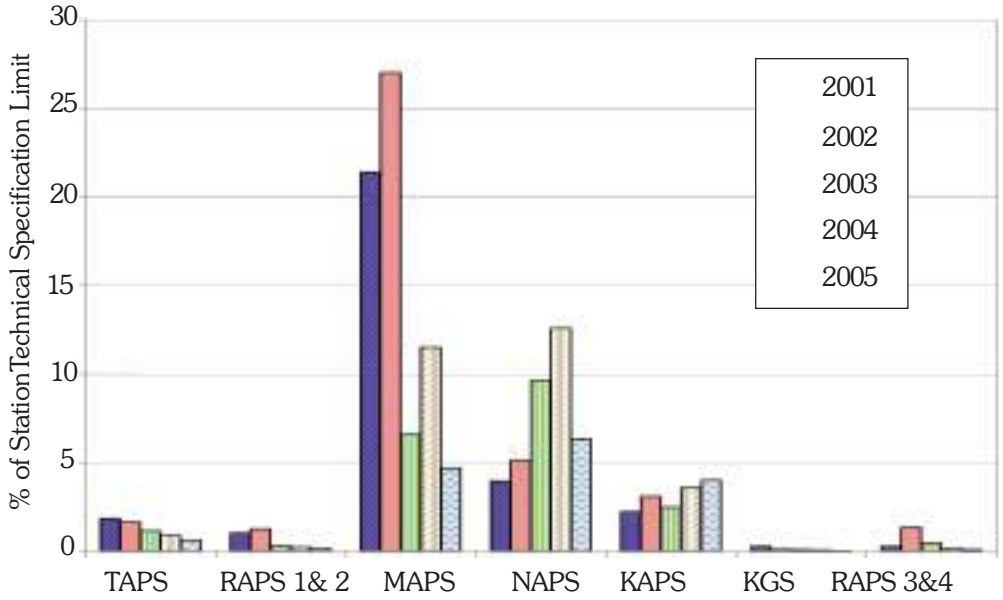
Figure 4.1a : Liquid Waste Discharges From NPPs (Tritium)



Note:

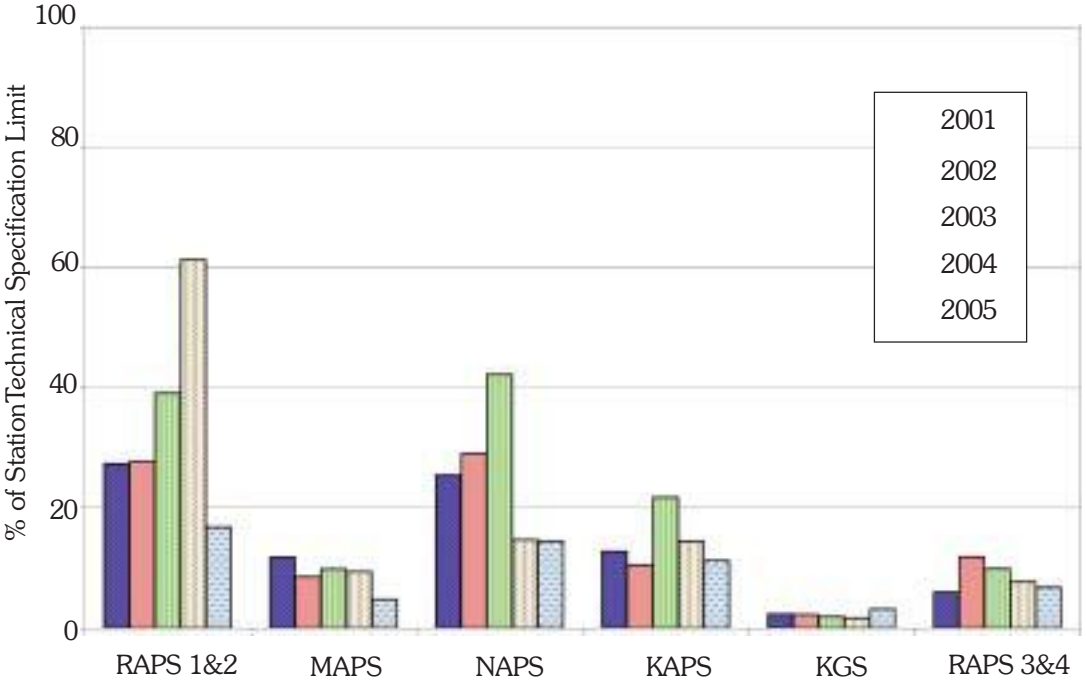
1) TAPS is a Boiling Water Reactor. Hence, there is no generation/dishcharge of Tritium.
2) The data of MAPS pertains to transfer of liquid waste to Centralised Waste Management Facility, Kalpakkam for processing & discharge to the environment.
3) During 2003 RAPS-1 was shut down throughout the year.
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. During 2005, MAPS-1 remained shutdown for enhance Coolant Tube Replacement.

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



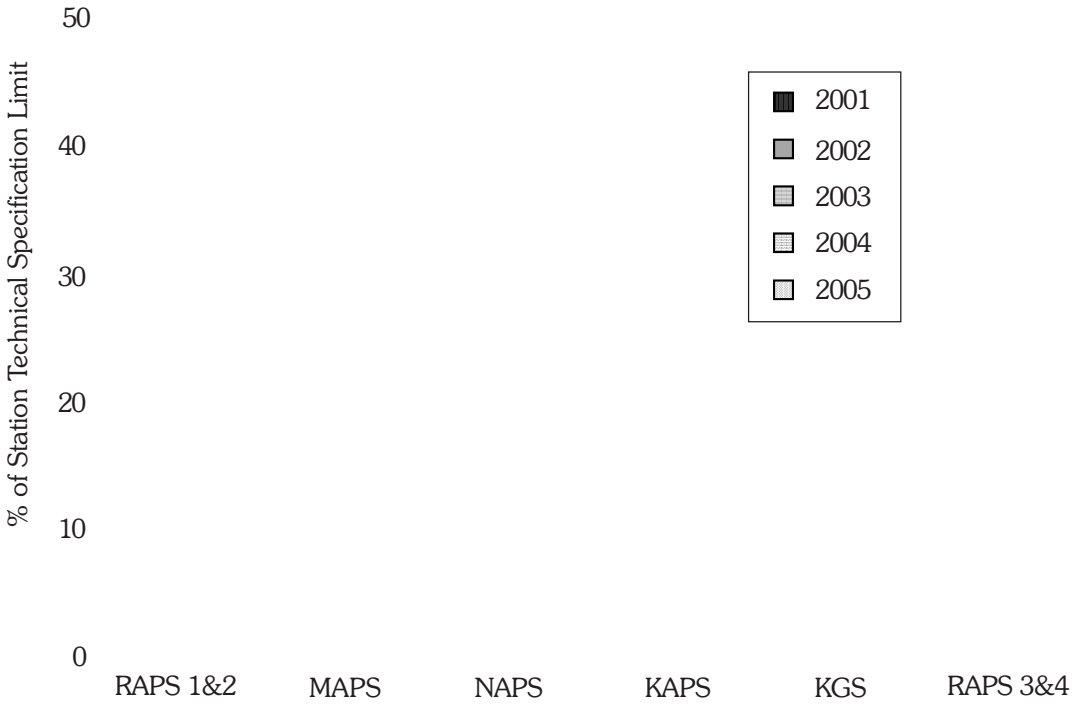
Note: The data of MAPS pertains to transfer of liquid waste to Centralised Waste Management Facility, Kalpakkam, for processing and discharge to the environment.

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)

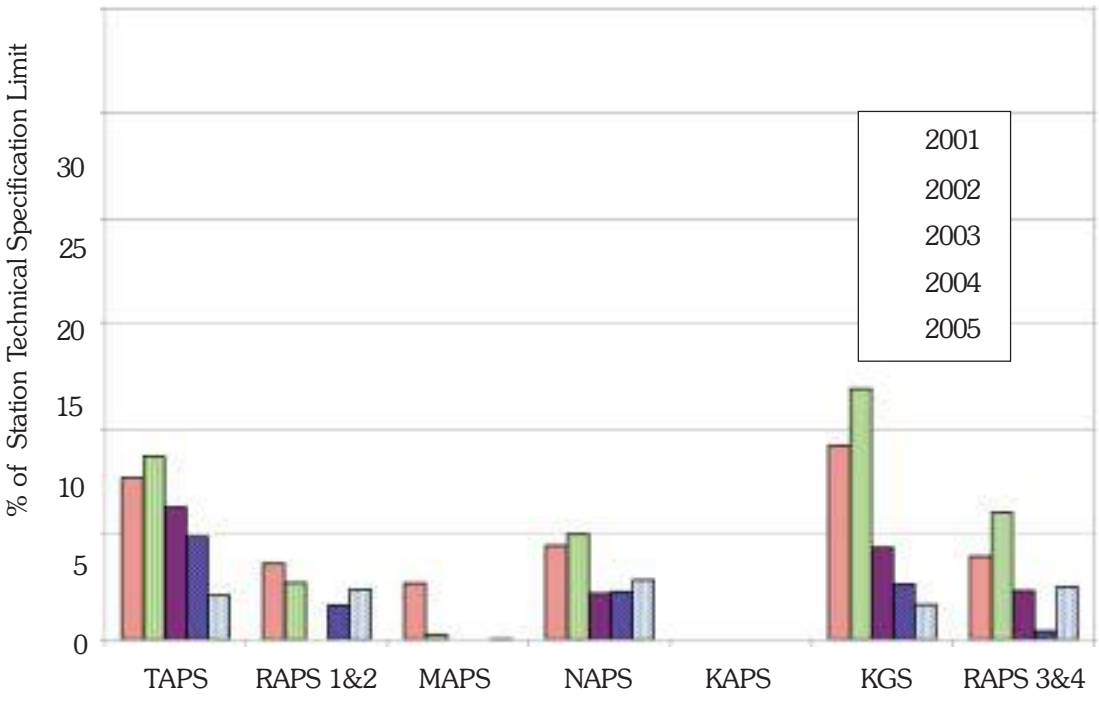


Fig 4.2a: Public Dose at 1.6 km Distance from NPPs

(AERB Prescribed Annual Limit is 1000 micro-Sv)

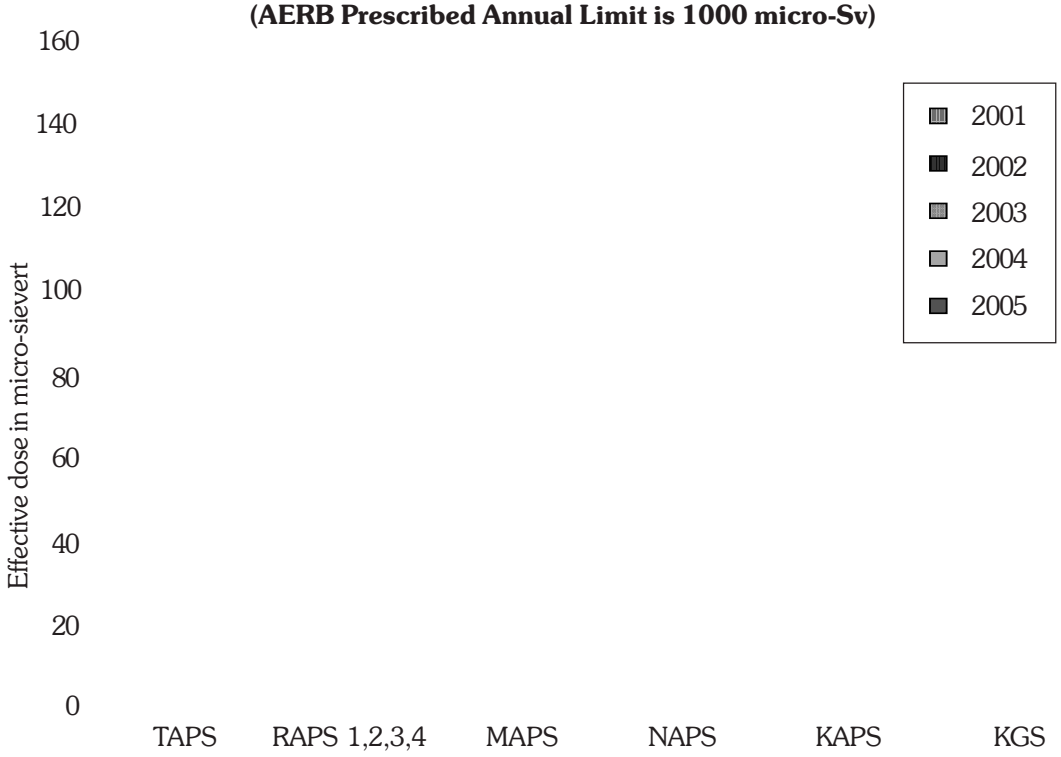
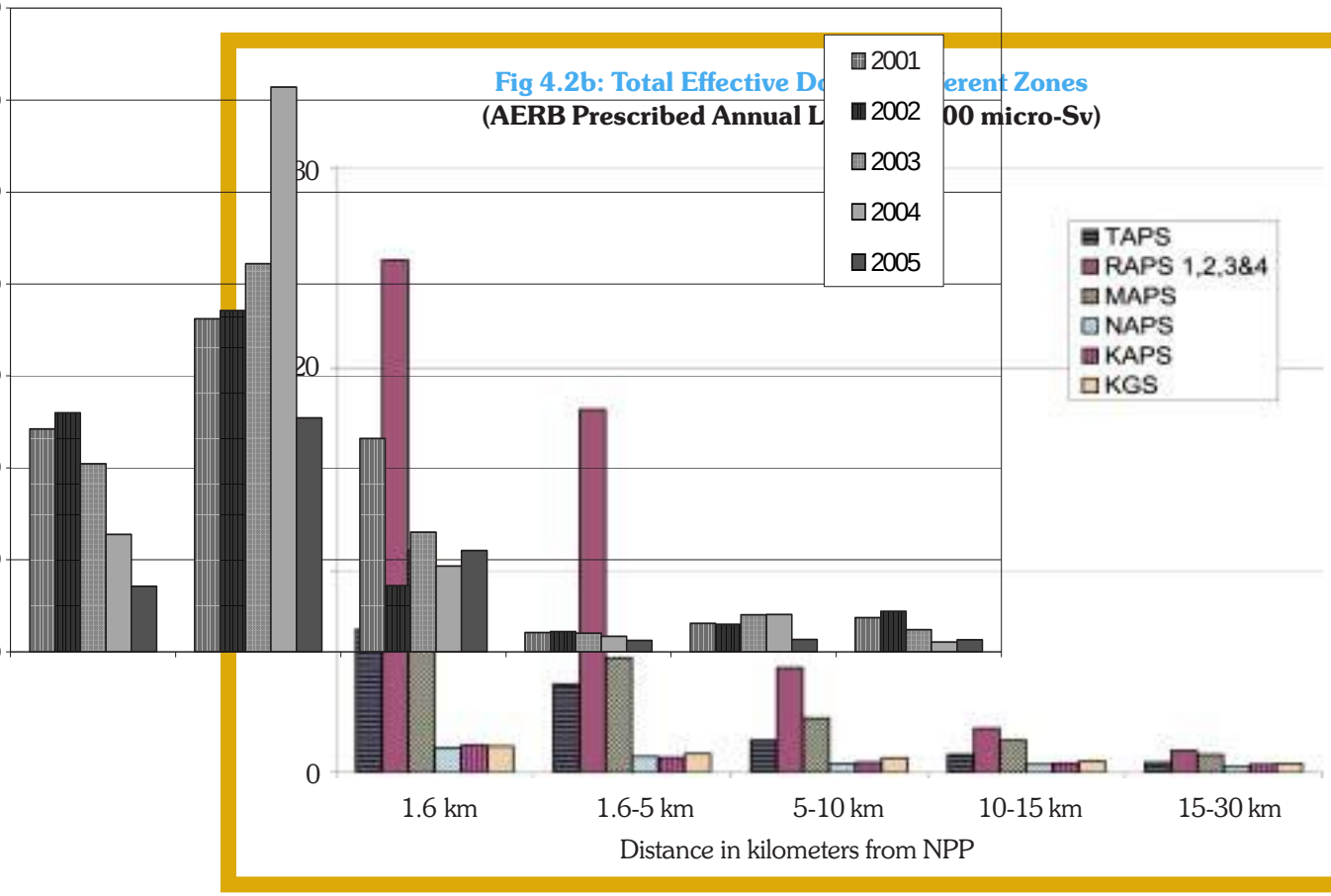


Fig 4.2b: Total Effective D erent Zones

(AERB Prescribed Annual L 00 micro-Sv)



4.2 OCCUPATIONAL EXPOSURES

No worker in the Front End Fuel Cycle Facilities of DAE [IREL (Udyogamandal, Chavara, Manavalakurichi, OSCOM); UCIL (Jaduguda, Bhatin, Narwapahar, Turamdih); NFC-Hyderabad] received radiation dose greater than the Anual Dose Limit of 30 mSv during the year 2005. Number of workers of these facilities who received radiation doses between 20 mSv and 30 mSv during the period 2001 to 2005 is given in Table 4.1.

The number of workers who received radiation doses between 20 mSv and 30 mSv during the years 2001 - 2005 in NPPs is given Table 4.2a. Details of radiation doses received by workers in medical, industrial and research institutions 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 Level) and 30 mSv (Annual Limit)

Year	2001	2002	2003	2004	2005
IRE- Udyogamandal	1	0	4	0	1
IRE- Manavalakurichi	1	0	0	0	0
NFC	0	0	1	0	0
All other Industrial Plants	0	0	0	0	0

Table 4.2 a: Number of Workers in NPPs Exposed to > 20 mSv (Investigation Level) and 30 mSv (Annual Limit)

Year	2001		2002		2003		2004		2005	
	20-30mSv	>30 mSv	20-30mSv	>30 mSv	20-30mSv	>30 mSv	20-30mSv	>30 mSv	20-30mSv	>30 mSv
TAPS-1&2	0	0	2	0	0	0	0	0	0	0
RAPS-1&2	37	1	0	0	0	0	0	0	0	0
MAPS-1&2	0	0	2	1	0	0	0	0	1	0
NAPS-1&2	16	1	10	1	1	0	0	0	0	0
KAPS-1&2	1	0	1	0	3	0	1	0	0	0
KGS-1&2	0	0	0	0	0	0	0	0	0	0
RAPS-3&4	0	0	0	0	0	0	0	0	0	0

Table 4.2b: Radiation Doses Received by Workers in Medical, Industrial and Research Institutes (Year 2005)

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	17564	0.40	1.14	6263	8	2	3	1	7
Radiation Therapy	5382	0.24	0.72	1801	1	-	-	-	-
Nuclear Medicine	1178	0.69	1.67	484	-	1	2	2	-
Industrial Radiography & Radiation Processing	5656	0.45	1.66	1525	10	1	1	2	-
Research	2951	0.10	0.62	481	-	-	-	-	-

4.3 OCCUPATIONAL HEALTH AND SAFETY

4.3.1 Advisory Committee on Occupational Health

Two meetings of ACOH were held during the period with Certifying Surgeons from all participating DAE Units. The committee reviewed occupational health aspects at DAE Units and observations are brought out in the yearly "Health Status Report on Occupational Health and the Industrial Hygiene Surveillance Report". The committee decided to maintain the frequency of periodical medical examination for classified radiation workers of all DAE Units as once in a year.

4.3.2 Fire Safety

Advisory Committee on Industrial & Fire Safety

Advisory Committee on Industrial & Fire Safety (ACIFS) was constituted this year to advise AERB on generic issues of industrial and fire safety. Two meetings of ACIFS were held for discussing the issues like fatalities at construction site, enforcement of regulations, fire protection, and fitness of fire personnel, in-service testing of pressure vessels, industrial safety statistics and review of Atomic Energy (Factories) Rule 1996.

Fire Safety in Resin Fixation Systems at RAPS and KGS

A review of fire safety and industrial safety aspects related to resin fixation systems installed at RAPS was carried out. Hazards were identified and recommendations were made for controlling the hazards. These recommendations are also applicable to similar systems designed for KGS.

CHAPTER 5
EMERGENCY PREPAREDNESS

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

During the year 2005, 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 were satisfactory.

Table 5.1 : Number of Emergency Exercises

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

CHAPTER 6
DEVELOPMENT OF SAFETY DOCUMENTS

6.1 MODIFIED PROCEDURE FOR PREPARATION OF SAFETY DOCUMENTS

AERB develops safety documents, which include codes, standards, guides and manuals for nuclear and radiation facilities and related activities. A revised procedure for this purpose was put in place this year for improved management of developing safety documents. It consists of two stages (a) Safety Document Development Proposal (SDDP) and (b) Document Preparation, Review and Publication.

(a) SDDP

As a first step, SDDP is prepared by the concerned AERB division. The objective of the SDDP is to establish the need for development of the document, identify clearly its scope and define well its structure and contents. At the next level, SDDP is reviewed by an advisory committee and then by an apex committee. The revised SDDP is then taken up for preparing the draft document. The responsibility for preparation of the safety document is assigned either to a working group or to a consultant.

(b) SAFETY DOCUMENT PREPARATION

The draft safety document then undergoes a multi tier review. The initial draft of the document prepared by the working group/consultant is reviewed by the standing advisory committee. The revised draft based on this review is sent to outside experts for comments. These comments are appropriately incorporated and the draft is then sent for technical editing to focus on flow of language and presentation of technical contents. The apex committee further reviews the draft along with technical editor's comments. Appropriate modifications to the document are made and it is sent for copy editing before putting up for approval of Chairman, AERB. In case of safety codes and standards, approval of Board is necessary.

A similar procedure is followed for revision of the documents, which is carried out after significant time period after its publication, to include changes based on operating experience and knowledge gained through research.

Flowchart for Preparation/Revision of Safety Documents in AERB is shown in Figure 6.1. Tables 6.1 and 6.2 give the list of AERB Advisory Committees for Safety Documents and the Apex Committees respectively.

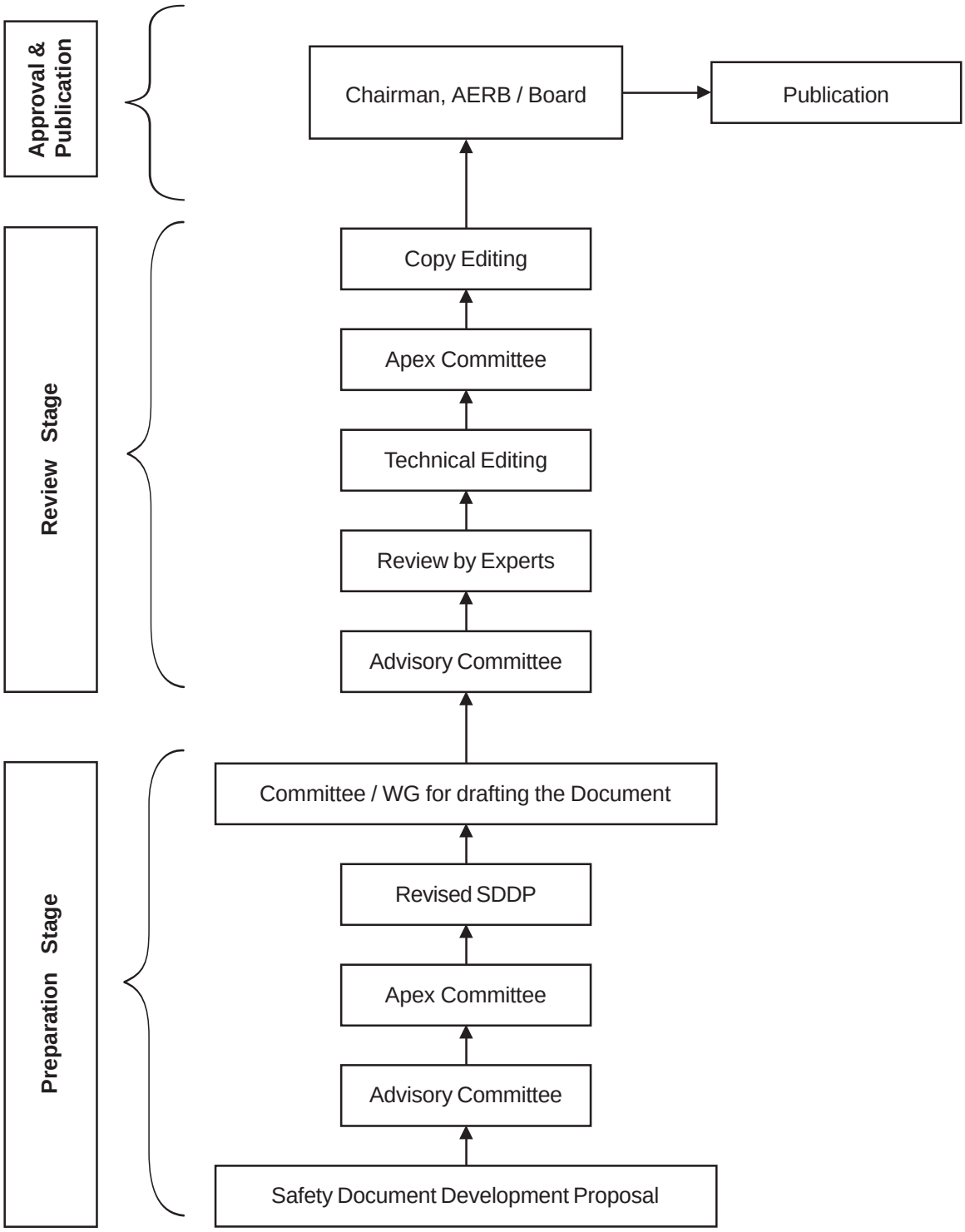
Table 6.1: AERB Advisory Committees for Safety Documents

ACCGORN	Advisory Committee for Codes, Guides & Manuals for Government Organisation
ACRDS	Advisory Committee for Regulatory Documents on Safety in Nuclear Power Plant Siting
ACCGD	Advisory Committee for Codes, Guides & Manuals for Safety in Design of NPPs
ACCGASO	Advisory Committee for Codes, Guides & Manuals for Safety in Operation of NPPs
ACCGQA	Advisory Committee for Codes, Guides & Manuals for Safety in Quality Assurance of NPPs
ACRDCSE	Advisory Committee for Regulatory Documents on Safety in Civil and Structural Engineering
ACSDRW	Advisory Committee for Preparation of Safety Documents on Radioactive Waste Management
SCRSD	Standing Committee on AERB's Radiation Safety Documents
ACOH	Advisory Committee on Occupational Health
ACSDFCF	Advisory Committee on Safety Documents relating to Fuel Cycle Facilities other than Nuclear Reactors

Table 6.2: AERB Apex Committees

ACNS	**Advisory Committee on Nuclear Safety**
ACRS	**Advisory Committee on Radiation Safety**
ACIFS	**Advisory Committee on Industrial and Fire Safety**

Fig. 6.1 : Flowchart for Preparation / Revision of AERB Safety Documents



6.2 SAFETY DOCUMENTS PUBLISHED

1. Site Considerations of Nuclear Power Plants for Off-Site Emergency Preparedness (AERB/NPP/SG/S-8).
2. Safety Systems for Pressurised Heavy Water Reactors (AERB/NPP-PHWR/SG/D-10).
3. Radiation Protection Aspects in Design for Pressurised Heavy Water Reactor Based Nuclear Power Plants (AERB/NPP-PHWR/SG/D-12).
4. Establishing and Implementing Quality Assurance Programme for Nuclear Power Plants (AERB/NPP/SG/QA-6).
5. Guidelines for Pre-employment Medical Examination and fitness for Special Assignments (AERB/SG/IS-4).
6. Safety Guidelines on Accelerators (AERB/SG/IS-5).
7. Radiation Protection for Nuclear Facilities [AERB/NF/SM/O-2 (Rev. 4)].

6.3 SAFETY CODES TAKEN UP FOR REVISION

1. Code of Practice on Design for Safety in Pressurised Heavy Water Based Nuclear Power Plants (AERB/SC/D).
2. Code of Practice on Quality Assurance for Safety in Nuclear Power Plants (AERB/SC/QA).
3. Code of Practice on Safety in Nuclear Power Plant Operation (AERB/SC/O).

6.4 SAFETY DOCUMENTS TRANSLATED AND PUBLISHED IN HINDI

1. Code of practice in Quality Assurance for safety in Nuclear Power Plants (AERB/SC/QA).
2. Code of practice for safety in Nuclear Power Plant Operation (AERB/SC/O).
3. Code of Regulation of Nuclear and Radiation Facilities (AERB/SC/G).
4. Code for Transport of Radioactive Materials (AERB/SC/TR-1).
5. Fuel Design for Pressurised Heavy Water Reactors (AERB/NPP-PHWR/SG/D-6).
6. Loss of Coolant Accident Analysis for Pressurised Heavy Water Reactor (AERB/SG/D-18).
7. Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities (AERB/SG/G-4).
8. Regulatory Consents for Nuclear and Radiation Facilities: Contents and Formats (AERB/SG/G-7).
9. Safety Guide for Preparation of Safety Report of Industrial Plants other than Nuclear Power Plants in the Department of Atomic Energy (AERB/SG/IS-2).
10. Procedure for Forwarding, Transport, Handling and Storage of Radioactive Consignments (AERB/SG/TR-3).
11. Preparation of Site Emergency Preparedness Plans for Nuclear Installations (AERB/SG/EP-1).
12. Preparation of Off-site Emergency Plans for Nuclear facilities (AERB/SG/EP-2).
13. Preparation of Site Emergency Preparedness Plans for Non-Nuclear Installations (AERB/SG/EP-3).
14. Preparation of Off-site Emergency Preparedness Plans for Non-nuclear Installations (AERB/SG/EP-4).
15. Radiological Safety in Design and Manufacture of X-ray Analysis Equipment (AERB/SS-5).

6.5 SAFETY DOCUMENTS UNDER DEVELOPMENT

1. Code of Practice on Design for Safety in Pressurised Heavy Water Reactors (AERB/SC/D).
2. Code of Practice on Radwaste Management (AERB/SC/RW).
3. Consenting Process for Nuclear Power Plants and Research Reactors (AERB/NPP/SG/G-1).
4. Consenting Process for Nuclear Fuel Cycle Facilities and Related Industrial Facilities (AERB/NF/SG/G-2).
5. Containment System Design (AERB/NPP/SG/D-21).
6. Computer Based Systems of Pressurised Heavy Water Reactors (AERB/SG/D-25).
7. Reliability Database for Probabilistic Safety Assessment of Nuclear Power Plants (AERB/TR/O-1).
8. Operational Experience Feedback on Nuclear Power Plants (AERB/NPP/SG/O-13).

9. Non-Conformance Control, Corrective and Preventive Actions for Nuclear Power Plants (AERB / NPP / SG / QA-8).

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

11. Predisposal Management of Low and Intermediate Level Waste (AERB / SG / RW-2).

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

13. Management of Radioactive Waste from Mining and Milling of Uranium, Thorium and Processing of Naturally Occurring Radioactive Materials (AERB / SG / RW-5).

14. Decommissioning of Nuclear Fuel Cycle Facilities other than Reactors (AERB / SG/ RW-7).

15. Atmospheric Dispersion and Modelling (AERB / SG / S-1).

16. Extreme Values of Meteorological Parameters (AERB/ SG / S-3).

17. Man-Induced Events and Establishment of Design Basis (AERB /SG / S-7).

18. Design of Nuclear Power Plant Containment Structures (AERB /SS / CSE-3).

19. Geotechnical Aspects for Buildings and Structures Important to Safety of Nuclear Facilities (AERB / SG / CSE-2).

20. Safety in Thorium Mining and Milling (AERB / SG/ IS-6).

21. Regulatory Inspection and Enforcement in Nuclear Power Plants and Research Reactors (AERB / SM / G-1).

CHAPTER 7
SAFETY STUDIES

7.1 SAFETY STUDIES IN SUPPORT OF REGULATORY REVIEW

7.1.1 Code Comparison for Severe Accident Analysis of VVER-1000

The process of licensing of reactors also includes reviewing severe accident analysis. The details of the computer code used for carrying out severe accident analysis by the designers are presented in the topical reports. In the absence of the availability of the codes used by designers to AERB, a process of code to code comparison for selected accident sequences was done for cross checking. For this, a number of analyses were carried out using RELAP 5/SCDAP code. The results were compared with those obtained by BISTRO code used by the designers. The reactor is simulated by modeling coolant circuit, pressuriser, core, secondary circuits and emergency core cooling system etc. Following transients were analysed.

a. Simultaneous rupture of all steam lines with failure of Main Steam Isolation Valves (MSIVs) to close.

b. Inadvertent opening of pressuriser safety valve and remaining stuck open.

It was observed that the predictions of the two codes have similar trends and the designer's code give a conservative predictions.

7.1.2 Analysis of Postulated Severe Core Damage Accident for Indian PHWRs

Severe accident analysis was carried out in AERB for MAPS 220 MWe using the computer code RELAP 5/MOD 3.2/SCDAP and ANSYS. Following two scenarios have been analysed:

i. Loss of coolant accident coincident with loss of emergency core cooling system.

ii. Loss of coolant accident coincident with loss of emergency core cooling system and loss of moderator heat sink.

The analysis proved useful in better understanding of the core disruption progression for these accidents for evaluating accident management procedures.

7.1.3 Code Comparison for Design Basis Accident Analysis for VVER -1000

The review of preliminary safety analysis report of Kudankulam nuclear power plant is in progress in AERB. As a part of review process, it was considered prudent to carry out analysis of some chosen design basis accidents with the available codes in AERB and compare with the results submitted in PSAR. A number of such analyses were carried out as given below .

a. Inadvertent opening of BRU-A followed by its failure to reseat.

b. Increase in feedwater flow of steam generator.

c. Decrease of feed water inlet temperature to the steam generator.

d. Primary coolant inventory increase.

e. Complete loss of forced reactor cooling due to sudden drop in grid frequency.

f. Loss of condenser vacuum.

g. Design Basis Station Blackout Accident.

In all the cases, the predictions by the designer's codes are similar in nature to those by the codes used in AERB and the designer's predictions are conservative.

7.1.4 Comparison of Design Criteria of PFBR with IAEA Standard NS-R-1

PFBR's safety criteria were established much before corresponding IAEA safety standards were published. Consequently to evaluate PFBR safety criteria against current IAEA standards, a comparison study was carried out with IAEA-NS-R-1. Some differences were observed and the designers have been asked to address the same.

7.1.5 Comparison of the Draft AERB Design Standard for Containment Design (AERB/SS/CSE-3) with Corresponding French Design Standard (RCC-G)

An analytical study was performed for comparison of different codes/approaches for design of inner containment structure. A typical finite element model of the containment structure used in the analysis is given in Figure 7.1. The deformed shape of containment due to applied load is shown

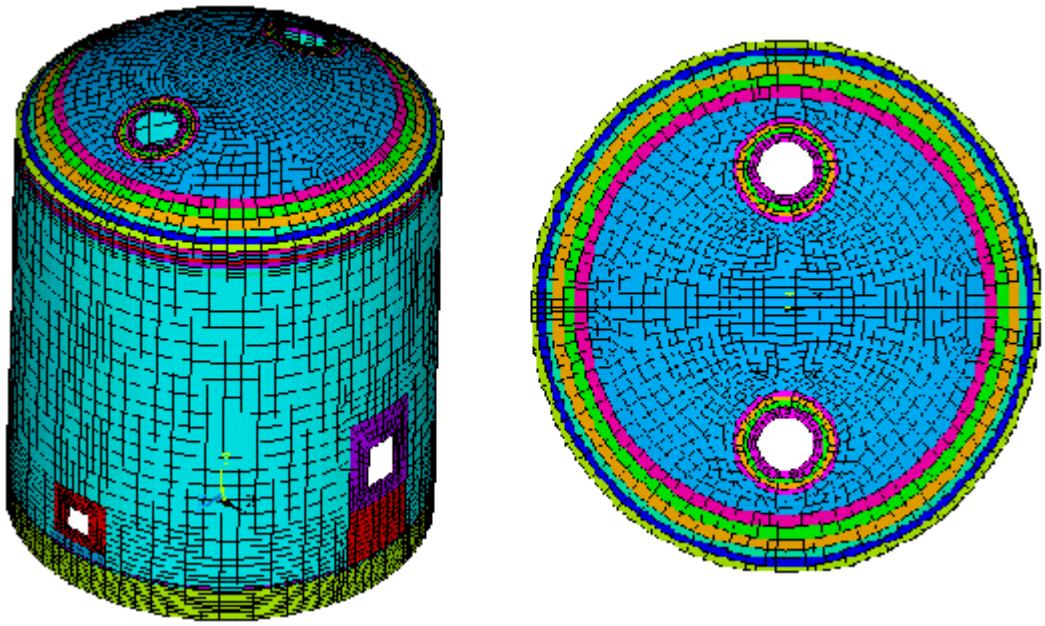


Figure 7.1 : Finite Element Model of the Containment Structure

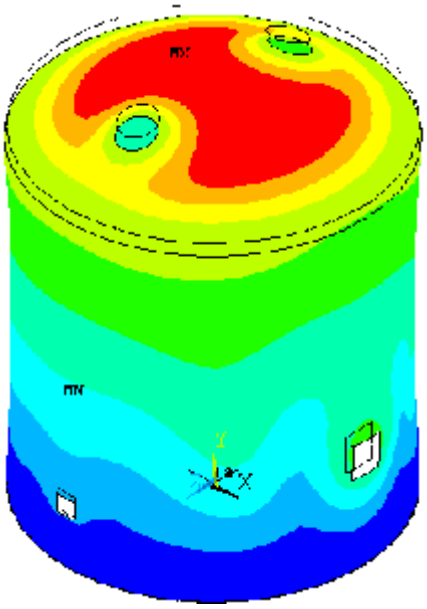


Fig. 7.2 : Displaced Shape (USUM) of the Structure due to Applied Loads

in Fig 7.2. Structural analysis was done as per draft AERB/SS/CSE-3 standard and also as per RCC-G design standard and its supporting standard BPEL-83.

It was noted that the design requirements of draft AERB standard compare well with that of RCC-G in general areas of the containment structure. Near the openings and other discontinuities, as per the draft AERB standard, higher

amount of reinforcement or increased section thickness is required to be provided compared to RCC-G.

7.1.6 Status Report on Safety of Indian NPP against External Flooding Hazards

As per regulatory requirements, NPP safety needs to be assured against external flooding hazard, either by raising site grade level above design basis flood level or by suitable engineering protection measures. There are seven NPP sites in India housing sixteen operating reactors and seven reactors under construction stage. Details of external flooding hazard at all these sites were studied and a report issued. The report discusses the safety status of all these NPP sites against external flooding hazards. The report also brings out generic recommendations for protection against external flooding and local flooding of the NPP sites and is expected to be useful during design safety review of NPPs in India.

7.2 OTHER SAFETY STUDIES

7.2.1 Reliability Evaluation of Passive Safety Systems

Passive safety systems are increasingly being used in new nuclear reactors in India such as VVER-1000, PFBR and AHWR. The review of the reliability assessment for the passive systems is required. For understanding the intricacies of passive system reliability evaluation methodology, a case study based on 'REPAS', a methodology developed by European Union for the purpose, was taken up. A study for 'Isolation condenser decay heat removal system' was carried out for gaining insights into the method using the best estimate thermal hydraulic code.

7.2.2 Integrity Assessment of 37 Element Fuel Bundles of TAPS -3&4

Sustained stratified coolant flow conditions may exist in the reactor core under certain accident conditions such as LOCA. Fuel pins submerged in liquid and those exposed to steam, may see significantly different thermal expansion due to different temperature rise. This may threaten fuel bundle integrity due to end plate failure. An analysis was carried out to assess the integrity of 37 element fuel bundle of TAPS-3&4, under stratified flow conditions. The system was analysed for different sets of differential temperature loading. The model includes plasticity and creep as material non-linearity. The total strain was observed to exceed the fracture strain in some cases, which in turn can lead to failure of the end plates. This aspect would need to be studied further and taken into account in the safety analysis.

7.2.3 Uncertainty Evaluation in the Accident Analysis using Best Estimate Approach

The current standards of accident analysis demand a best estimate approach with uncertainty evaluation. In order to understand the uncertainties in an accident analysis, an exercise was carried out where the effect of uncertainties in important input parameters on the output was estimated using a best estimate thermal hydraulic code. For carrying out this study, a postulated initiating event viz. station blackout for VVER-1000 MWe, is considered. Through analysis the safety margin to acceptance criteria limits is quantified. An uncertainty analysis is carried out and its effect on safety margin is accounted. It is observed that uncertainties significantly affect safety margins. Further work in this direction will be continued.

7.2.4 Fire Dynamics Simulation

A computer code FDS was commissioned for simulating fire progression in enclosed spaces. A round robin exercise was carried out by NPCIL for predicting the progression of fire in a given room, in which AERB participated. The results obtained by AERB using FDS code compared well with the standard results.

7.2.5 Simulation of Primary Heat Transport System of AHWR

The 452 coolant channels of AHWR, each containing 54 fuel rods and a central water rod were modeled. The emergency core cooling system consisting of advanced hydro accommulators and gravity driven water pool were also modeled. The isolation condenser system was simulated for emergency core decay heat removal. The point reactor kinetics was modeled and various trips were simulated as boundary conditions. Analysis was carried out for time period of 2000 s till steady state is reached. The steady state values of various parameters such as pressure, temperature and flow compared well with the design values. The input file thus prepared will be used for verification of designer's predictions.

CHAPTER 8
SAFETY RESEARCH INSTITUTE

The following research activities are being pursued at Safety Research Institute (SRI), Kalpakkam.

- Nuclear Plant Safety Studies
- Reactor Physics Studies
- Radiation Safety Studies
- Environmental Safety Studies

Besides research, other components of SRI activities include the following.

- Periodic Training Workshops and Discussion Meetings
- Archiving of Technical and Research Reports, Course Materials, Management of Data Bases and Safety Related Computer Codes
- Regulatory inspections in the southern region

The progress made in the above activities during the year 2005-2006 is described below.

8.1 NUCLEAR PLANT SAFETY STUDIES

8.1.1 Flexibility Analysis from Steam Generator to Secondary Sodium Pump

At present flexibility analysis of piping of PFBR is being carried out with the Finite Element Analysis (FEA) code, CASTEM-2001. Analysis has been done for a segment of the pipeline extending from Steam Generator (SG) to Secondary Sodium Pump (SSP) of the Secondary Sodium Circuit. Analysis also includes the hanger hot load, travel and cold load calculations. The load case considered for the pipeline qualification in flexibility is Design Condition and Level A Service Limit. Qualification has been done using ASME Section-III, Subsection NC. Material properties are taken from RCC-MR code.

Stress ratio has been calculated by taking the ratio of stress induced in the pipeline to the allowable stress prescribed by code. Maximum stress ratio for the design condition is 0.12 and that for normal operating condition is 0.22. Stress ratio due to only thermal expansion at design temperature is 0.30, from which it can be seen that enough margins for inclusion of pipe support for the seismic analysis are available in the present design. Hanger loads obtained from FEA Code-CEASER are compared with the loads obtained from FEA computer code, SAP IV. The loads on hanger are within 10% of load calculated from SAP IV, which is considered satisfactory.

8.1.2 A Database Application for Fast Reactor Components

A visual basic application was developed with MS access as the backend to maintain a database of failure rate data on fast reactor components. The application provides a user-friendly interface to add, modify and retrieve the data collected and stored from different sources during the reliability studies carried out for PFBR. Apart from graphical representation of the collected data and calculation of basic statistical information such as mean, median, standard deviation, the application also provides a facility to combine the operating experience with the stored data and estimate the posterior failure data using Bayesian technique. So far about 2000 component failure data have been collected and stored in the database. It is intended to provide this application on intranet and make it available for the users during reliability analysis.

8.2 REACTOR PHYSICS STUDIES

8.2.1 PWR Physics Analysis

SRI has initiated a collaborative project with BARC and NPCIL to develop expertise in the PWR physics calculations and fuel management strategy. SRI plans to acquire the relevant computer codes and develop a set of interfaced computer codes (Graphical User Interfaces) for rapid input/output processing. Two computer codes, namely EXCEL and TRIHEX-FA, along with 172-energy groups IAEAGX cross section library in WIMS-D format, developed at LWRPS, RPDD, BARC, have been acquired and preliminary tests have been completed. EXCEL code which is a hexagonal lattice assembly cell burn up code and is meant for fuel cell calculation (the pre-runner for reactor core physics parameter analysis), has been used to generate the required input for different types of fuel assemblies, which will be used in VVER, KK-NPP. TRIHEX-FA is a diffusion theory code for estimation of reactor core parameters in hexagonal lattice arrangement of fuel assemblies and makes

use of database generated by the EXCEL Code. Exploratory computations for KK-NPP project have been carried out and the results are being analysed.

8.2.2 External Neutron Source Calculations for PFBR Start Up

A collaborative work with IGCAR has been carried out to analyse the use of external neutron source subassemblies for finding out the shutdown neutron count rate. The use of external neutron source of Sb-Be type has been explored to obtain an enhanced count rate at the detector location (in vessel near core cover plate) for the efficient start up of PFBR. The external sources considered in the present calculations are of 35 cm length, located at the first blanket ring of the core. The length of external source is arrived at by parametric analysis, in order to handle it safely by the existing IFTM and replace it after 5 cycles of operation and storage. It is found that with 3 such external source subassemblies, it is possible to get a maximum of 45.5 cps as shutdown count rate (with detector sensitivity of 1 cps/nv) on the control plug detectors after 2 months of reactor operation. This count rate reduces to 9.1 cps if the detector efficiency reduces from 1 cps/nv to 0.2 cps/nv. During the source subassembly replacement, only 2 active external source subassemblies will be present in the core, which can give count rates of 30.5 and 6.1 cps with detector sensitivities of 1 and 0.2 cps/nv respectively.

The above calculations are being checked using 3-D neutron transport code TORT. Calculations were carried out to estimate the k_{eff} of the core with all the absorber rods inserted in the core and the neutron flux at the desired location estimated without introducing the external sources. Another set of calculations have been made with the external sources (Sb-Be) in place. The analysis of the results is in progress.

8.3 RADIATION SAFETY STUDIES

8.3.1 Investigation of High Energy LINAC Beam Characteristics

High-energy electron Linear Accelerators are being widely employed for treatment of tumors in the country. One of the essential passive components in the LINAC is the radiation beam flattening device. A new approach for the beam flattening filter design has been proposed based on the iterative algorithm. Typical results generated for 6 and 18 MV cases agree with the published values and thus validates the algorithm proposed. LINACs operating at higher voltages (> 10 MV) can also produce photo-neutrons, which would expose the entire body of the patient. The magnitudes of such doses in relation to the photon doses are of importance. Neutron production and doses for 18 MV beam used for photon radiotherapy have been investigated. The results of the studies show that the neutron doses are marginal and the magnitude is 200 μSv for one Gray of photon dose.

8.3.2 Gamma Ray Shielding: A Web Based Interactive Program

A web based interactive computing program is developed using JAVA for quick assessment of Gamma Ray shielding problems. The program addresses common source geometries like "POINT, LINE, CYLINDRICAL, SPHERICAL, BOX", followed by "SLAB" shield configurations. The calculation is based on point kernel technique. The application allows the user to select one of the seven regular geometrical bodies and provision exists to give source details such as emission energies, intensities, physical dimensions and material composition. Similar provision is provided to specify shield slab details. To aid the user, atomic numbers, densities and standard buildup factor materials are given in dropdown combo boxes.

Typical results obtained from this program are validated against existing point kernel gamma ray shielding codes. Additional facility is provided to compute fission product gamma ray source strengths based on the fuel type, burn up and cooling time. Plots of fission product gamma ray source strengths, gamma ray cross-sections and buildup factors can be optionally obtained, which enable the user to draw inference on the computed results. It is expected that this tool will be handy to all health physicists and radiological safety officers as it will be available on the internet and accessible by all the browsers. The application is now available on the intranet server and is being currently tested and used by the health physicists in IGCAR.

8.4 ENVIRONMENTAL SAFETY STUDIES

8.4.1 Remote Sensing and Geographic Information System - EIA of NPPs

The data on environmental radiation exposures both external and internal was collected from ESL for the years 1974, 1984, 1994 and 2004 and analysed. It was observed that the total dose received by the persons in all the zones did not exceed 6 μSv/y as against the allowed limit of 1000 μSv/y. Fig.8.1 depicts the different zones demarcated for the purposes of radiation monitoring (as per the AERB

guidelines). Zone-1 corresponds to 1.6 to 5 km; zone-2 corresponds to 5 to 10 km; zone-3 corresponds to 10 to 15 km and zone-4 corresponds to 15 to 30 km. Fig.8.2 depicts a typical sketch highlighting the radiation impact due to external exposure for four zones of 2004.

8.4.2 Tsunami Impact Assessment of Kalpakkam Site

8.4.2.1 Tsunami Inundation Mapping

The prime objective of the study is to determine the flood inundation pattern for every one-meter water level rise in and around Kalpakkam plant site and township and its impact on the existing land use/land cover pattern.

8.4.2.2 Simulated (Sea) Water Inundation Model (SWIM)

A SWIM model has been developed to identify different land areas under inundation due to the rise in water levels. Using GRID module in Arc/Info GIS, a query-based model has been developed. In the background, map or imagery of the study area is being displayed and query can be performed over it for each 1 m of water level rise using the derived Digital Elevation Model (DEM) (Fig.8.3) based on the logical condition applied on to the grid layer. This DEM was used to evaluate the flood inundation patterns for every 1 m level water rise in the vicinity of Kalpakkam Nuclear Power Plant site (50 km radius from NPP). This DEM was used to query and find out the inundation areas under different conditions of water level rise. All the cells which satisfy the query condition (of elevation) get highlighted in DEM with a particular color and suggest the inundation area. The DEM was employed for generating inundation map with 4 m, 5 m, 6 m and 7 m water level rise in the study area keeping the satellite imagery in the background (Fig.8.4). It was observed that agreement between predicted and actual inundation was satisfactory.

It was quite evident that the inundation pattern and its impact are not constant along the coast. It varies with respect to different undulating patterns of the terrain, depressions and land cover type and bathymetry. These results are validated with the help of a detailed field survey carried out in the study area.

The experience from this study reveals that it is a cost-effective approach, which can be employed to generate required information fast for suggesting mitigation measures at a gross level. GIS techniques help in integrating multi-parameter spatial information for generating locale-specific plans.

Fig. 8.1 Different Monitoring Zones Around MAPS

Fig. 8.2 Typical Sketch External Dose at 4 Zones for the year 2004

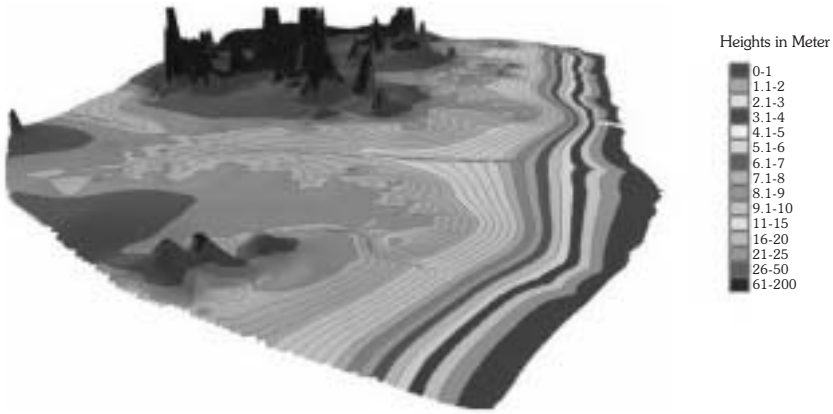


Fig-8.3 : 3D Model Generated from Composite DEM's of SOI and SRTM

As SRTM data provides elevation information of buildings and treetops, the inundation simulation using SWIM predicted a rise of wave height by 5 m for 500 m stretch of Casuarinas plantation in the power plant site. The simulation showed agreement with ground truth data. From the simulated patterns one could also effectively plan emergency evacuation with available infrastructure.

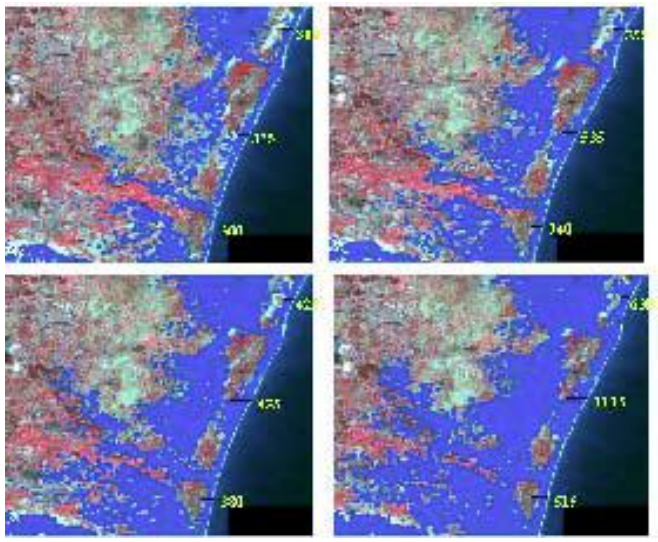


Fig-8.4 Simulation of Inundation Area for 4 m, 5 m, 6 m and 7 m Water Level Rise

8.4.3 Mapping of Morphological and Bathymetry Changes

Studies were undertaken to map the morphological and bathymetry changes at Kalpakkam site for pre and post Tsunami period of the 26th December, 2004. Initially, the post-tsunami bathymetry chart of decimeter accuracy [4.5 km length (parallel to the coast) and 2 km width (across the coast)] was scanned and digitised using GIS software. Totally, 9892 point data was digitised. From this point data, contour maps of decimeter and 1 cm interval were created. After creating contour map, using spatial analyst tool extension of GIS software, the bathymetry (surface) of the Kalpakkam near shore was created. A typical surface generated with 1 cm contour interval is shown in Fig. 8.5. Creation of the surface for the pre-tsunami period is going on. After, the creation of pre-tsunami surface, comparing the post and pre surfaces, identification of the morphological changes of the Kalpakkam near shore, will be taken up. It is observed that the depth varies from 0.7 m to 14 m in the above mentioned area and depth increases from west to east. Around the intake well of MAPS the depth varies from 5 m to 8 m.

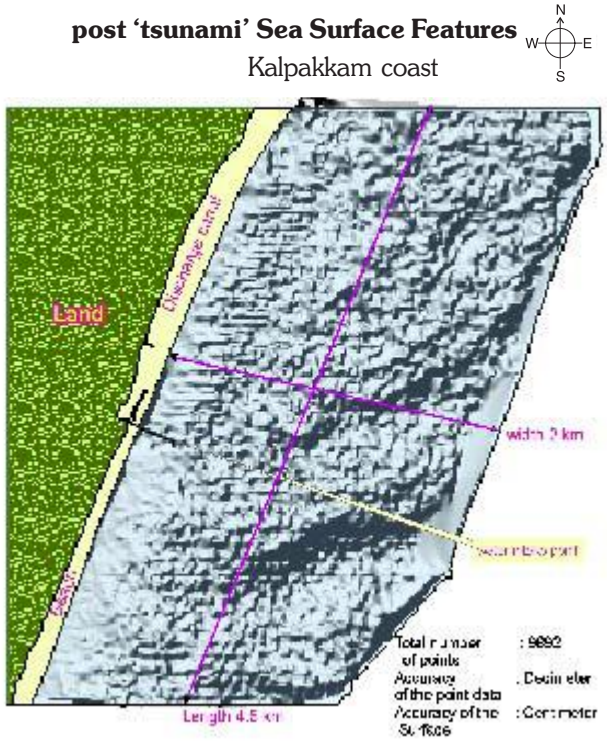


Fig- 8.5: Post-Tsunami Bathymetry of Kalpakkam Site

8.4.4 Hydrogeological Investigations at Kalpakkam

The monthly water table measurements at Kalpakkam site were carried out to generate contour maps and velocity flow field for the entire year. The study area and borewell locations are given in Fig. 8.6. The water samples are also collected every month and are being analysed for physico-chemical parameters with a view to drawing iso-concentration curves. The water table fluctuations in the borewells correlate with the rainfall. Also the fluctuation trends indicate that rainfall is the only recharge mode for the shallow aquifer in the study area. In general the water flow is towards the sea (Fig. 8.7). The direction of the water flow in the regime is in North East direction.

The salinity variation trend for a typical period, October 2005 to January 2006, as shown in Fig. 8.8. indicates that the entire aquifer is homogeneous. Also, the consistent higher salinity levels for Borewells 6, 7 and 8 are attributed to their proximity to Buckingham Canal.

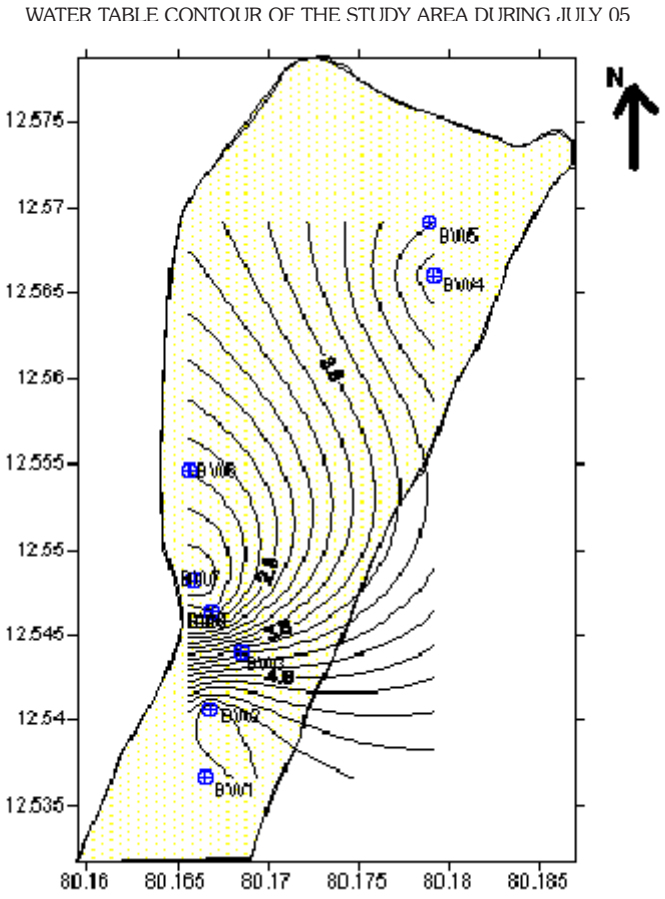
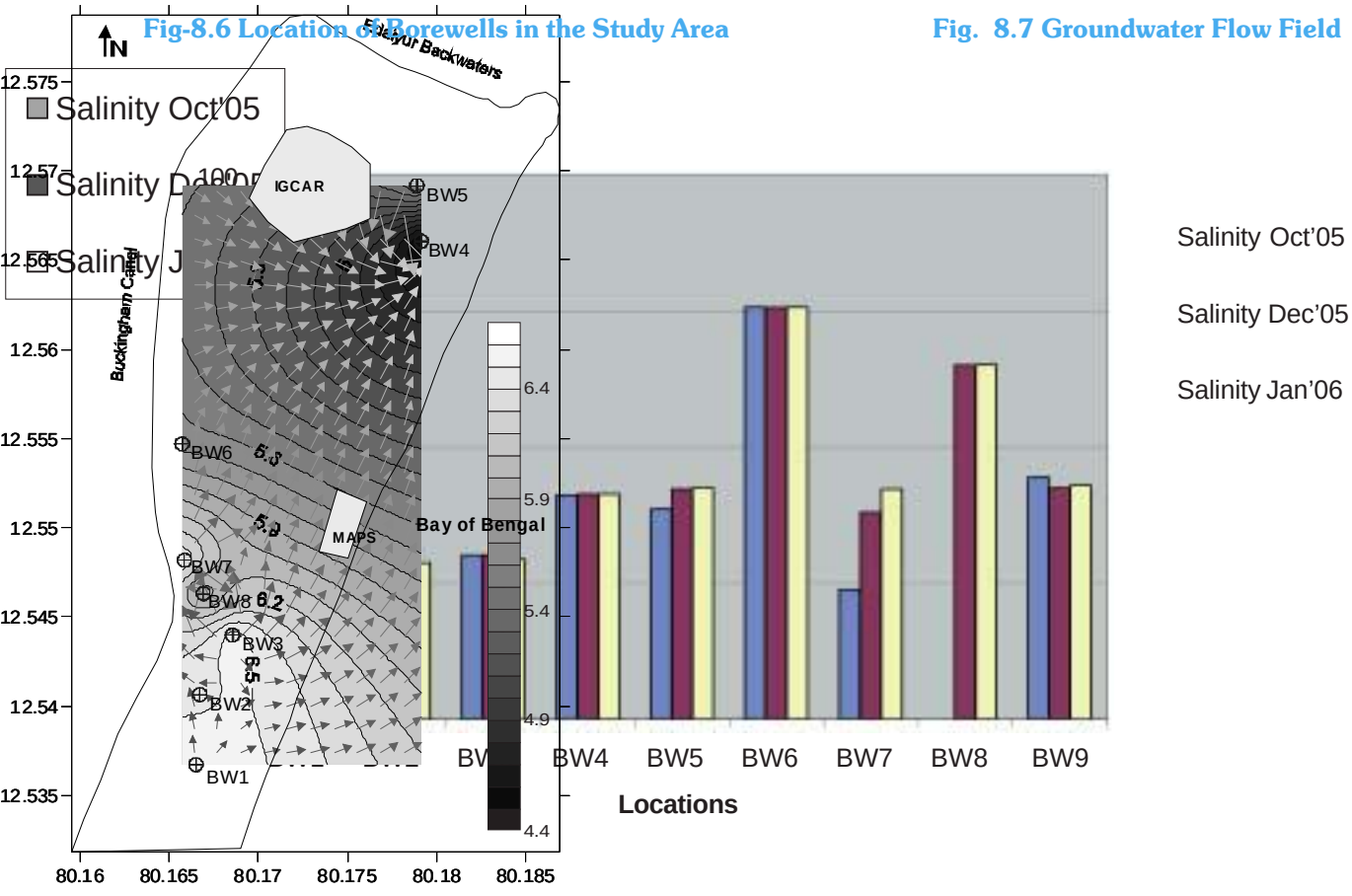


Fig-8.6 Location of Borewells in the Study Area

Fig. 8.7 Groundwater Flow Field



8.4.5 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. Attempts are also made to simulate the marine dispersion phenomenon using CORMIX evaluation software. Preliminary studies indicate a sharp decrease in concentration of radionuclides released at the discharge point along the direction of north within 100-150 m. Further studies are in progress.

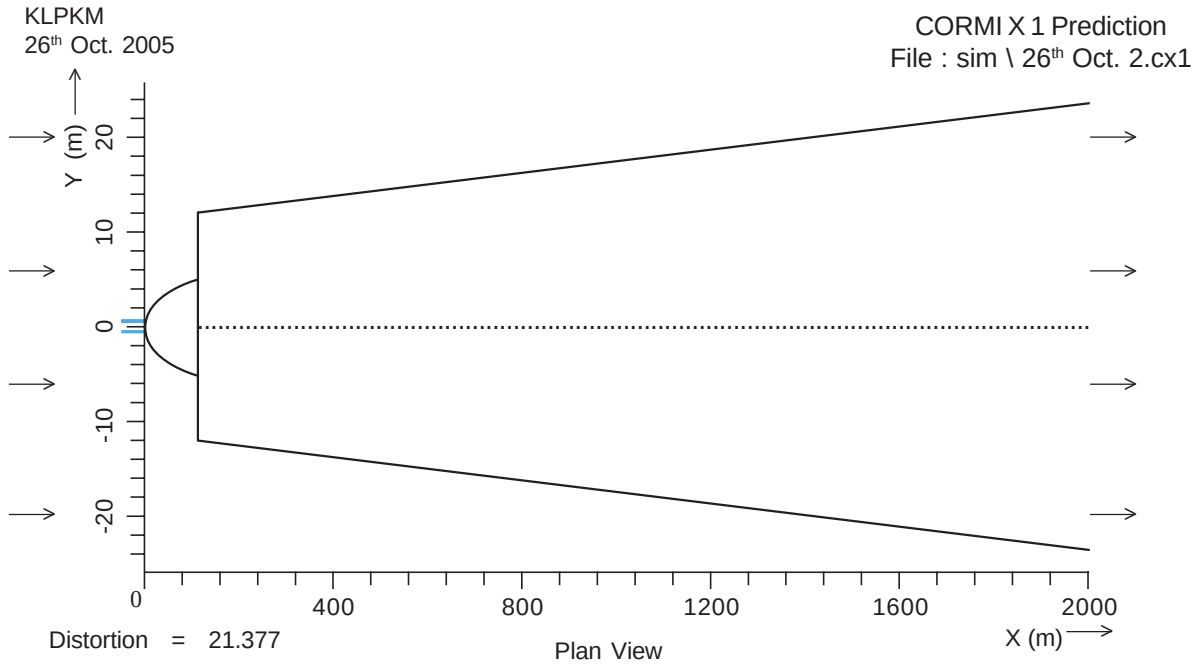


Fig- 8.9 Predicted Shape of the Plume based on the Data of 26th October 2005.

8.4.6 Migration of Radionuclides in Porous Media

A computer code to model the transport of radionuclides in fractured porous medium at Kalpakkam was written in FORTRAN language and benchmarked with existing literature. The concentrations were computed for H-3, Cs-137, Sr-90, C-14 and I-129 using site-specific parameters as the input. Concentrations were computed with constant flux model and exponentially decaying flux model at the interface boundary. Annual dose received was calculated for all the species mentioned above. In order to explain the oscillations observed in Sr-90, sensitivity analysis was carried out with Retardation factor(R) and Half-life taken into account. An SRI technical report has been prepared on the study, which has been carried out in collaboration with IGCAR, Kalpakkam.

8.4.7 Environmental Impacts of Power Plant Discharges on Entrained Organisms

The aim of study is to understand the effect of chlorine, which is being used in Madras Atomic Power Station (MAPS) as biocide to control biofouling of marine organisms, on the entrained phytoplankton and zooplankton. Experimental works have been taken up to study the various effects of chlorine. Both field and laboratory experiments are being carried out. Fortnightly samples are taken from the sampling stations (Intake, Pump house, CCWP, PSWP, Mixing point) analyzed for total residual oxidants, chlorophyll estimation, and nutrient analysis. Residual Chlorine was analyzed using DPD Loviband Comparator. The residual chlorine levels were below detectable level in the intake and the mixing point whereas in the outfall (CCWP, PSWP) and the pump house the levels were between 0.1-0.45 mg/l. The chlorophyll level showed a reduction in the outfall and pump house for about 55-60 % compared to the intake, which was considered control, whereas in the mixing point it showed about 10-16 % less than the intake.

The most dominant form of chlorination byproduct was Bromoform, the levels ranged from 80.56 – 365.76 ppb at pump house, 74.6- 291.29 ppb at CCWP 91.76-314.66 ppb at PSWP and around 56. ppb at mixing point (Fig. 8.10)

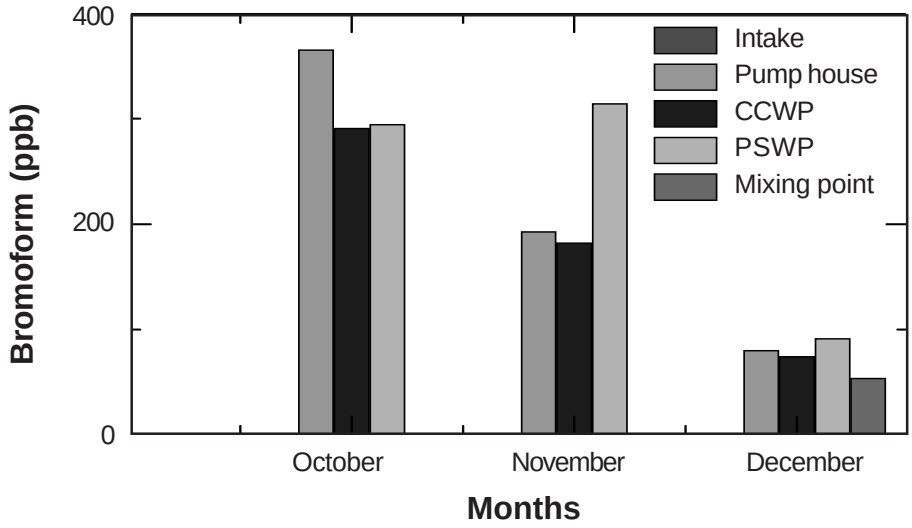


Fig- 8.10 Concentration of Bromoform Levels at Various Locations Near MAPS Jetty Area

The residual chlorine levels were below detectable level in the intake and the mixing point whereas in the outfall (CCWP, PSWP) and the pump house the levels were between 0.1-0.45 mg/l. The chlorophyll level showed a reduction in the outfall and pump house for about 55-60 % compared to the intake, whereas at mixing point it showed about 10-16 % less than the intake (Fig. 8.11).

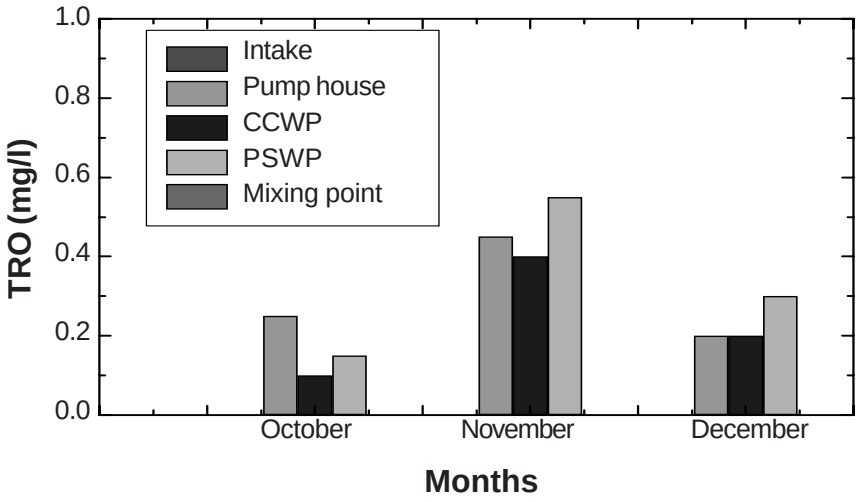


Fig- 8.11 Concentration of Residual Chlorine Levels at Various Locations near MAPS Jetty Area

8.5 OTHER ACTIVITIES

8.5.1 Regulatory Inspections

SRI officers were members of the AERB teams, which carried out Regulatory Inspections of the following projects.

- DFRP Project
- PFBR Project
- Radio Chemistry Laboratories (RCL), IGCAR
- EMCCR works of MAPS-1

CHAPTER 9
PUBLIC INFORMATION

9.1 PRESS RELEASES ISSUED

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

- The first criticality of the indigenously designed 540 MWe Tarapur Atomic Power Station Unit-4 (TAPS-4) on March 6, 2005 after due authorisation by the Atomic Energy Regulatory Board.
- Visit to AERB of a five-member delegation of the French Nuclear and Radiation Regulatory Organisation led by Director General Dr. A. C. Lacoste on October 25, 2005 and renewal of the agreement between the two regulatory bodies for Exchange of Information and Co-operation in the Regulation of Nuclear Safety and Radiation Protection.
- A meeting of Senior officials of the Nuclear Regulatory Bodies of Argentina, Canada, China, India, Korea, Pakistan and Romania, the countries operating CANDU type Pressurised Heavy Water Reactors (PHWRs) held in Mumbai from November 14 to 18, 2005.
- Grant of AERB Permission for Restart of Tarapur Atomic Power Station (TAPS) Units 1&2 on February 14, 2006 after safety upgradation.
- Annual function on March 6, 2006 for presentation of Industrial Safety Awards for the best safety performance among the DAE units.

9.2 AERB NEWSLETTER

AERB News Letter covers AERB press releases, important national and international news, safety reviews of plants / projects and permissions issued to nuclear and radiation facilities, activities related to training, workshops, colloquia, seminars, symposia, etc., The News Letter regularly carries experts' views regarding safety of nuclear and radiation facilities. AERB News Letters Vol. 18 No. 1- 3 were published both in Hindi and English during the year 2005. A home page covering new appointments, retirements, AERB staff club activities, obituaries, etc., has also been included in the News Letter.

9.3 ANNUAL REPORT

Annual Report of AERB brings out the details of works carried out in various Divisions of AERB during every financial year. The Report is widely circulated to all the Units and PSUs under the Department of Atomic Energy, Nuclear Regulatory Agencies of other countries, IAEA, premier educational and research institutions in India, Radiological Safety Officers of various hospitals and nuclear installations, news papers and news agencies in India, ex-members and Chairmen of AERB, Ex-Directors and Ex-Heads of the Divisions of AERB.

9.4 INTERVIEW

Secretary, AERB gave a video interview along with another colleague from Radiological Safety Division (RSD) on the Regulatory Aspects of Diagnostic Radiology for a TV Channel. Senior officials of AERB responded to queries of the media on regulatory and safety aspects of nuclear energy and applications of radiation for societal benefits.

9.5 PRESS MEET

Regulatory aspects of radiation safety were highlighted by Secretary, AERB in a 'Press Meet' organised during the third conference of the Association of Radiation Oncologists of India (AROI) in Guwahati from Sept. 9-10, 2005.

9.6 RIGHT TO INFORMATION ACT

Shri S. K. Chande, Vice-chairman AERB has been appointed Appellate Authority. Dr. Om Pal Singh, Director, Information and Technical Services Division (ITSD) and Shri A. Ramakrishna from ITSD have been designated as Public Information Officer (PIO) and Assistant Public Information Officer, (APIO) in AERB respectively for the implementation of 'The Right to Information Act, 2005'.

In the light of this Act, seventeen documents giving the details about the responsibilities of AERB, the functioning of Divisions, organisation structure, etc., have been put on AERB website.

CHAPTER 10
INTERNATIONAL COOPERATION

10.1 COLLABORATION WITH FOREIGN ORGANISATIONS AND REGULATORY BODIES OF OTHER COUNTRIES

10.1.1 AERB – USNRC Discussion Meeting / Workshop on Nuclear Safety

The nuclear safety cooperation between United States Nuclear Regulatory Commission (USNRC) and AERB was resumed in Feb. 2003. The 6th and 7th meetings of the program were held during the year 2005 – 2006. The objective of these meetings continues to be furthering the dialogue regarding Nuclear Safety between US and Indian Governments. The 6th meeting of the program was held in Washington during Sept. 26 – 30, 2005. The AERB delegation was led by Shri S.K.Chande, Vice Chairman, AERB. The presentations on Accident Analysis and Accident Management Guidelines, Passive Systems Reliability Evaluations, Long Term Performance of Concrete Structures and Standard Problem activities on Thermal Hydraulics and Severe Accidents were made by USNRC staff. The Indian delegation members presented information on severe accident analysis studies on Indian PHWRs, accident analysis and vessel integrity assessment in PFBR, containment structures and high performance concrete and reliability evaluation of passive systems. The AERB and USNRC representatives held joint discussion on possible standard problems in thermal hydraulics and severe accident that would be analysed by each side separately. The presentations were followed by intense discussions. The participants agreed that the on-going co-operation program had been very beneficial and would lead to improved understanding of issues related to safety of Nuclear Power Plants.

The seventh discussion meeting was held at AERB, Mumbai from March 27 to April 4 2006. The USNRC delegation was led by Commissioner, Lyons. NRC staff made the presentations on severe accident analysis and management and source term evaluation of light water reactor. AERB representatives and experts from NPCIL, BARC and IGCAR made presentations on these topics for PHWRs and PFBR. Another set of presentations was made on Digital Control and Instrumentations by both the sides. Discussions were initiated on standard problems in thermal hydraulics and severe accidents and ultimate load capacity of containment structures. At the end of the meeting on April 4, 2006, NRC and AERB participants agreed that the ongoing cooperation program is helping in improved understanding of the issues related to safety of NPPs in both the countries and the program should continue in future. The standard problem exercises were initiated on thermal hydraulics to assess selected thermal hydraulic computer codes for analysis of passive containment cooling systems and severe accidents aimed at re-analysis of the Three Mile Island Unit-2 accident and assessment of ultimate load capacity of pre-stressed concrete containment.

AERB – USNRC Discussion Meeting on Nuclear Safety (Sitting from L to R: Dr.R.B. Grover, Director, SPG, DAE, Shri S.K.Chande, Vice-Chairman, AERB, Shri S.K.Sharma, Chairman, AERB, Dr. Peter B.Lyons, Commissioner, USNRC, Dr. A. C. Thadani, Member USNRC Delegation and Mr. James E.Lyons, Member, USNRC Delegation)

10.1.2 AERB – DGSNR Meeting

A meeting between French delegation headed by Mr. Andre Claude Lacoste, Director General of DGSNR (Directorate General for Nuclear Safety and Radiation Protection) and AERB was held on Oct. 25, 2005. The meeting was part of the co-operation agreement signed between AERB and DSIN in July 1999. The functions of DSIN have been taken over by DGSNR consequent to its formation in Feb. 2002. In this meeting the old agreement was renewed for a further period of five years. In addition to the areas of co-operation covered previously by 1999 agreement, the fields of radiation protection and safety of transport of radioactive sources and materials were added in the new agreement.

In the meeting, technical presentations were made by AERB on Tusnami event in India and French on the Flooding Event at Le Blayais Nuclear Power Plant in France. AERB and DGSNR presentations were made on, 'Safety and Leak Tests of Pre-stressed Concrete Containments' and 'Safety in Transport of Radioactive Materials.' The presentations were followed by intense and useful discussions.

Shri. S. K. Sharma, Chairman, AERB and Mr. Lacoste, Director General of DGSNR Exchanging the Co-operation Renewal Documents

10.1.3 Meeting of Senior Regulators of Countries Operating CANDU type Reactors

A meeting of senior officials of the Nuclear Regulatory Bodies of Argentina, Canada, China, India, Korea, Pakistan and Romania, the countries operating CANDU type Pressurised Heavy Water Reactors (PHWRs), was held in Mumbai from November 14 to 18, 2005. The objective of the meeting was to share information on regulatory matters and operational experience of PHWRs with a view to enhancing safety. The meeting was hosted by AERB and was organised under the auspices of IAEA. The venue of this annual meeting is rotated among the participating countries.

The topics covered in this meeting were performance of the reactors, safety significant events, design issues emerging from operational experience and results of periodic safety review of the plants. Currently there are 42 PHWRs operating in the world of which Canada has 20. India has 13 in operation and 5 under construction.

Meeting of Senior CANDU Regulators in Progress (Shri S.K.Chande, Vice-Chairman, AERB and to his right Dr.George Phillip, IAEA are seen in the Centre)

10.1.4 IAEA Coordinated Research Program

AERB is participating in the IAEA sponsored Coordinated Research Project on the "Safety Significance of Near Field Earthquakes". The Coordinated Research Project 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.

As required by IAEA, further non-linear analyses using input motions scaled to different levels of peak ground acceleration were conducted as part of the third year's work plan. Two different input time histories were identified to carry out the study and about twelve different non-linear analyses were conducted. The final report was prepared and submitted to IAEA. The results of the study were also presented during the 3rd Research Coordination Meeting of IAEA held at Joint Research Centre, Ispra, Italy.

CHAPTER 11
HUMAN RESOURCE DEVELOPMENT

11.1 GENERAL

AERB is involved in the challenging task of regulating 15 operating plants, 2 research reactors, 8 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, the mandate of AERB includes radiation safety in medicine, industry and research organisations. AERB also enforces safety provisions in plants and fuel cycle facilities like uranium mines and mills and nuclear fuel fabrication and heavy water plants and facilities of IREL and in major R&D organisations. 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) has also been taken up. Considering the present and future volume and range of activities, human resource development in AERB has become a vital and challenging activity at this juncture.

11.2 MANPOWER AUGMENTATION

AERB manpower is being augmented at various levels and through various channels taking into consideration the expanding nuclear power programme and increasing use of radiation for the societal benefits. This is being done through fresh recruitments, transfer of experienced personnel from operating plants and R&D institutes like BARC and IGCAR and induction of postgraduates through AERB sponsored schemes in IIT Bombay and IIT Madras. During the year, 20 personnel in different grades were added. Two students, one each in IIT Bombay and IIT Madras were sponsored for M. Tech. Before inducting these M.Tech engineers in AERB, they are required to go through the BARC Orientation Course in Engineering for Post-graduates (OCEP). The total personnel in AERB as on March 31, 2006 is 175, technical staff being 136 and supportive staff being 39.

11.3 AERB IN-HOUSE TRAINING SCHEME

In order to train the directly recruited engineers and refresh the middle level engineers in AERB, an In-house Training Course was conducted during June to August 2005 covering selected topics in 'Nuclear Science and Engineering' and 'Operation of Nuclear Power Plants' with emphasis on 'Regulatory Activities of AERB'. As part of this Training Course, 52 technical lectures and 21 examinations were conducted and the performance of the trainees was assessed and recorded.

AERB Refresher Courses were introduced on selected topics of regulatory interest for updating the technical knowledge of AERB staff. During the implementation, free exchange of technical information and intensive discussions were encouraged citing the incidents from the operating NPPs and other facilities under AERB control, so that participants would gain from the experience of in-house expertise. To begin with, two courses were organised on 'Operational Reactor Physics' and 'Reactor Kinetics' during February 2006 and March 2006. The participants from various Divisions found the courses extremely useful to their role as regulators.

11.4 NTC COURSE AT NTC, KOTA

AERB nominated five engineers from different Divisions to undergo the Training Programme of Nuclear Training Centre (NTC) along with the 14th batch of NPC Engineering Trainees at Kota. Under NTC Training, the Foundation Courses in Nuclear Reactor Technology, Core Courses on Nuclear Reactor Systems and On-Job Field Training in an Operating Reactor would be implemented. This training course provides the new engineers with adequate background and skill to carry out their regulatory assignments in AERB.

11.5 CONTINUED EDUCATION PROGRAMME COURSE AT BARC

Five scientific officers from AERB attended the courses conducted by Human Resource Development Division of BARC under the Continued Education Programme on the topics "Seismic Design of Nuclear Reactors and Facilities", "Preparedness and Response to Nuclear Emergencies" and "Programming Languages" during May 2005 to July 2005.

11.6 MEMORANDUM OF UNDERSTANDING BETWEEN AERB AND IIT-MADRAS

A Memorandum of Understanding (MOU) between AERB, Mumbai and IIT Madras, Chennai was signed to establish an AERB Graduate Fellowship Scheme (AGFS) in

various engineering disciplines. A similar MoU is already in operation with IIT Bombay, Mumbai for the last few years. One each from IIT Madras, Chennai and IIT Bombay, Mumbai was sponsored for M. Tech. Currently these students are undergoing the Courses in the respective institutes.

11.7 QUALIFICATION IMPROVEMENT AND TRAINING

AERB Staff is encouraged to acquire higher educational qualification. During the year, one officer from SRI was awarded Ph.D. Degree by the Department of Statistics, Anna University, Chennai. His Ph.D thesis is on 'New Approaches in Reliability Analysis of Nuclear Reactor Safety Systems'. One officer from CSED completed M. Tech in Structural Engineering from Kerala University.

Three officers from RSD, one from ITSD are registered for Ph. D Degree with University of Mumbai; one officer from SRI is registered for M. Tech with IIT Madras, Chennai.

One officer from SRI is on Deputation in Japan under the fellowship of Japan Society for Promotion of Science since November 2005. He is working in Simulation of Radionuclide Migration through Bentonite-sand Backfill in a Geometrical Centrifuge. One of the officers of RSD completed Post Doctoral Fellowship in the University of Nebraska Medical Centre, Omaha, USA during the period January 2004 to December 2005.

One officer from SADD is in the University of Pisa, Italy since January 2006. He is working on Uncertainty Analysis of Thermal Hydraulic Safety Studies with Prof. D' Auria. Two officers, one from SADD and the other from OPSD are deputed to USNRC, Washington for one year with effect from July 2006 and will be working on Nuclear Reactor Regulation, in the Probabilistic Risk Assessment (PRA) licensing branch and Nuclear Regulatory Research in PRA support branch.

11.8 PARTICIPATION IN TRAINING COURSES/ WORKSHOPS

AERB staff is encouraged to participate in training courses and workshops of relevance to AERB. Some of the courses/workshops in which the staff from AERB participated are:

- Environmental Legislation and Management.
- Occupational Health and Safety Management System based on Requirements of OHSAS (ISO 18001).
- Radiation and Environmental Safety in Uranium Mining.
- Regional Training Course of Regulators on Authorisation and Inspection of Cyclotron Facilities.
- Radioisotopes and Radiation Technology- Users Perception and Experience.
- Residual Training Course on Physical Protection of Nuclear Installations.
- Probability Methods in Earthquake Engineering.
- Mathematical Modelling in Hydrogeology: Numerical Simulation of Groundwater Flow and Solute Transport.
- Preparedness and Handling of Nuclear Emergencies.

In many of the courses, AERB staff delivered invited lectures and also served as faculty members.

11.9 AERB EXPANSION PROJECT

Construction of AERB Annex building adjacent to existing Niyamak Bhavan started in Dec 2004 as part of 10th plan "AERB expansion project" is nearing completion.

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 to evaluate, 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 28 such seminars, etc., was provided during the year.

The CSRP met thrice during the year and deliberated on the new project proposals, renewal of on-going research projects and grants for seminars. A total of 20 new project proposals were reviewed during the meetings. The committee deliberated on the proposals along with the comments/views/ suggestions from the relevant referees and experts. The committee approved the following nine proposals.

Sr. No.	Project No.	Project Title	Principal Investigator / Organization
1.	31/07	Soil-Structure Interaction Problem for Earth Retaining Structures under Seismic Condition	Dr. Deepankar Choudhury IIT-Bombay, Mumbai
2.	31/08	Microbiologically Induced Calcite Precipitation Mortar and Concrete under Indian Conditions	Dr. Abhijit Mukherjee IIT-Bombay, Mumbai
3.	31/12	Simulation of Spontaneous Crack Growth and Arrest in Rate-dependent Structural Steels used in Nuclear Containment Vessels and Steam Pipelines	Dr. D. V. Kubair IISc, Bangalore
4.	32/03	Study of Mean Glandular Dose During Diagnostic Mammography and the Evaluation of the Factors affecting it in Indian Context	Dr. S. P. Mishra Kamala Nehru Memorial Hospital, Allahabad
5.	33/02	Prediction of Oceanic Dispersion of Radionuclides Released from MAPS into the Coastal Waters of Kalpakkam	Dr. Usha Natesan Anna University, Chennai
6.	33/04	Remote Sensing and GIS Applications in Emergency Preparedness Plan and Radiological Impact Analysis for NPPs	Dr. Ajai FLPG, ISRO, Ahmedabad
7.	34/01	Evaluation of Radiation Doses from CT Scanners- A Survey	Roshan S. Livingstone CMCH, Vellore
8.	34/02	Development of Optical CT-Gel Dosimetry	Dr. E.James Jabaseelan Samuel, VIT, Vellore
9.	34/06	Centrifuge Model Studies on Integrity of Compacted Soil Barriers in Near Surface Disposal Facilities for Radioactive Wastes	Dr. B.V. S. Viswanadham, IIT-Bombay, Mumbai

The committee reviewed the progress of the 10 on-going research projects and approved their renewal.

The principal investigators of the following on-going projects made presentations before the committee to bring out the progress made, results obtained from experiments carried out and future plan on the work.

Sr. No.	Project No.	Project Title	P. I. & Organisation
1.	31/06	Investigation & Modeling of the Instability Mechanisms involved in Core Melt Jet Fragmentation in a Severe Accident Scenario	Dr. Balachandra Puranik IIT-Bombay, Mumbai
2.	24/08	Integrated Studies on Radionuclide Migration at Shallow Land Disposal Facility	Dr. D. N. Singh IIT-Bombay, Mumbai
3.	31/13	Phytoextraction of Caesium-137 from Contaminated Soil	Dr. S. Meena TNAU, Coimbatore
4.	26/01	Validation on the Measurement of Translocation Frequency for Cumulative Dose Estimation	Dr. P. Venkatachalam SRMC, Chennai

12.2 INDUSTRIAL SAFETY STATISTICS OF DAE UNITS

A total of 127 injuries including 13 fatal accidents have taken place due to accidents in the DAE Units, causing loss of 69501 mandays. The overall Frequency Rate (F.R.) i.e., number of lost time injuries per million man-hours worked), Severity Rate (S.R) i.e., the number of man-days lost per million man-hours worked and Injury Index (I.I) i.e., product of Frequency Rate & Severity Rate divided by thousand for the DAE Units are: 0.739, 404.633 and 0.299 respectively. The higher severity rate compared to previous years is due to the fatalities at project sites.

The analysis shows that maximum number of injuries and loss of mandays occur due to equipments such as pressurised piping, gas cylinders, vacuum vessels, rotating machines, electric and hand tools, and scaffolding and 'Moving Equipment' like cranes, lifting machines, pulley blocks, tractors, trucks and mechanical conveyors. More than 50 % of the injuries and 70 % of the mandays loss including 8 fatal injuries are due to 'Fall of Person' or 'Fall of an Object'.

The Human Factor Analysis of accidents shows that working with Equipment/ 'Moving Equipment taking unsafe position/ posture had caused 18 injuries with 5 fatal injuries. It also brings into light that unsafe action, i.e., 'Taking Unsafe Positions' /Posture' is mainly due to prevailing unsafe conditions and Improper Arrangement/ Procedure.

The Frequency Rate and Severity Rate of DAE Units are given in Figures 12.1 and 12.2. The Frequency Rate and Severity Rate of DAE Units are compared with other industries in Fig. 12.3. Trend of reportable injuries in DAE Units during the period 1999 to 2005 is shown in figure 12.4.

Heavy Water Plants, Nuclear Power Plants and plants of Indian Rare Earths Ltd. had less number of injuries compared to earlier years resulting in lower Frequency Rate and Severity Rate.

The frequency rates of IGCAR and NFC are consistently above 1 and are slightly higher compared to Frequency Rate of overall DAE Units whereas the Severity Rate value is low for IGCAR. R&D Units have a trend of low Frequency and Severity Rate.

Fig. 12.1: Frequency Rate of DAE Units

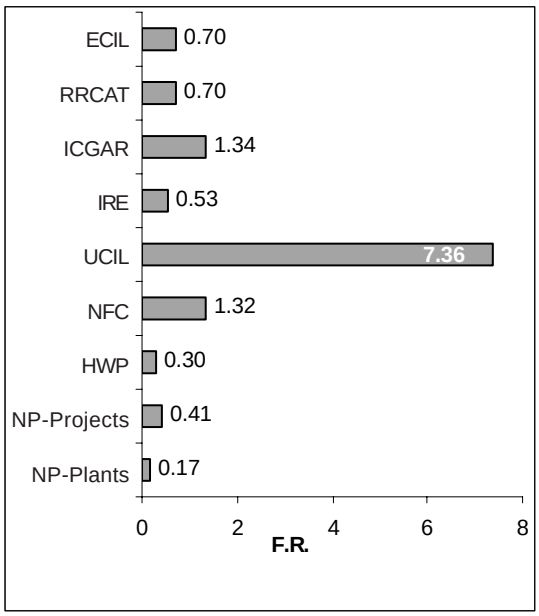


Fig.12.2: Severity Rate of DAE Units

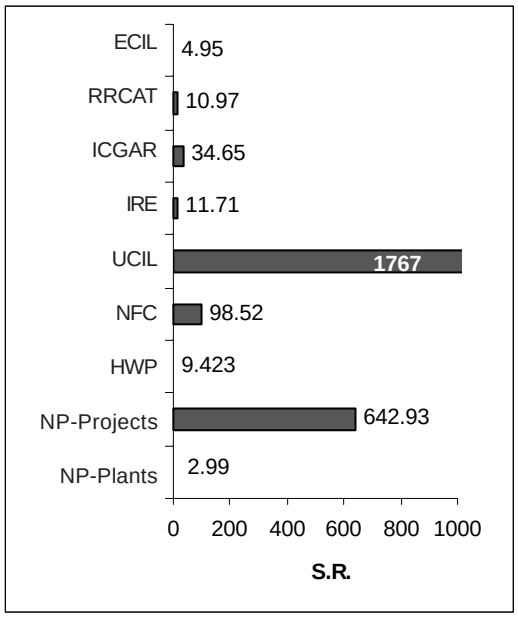


Fig. 12.3: Comparison of Frequency Rate & Incidence Rate of DAE Units with other Industries

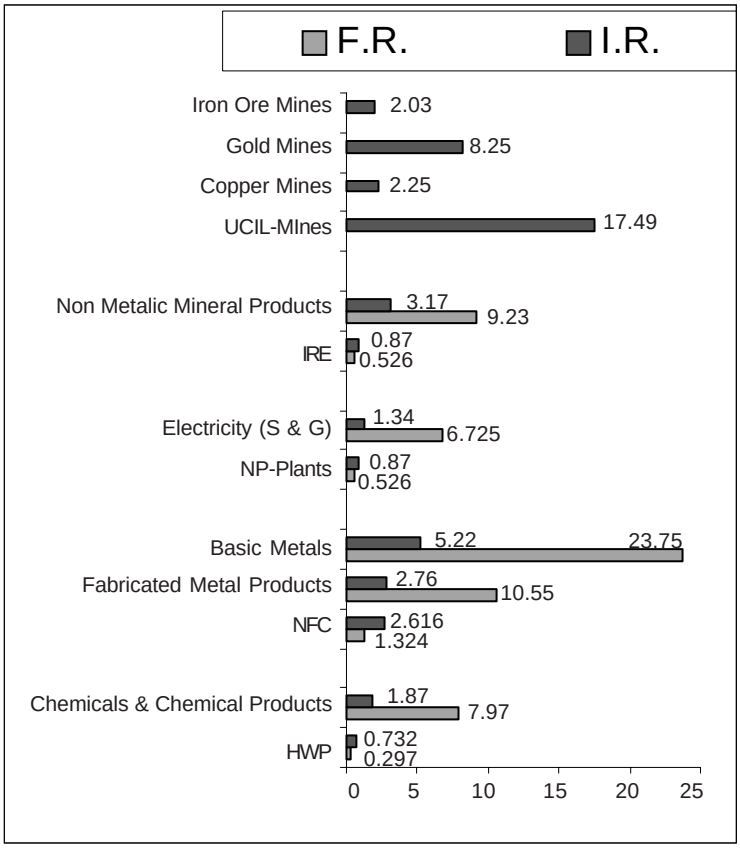
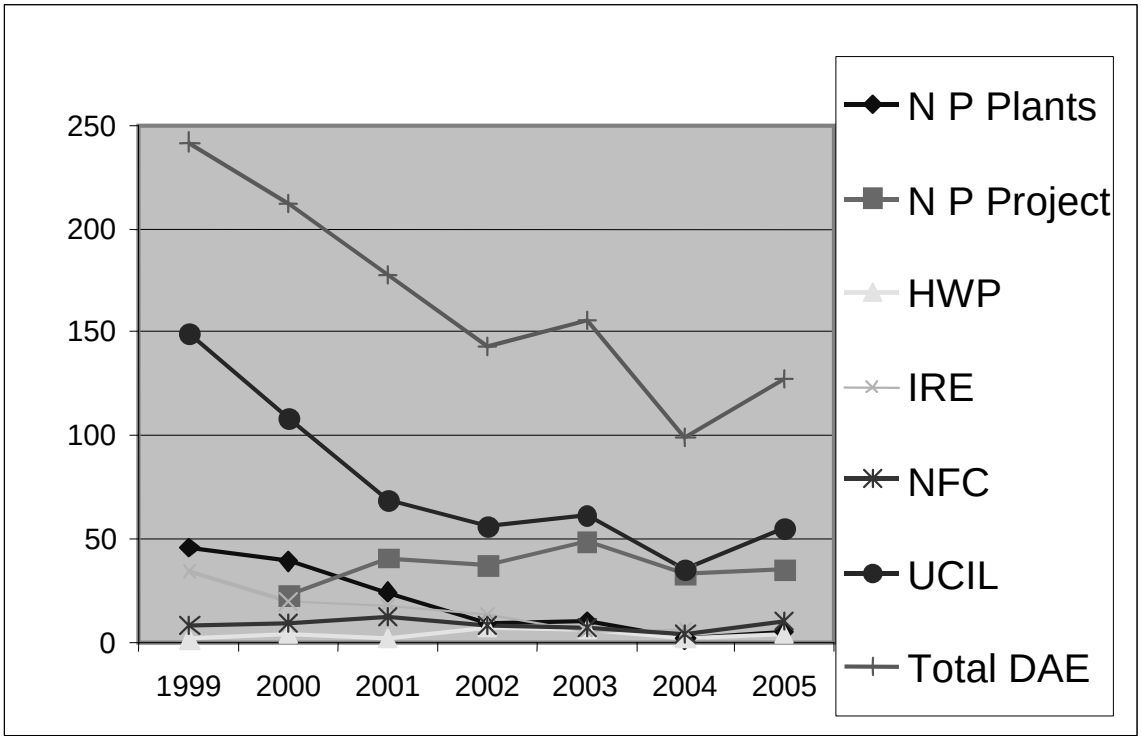


Fig. 12.4 : Trend of Reportable Injuries in DEA units



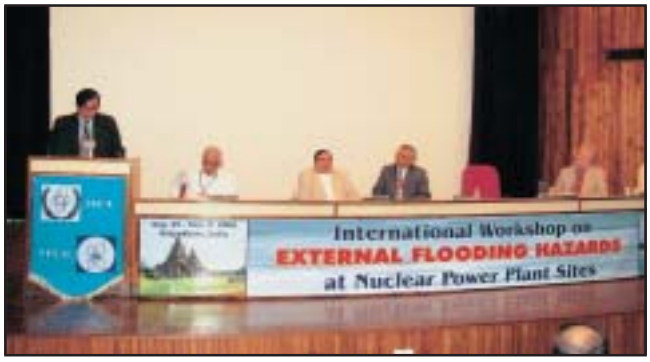
12.3 WORKSHOPS/SEMINARS PROGRAMME

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

12.3.1 International Workshop on External Flooding Hazards at NPP Sites

International Atomic Energy Agency (IAEA) organised jointly with AERB and NPCIL an "International Workshop on External Flooding Hazards at NPP sites". The workshop was held as an experts' meeting in the field of safety of NPP against external flooding with emphasis on tsunami. The workshop was held at Kalpakkam during 29th Aug. to 2nd Sept-2005.

The main objectives of the workshop were to share experience from the regulatory, designer, utility and academic points of view of hazard assessment, the design of protective measures, monitoring and warning aspects in relation to the external flooding, compilation and sharing of good practices and lessons learned and to identify further work in this vital area. A total of 81 experts participated in the workshop, of which 44 were from India, 4 from UN/IAEA and 32 from fifteen other member states of IAEA.



Chairman, AERB addressing the delegates at the International Workshop on External Flooding Hazards at NPP sites, SRI, Kalpakkam 29 Aug-2 Sep 2005. Seating on the dais (L to R): Shri S. A. Bhardwaj, Director(T), NPCIL, Shri S. K. Jain, CMD, NPCIL, Shri Anil Kakodkar, Chairman, AEC, Dr. Brockman, IAEA

The technical sessions covered different fields like experiences and case studies on external flooding hazards, current methodologies and techniques for tsunami flooding hazards, warning systems and emergency planning and preparedness, and regulatory requirements in member states. The workshop brought out the necessity of conducting periodic review of external flood hazards in view of recent events, need for revision of existing safety guides on external flooding hazard and development of a unified procedure on tsunami hazard evaluation.

12.3.2 Workshop on Issues Related to Design, Construction, Operation and Maintenance of Spent Fuel Storage Pools

The DAE Units dealing with the spent fuel storage and handling facilities faced many challenges pertaining to Design, Construction, Operation and Maintenance (O&M) of these facilities and have successfully resolved these issues. However, it was felt that at times, issues solved in one facility recurred in other facilities. Though guidelines developed for Design and O&M over the years are being followed as a practice, there is no formal code or guide available exclusively for this type of facilities.

Therefore, AERB organised a workshop on 25th November 2005 in AERB with the objective to arrive at recommendations for optimized standard designs of Spent Fuel Storage Pools as well as improvements in existing pools, where feasible. Officers from different DAE Units, design consultants, contractors, representatives from AERB including members of its safety review committees participated in the workshop. A total of eight presentations were made in two technical sessions followed by a panel discussion on the identified issues.

After detailed deliberations it was concluded that concrete tank-in-tank design with provision for liner and for partitioning of the pool when required, may be adopted as a standard design for Spent Fuel Storage Pools. Some of the important points that emerged during the discussions include the following.

- Construction of the pool should take advantage of achieving higher grades of concrete and the use of higher strength reinforcing steel available now in the Indian market.
- Design of air conditioning and ventilation should ensure operator comfort in addition to control of air contamination.
- AERB safety documents on the subject should address aspects like borewell monitoring, leak detection, deployment of single failure proof cranes and security concerns.

12.3.3 Workshop on Experiences In Implementation of Fire Safety Measures In Operating Plants

Workshop on "Experiences in Implementation of Fire Safety Measures in Operating Plants" was organised at AERB on April 13-14, 2005 to commemorate Fire Safety Day. About 42 participants comprising of CFO, Deputy-CFO, Fire Protection Engineers, Station Officer, Sub-Officers, Head (IS&F) and Safety officers from various Units of DAE, viz., NPCIL, HWP, IREL, UCIL, NFC, BRIT, VECC, ECIL and officers of AERB participated in the workshop. Participants found the fire safety audit checklist comprehensive and very useful.

12.3.4 DAE Safety and Occupational Health Professionals Meet

The 22nd DAE Safety and Occupational Health Professional Meet was held at HWP, Manuguru during Nov 21 –23, 2005 and organised jointly by HWP, Manuguru and AERB, Mumbai. The theme of the meet was "Process Safety Management". Chairman, AEC and Secretary, DAE inaugurated the meet and presented AERB's Green Site Award to IREL-OSCOM. Chairman, AERB presided over the function and addressed the gathering. A endowment lecture on Chemical Process Safety, by Former Chairman & Managing Director, Indian Rare Earths Ltd followed by two plenary sessions and two parallel sessions comprising lectures on "Injury Statistics" and "Occupational Health Statistics", "Fatal Accident Cases during the Past Year" and a Poster Session on "Innovative Measures taken to make Unsafe Jobs/ Conditions / Act safe" and "Near Miss Incidences-Case studies" were conducted. A parallel session on "Innovative Measures adopted for Fire Safety" and Papers on "Occupational Health Studies" was held by medical officers. There was a plenary session on "How the Effectiveness of Imparting Safety Training is improved at various DAE Units". A feedback on "Modified Industrial Safety, Fire Safety and Green Site Awards" was discussed.

12.3.5 Establishment of Directorate of Radiation Safety in the States

A workshop on "Establishment of Directorate of Radiation Safety (DRS) in the States" was held at AERB on 11th July 2005 to apprise the State Governments on the need of DRS in each State, its proposed structure, method of functioning of DRS and their co-ordination with AERB. The workshop was well attended and 26 participants from 20 states took part in the workshop. North Eastern states were very well represented in the workshop. It is noted that 11 States have come forward to form DRS.

12.3.6 Radiological Safety in Industries manufacturing Consumer Products incorporating Thorium Compounds

A workshop on "Radiological Safety in Industries Manufacturing Consumer Products incorporating Thorium

Compounds" was conducted by AERB on July 14, 2005. Twenty-six participants from the Gas mantle manufacturing Industry and Lamp starter Industry took part in the workshop. The main objective of the workshop was to familiarise the participants from the industry using thorium nitrate on current radiation safety and regulation requirements and to explain the role and responsibilities of manufacturers in implementation of appropriate radiation protection programme.

12.3.7 Discussion Meet on Low Level and Near Miss Events

Nuclear industry is striving to collect more and more information on occurrences, which can reveal latent weaknesses in order to improve operational safety performance. In India too, the need has been felt to have a system for detection of latent weaknesses in work practices or plant conditions, which may remain, undetected in view of the improved performance of the NPPs. Individually these weaknesses may appear to be insignificant and unconnected, however when viewed together they can reveal certain features, common patterns and trends that can lead to more significant events. Detection and correction of such weaknesses contribute to enhancing safety. This can be achieved by establishing a system for reporting and analysis of Low Level and Near Miss Events. These have potential to be instructive if reported and investigated in a timely and systematic manner.

In order to start a systematic program for collection and analysis of low level and near miss events in all NPPs in India, AERB's Safety Research Institute (SRI), Kalpakkam in association with Institution of Engineers, Kalpakkam organised a two-day discussion meet on 19th and 20th December 2005. Senior officers from NPPs, NPCIL Headquarters, Heavy Water Board (HWB), FBTR and AERB attended the meet. The discussion meet was inaugurated by Shri S. K. Chande, Vice Chairman, AERB. The discussion meet emphasised the need for lowering reporting threshold from events to anomalies within the plant, establishing a blame free culture and encouraging open communication between management and plant staff, which will help identify the problems early and in taking timely corrective actions. Recommendations were made on various elements of the system for low level and near miss events.

12.4 AERB COLLOQUIA

In an effort to keep pace with the growing nuclear technology and updating with the latest developments in the regulatory and safety activities, AERB Colloquia were organised at regular intervals. During the year the following colloquia were organised.

- "Tsunami and its Associated Hazards" by Dr. P.C. Basu, AERB on 28th April 2005.
- "Advances in Seismic Design and Requalification of Nuclear Facilities using Passive Control Devices" by Dr. G. R. Reddy, BARC on 30th September 2005.
- "Overview of AECL Safety Research" by Andrew White, AECL on 2nd February 2006.
- "IAEA Activities in the Area of Accident Analysis and Accident Management" by Sukho Lee, IAEA on 2nd February 2006.
- "Main Elements of CANDU Seismic & Fire practices in Canada" by R. Jaitley, AECL on 2nd February 2006.
- "Overview of Severe Accident Research in KAERI" by Young Ho Jin, KAERI, Republic of Korea on 2nd February 2006.
- "Making an Effective Presentation" by Prof. S.P. Sukhatme, Former Chairman, AERB on 7th February 2006.
- "Severe Accident Issues in CANDU Reactors" by Dr. Sunil Nijhawan, Consultant, AECL, Canada on 21st February 2006.

12.5 INDUSTRIAL SAFETY AWARDS

Chairman, AERB had constituted a committee to review the present evaluating procedure followed in deciding the AERB's Industrial Safety Award taking into account the overall industrial safety status of the Units. The committee worked out a new format based on **STEP** approach i.e. S - Safety **S**tatistics based on Injury Index, T- Safety **T**raining, E- **E**fforts for Improvements for Safety and P- Safety **P**romotional Activities. The Safety Number will be sum of marks scored in Safety Statistics (40 marks), Safety Training (30 marks), Efforts for improvements in safety (20 marks) and Safety Promotional Activities (10 marks). The Industrial Safety Awards were decided based on the above revised evaluation procedure.

The annual Industrial Safety Awards function of AERB was held in March 2006. Shri K.C.Gupta, Director General, National Safety Council presented the Safety Awards for 2005 to Kaiga Generating Station -1&2, Heavy Water Plant, Thal and Indian Rare Earths Ltd., OSCOM (Thorium Plant) for attaining high levels of Industrial Safety. On this occasion a compilation entitled "Industrial Safety Statistics-2005 of the Department of Atomic Energy Units" was also released.

12.6 FIRE SAFETY AWARD

The Fire Safety Award and Green Site Awards evaluation procedures were reviewed and following significant changes in Fire Safety Award evaluation procedure were made. i) Fire Hazard Index (FHI) will be calculated as summation of product of number of fire incidents and a factor based on classification of fire to give more weightage to fire incidents. ii) DAE Units were categorised based on fire potential and accordingly two awards will be given from each category. iii) Award will not be given in case a fire has taken place in the identified critical process area of the plant. The award is based on the highest value of Preventive Efforts and Fire Hazard Index (PEFHI) score amongst all the DAE Units. Based on the new format and computational procedure, Heavy Water Plant, Manuguru and Tarapur Atomic Power Station 1&2 jointly in Category –1 and Tarapur Atomic Power Project 3&4 in Category-II have been selected as the winners for the year 2005. The award function was followed by a discussion among participants from NPCIL, HWB, NFC, IREL, UCIL, IGCAR, BHAVINI and RRCAT on "Revised draft of AERB's Standard for Fire Protection Systems on Nuclear Facilities".

12.7 GREEN SITE AWARD

The evaluation procedure for Green Site Award has been revised and would be given from two categories, which was done based on total area of the plant including housing colony site. The Green Site Award for the year 2005 was awarded to IREL-OSCOM in category 'A' and KAPS-1&2 in category 'B'.

12.8 BEACH SAND MINERALS INDUSTRIES

Consequent to the conference organised by DAE in January 2005 to review the Beach Sand Policy of 1998 wherein it was proposed to delist ilmenite, rutile, and zircon from the list of 'prescribed substances', a committee was constituted by Chairman AERB in January 2005. The committee was to examine the radiological issues involved in mining and processing of beach sand minerals and to assess the radiological status in the major private sector facilities. The committee met several times and visited some operating units engaged in mining and mineral separation to obtain first hand information on their radiation status. The committee's recommendations on radiological issues involved in the Mining and Milling of Beach sand Minerals have been reviewed by the Board of AERB and forwarded to DAE. Some of the major recommendations of the committee were:

- Mining, separation and processing of beach sand minerals need to be assessed for radiation exposure - both occupational and public in the operational and post operational period.
- License shall be obtained under the Atomic Energy (Radiation Protection) Rules, 2004 from AERB. Mining lease/industrial license shall be issued by Issuing Authority after ensuring this.
- Authorisation under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 should be obtained if stipulated by AERB.
- The tailings/rejects/process wastes disposal shall be as per the guidelines provided by AERB.

AERB carries out regulatory inspection and periodic safety review of the beach sand industries pertaining to radiological safety.

12.9 SUPPORTIVE WORK FOR BUREAU OF INDIAN STANDARDS SAFETY DOCUMENTS

Codes of Safety for certain chemicals namely Chloroform, Hydrogen Peroxide, Acetylene, Ammonia, Vinyl Chloride were reviewed and comments were sent for amendments in the respective BIS (Bureau of Indian Standards) documents.

12.10 REVIEW OF IAEA SAFETY DOCUMENTS

Following draft safety documents of IAEA were received by AERB. The review by DAE Units and AERB was arranged and comments obtained were communicated to DAE for transmission to IAEA.

1. Safety of Radiation Generators and Sealed Radioactive Sources (DS114).
2. Management Systems for Technical Services in Radiation Safety (DS315).
3. Management Systems for Safe Transport of Radioactive Material (DS326).
4. Guidelines for Monitoring of Radioactive Material in International Mail Transported by Public Postal Operations.
5. Technical / Functional Specifications for Border Radiation Monitoring Requirements.
6. Nuclear Forensics Support.
7. Radiation Protection Programme for Transport of Radioactive Material (DS377).

CHAPTER 13
OFFICIAL LANGUAGE IMPLEMENTATION

In the year 2005-06 the Official Language Implementation Committee (OLIC), AERB continued its efforts to ensure effective implementation of the Official Language Policies and enhance the use of Hindi in AERB. The progress of implementation was reviewed by the Executive Committee on a regular basis.

Four Hindi Workshops were organised to train the employees on how to make notings, correspondence etc., in Hindi, jointly with other Units in Mumbai (DPS, DCS&EM and HWB). 13 employees from AERB attended the workshops.

During the year, a One-day Workshop was organised jointly with IREL in Hindi on "Radiological Safety in Use of Thorium Compounds for Manufacturing Gas Mantle Industry" by AERB. Representatives of the concerned industries from various states participated in the workshop. Dr. B.N. Patra, General Manager, IREL delivered a talk on "Processing and Prospects of Thorium Utilisation in India". Papers titled "Regulatory Requirement for Manufacture of Consumer Products incorporating Radioactive Material" by Shri. S. P. Agarwal and "Radiation Safety in Gas Mantle Manufacturing Industry" by Shri. K.C. Upadhyay were presented in the workshop.

Two scientific papers "Nabhikiya Urja Sanraksha Mein Niyamakta Ka Mahatva" by Dr. Om Pal Singh and "Bharat Mein Urja Ki Sambhavanayein" by Shri K. Srivasista were presented in a 2-day scientific conference of Hindi Vigyan Sahitya Parishad held in Shilong, February 23-24, 2006.

Hindi training classes were conducted in AERB through Hindi Teaching Scheme, Ministry of Home Affairs, Govt. of India, and 19 officers/staff members were imparted training for pragya/praveen examinations. One LDC passed Hindi-typing examination through correspondence course. Hindi stenography training classes commenced in February 2006.

A total of 48 Hindi books on various subjects were purchased for the AERB library. In addition 17 English-Hindi dictionaries were also purchased for use in Hindi Section and Divisions of AERB. Out of the 115 safety codes/guides, manuals and standards issued by AERB, 24 have been translated in Hindi. A total of 15 AERB documents were translated and printed in Hindi during this year. The translation work of 34 other AERB documents was completed in this year and their publication is being taken up.

To propagate the use of Hindi by the officers and staff in AERB, eleven competitions in Hindi such as story writing, shabda gyan, quiz, Hindi typing, noting, drafting, translation of scientific and technical terms, debate, essay, slogans, crossword puzzle, elocution, etc. were organized within AERB during the year.

Inaugural Function of Hindi Workshop on "Radiological Safety in Use of Thorium Compounds for Manufacturing Gas Mantle Industry" (Sitting from L to R : Shri G. M. Nair, DAE, Shri S. P. Agarwal, AERB, Shri K. C. Upadhyay, AERB, Dr. B. N. Patra, General Manager, IREL)

Officers and staff from AERB participated and won prizes in Hindi programmes organised by the Joint Official Language Co-ordination Committee for the DAE Units in Mumbai. A joint Hindi Day and prize distribution programme was conducted on 14 September 2005 at Multipurpose Hall of BARC Training School Hostel. The greeting messages received from the Hon'ble Home Minister Shri Shivraj Patil and also Dr. Anil Kakodkar, Secretary, DAE and Chairman, Atomic Energy Commission were read out on the occasion. A separate function was organised in AERB on September 19, 2005 for distribution of prizes to winners of various competitions conducted for AERB employees. The In-house magazine "NIYAMIKA" (combined edition 3 & 4) was released on this occasion by Shri S.K. Sharma, Chairman, AERB. A cultural programme was also organised on this occasion in which many of the employees participated.

Regarding use of Hindi with computers for official work, ISM-Office 2000 Hindi Software is now loaded on all the computers in AERB. In addition to this, Akruti Hindi Software is made available on 10 computers, which are mainly used for typing of codes, guides, manuals and such other documents in Hindi.

Annual Report, AERB Newsletter and general Brochures on AERB have been published in Hindi and English and circulated to DAE Units and various other organisations of Government of India, press media and Radiation Safety Officers. Press Releases were also issued in Hindi.

In Administration Division of AERB, service books are maintained in Hindi only. Majority of the noting/drafting in the files are also carried out in Hindi. All documents that come under the Official Language Act 343, Section 3(3) are issued bilingually. The Incentive Scheme for promoting the use of Hindi in official work is implemented and seven officials participated in these schemes.

Chairman and Member-Secretary of OLIC, AERB participated in the 8th All India DAE, OL Conference conducted at Tarapur Atomic Power Station, Tarapur, Maharashtra in November 2005.

APPENDIX

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ANNEXURE
LIST OF ABBREVIATIONS

ACCGASO	:	Advisory Committee for Codes, Guides & Manuals for Safety in Operation of NPPs
ACCGD	:	Advisory Committee for Codes, Guides & Manuals for Safety in Design of NPPs
ACCGORN	:	Advisory Committee for Codes, Guides and Manuals on Governmental Organisation
ACCGQA	:	Advisory Committee for Codes, Guides & Manuals for Safety in Quality Assurance of NPPs
ACI&FS	:	Advisory Committee on Industrial & Fire Safety
ACRDCSE	:	Advisory Committee for Regulatory Documents on Safety in Civil and Structural Engineering
ACRDS	:	Advisory Committee for Regulatory Documents on Safety in Nuclear Power Plant Siting
ACRS	:	Advisory Committee on Radiation Safety
ACNS	:	Advisory Committee on Nuclear Safety
ACOH	:	Advisory Committee on Occupational Health
ACPSR	:	Advisory Committee for Project Safety Review
ACPSR-FCF	:	Advisory Committee for Project Safety Review for Fuel Cycle Facilities
ADS	:	Accelerator Driven System
AFR	:	Away From Reactor
AGFS	:	AERB Graduate Fellowship Scheme
AGS	:	Annulus Gas System
AHX	:	Air Heat Exchanger
AHWR	:	Advanced Heavy Water Reactor
ALARA	:	As Low As Reasonably Achievable
AMD	:	Atomic Minerals Division
AOO	:	Anticipated Operational Occurrence
ARA	:	Application for Renewal of Authorisation
ARPF	:	Agricultural Radiation Processing Facility
ASDV	:	Atmospheric Steam Discharge Valve
ASME	:	American Society of Mechanical Engineers
BARC	:	Bhabha Atomic Research Centre
BDBA	:	Beyond Design Basis Accident
BDE	:	Backward Difference Formula
BHAVINI	:	Bhartiya Nabhkiya Vidyut Nigam
BRIT	:	Board of Radiation and Isotope Technology
BSA	:	Blanket Sub Assembly
CA	:	Chromosome Aberration
CB	:	Control Building
CCF	:	Common Cause Failure
CCWP	:	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
COIS	:	Computer based Operator Information System
CRD	:	Control Rod Drive
CSDV	:	Condenser Steam Dump Valves
CSIR	:	Council for Scientific and Industrial Research
CSRP	:	Committee for Safety Research Programmes
CT	:	Computed Tomography
CT	:	Coolant Tube
CV	:	Calandria Vault
CWMF	:	Central Waste Management Facility
DAE	:	Department of Atomic Energy
DBA	:	Design Basis Accident
DBR	:	Design Basis Report
DBE	:	Design Basis Events
DBFL	:	Design Basis Flood Load
DCR	:	Design Concession Request
DEM	:	Digital Elevation Model
DFRP	:	Demonstration Fast Reactor Fuel Reprocessing Plant
DGSNR	:	Directorate General for Nuclear Safety and Radiation Protection
DHDP	:	Decay Heat Drain Pump
DHX	:	Decay Heat Exchanger
DM	:	Drive Mechanisms
DNBR	:	Departure from Nucleate Boiling Ratio
DRDO	:	Defence Research and Development Organisation
EB	:	Electrical Buildings
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
ELCB : Earth Leak Circuit Breaker
EMCCR : En-Masse Coolant Channel Replacement
ERS : Event Reporting System
ESL : Environmental Survey Laboratory
FA : Fuel Assembly
FB : Fuel Building
FBR : Fast Breeder Reactor
FBTR : Fast Breeder Test Reactor
FEA : Finite Element Analysis
FFW : Fire Fighting Water
FMEA : Failure Mode Effect Analysis
FP : Full Power
F.R : Frequency Rate
FRERP : Fast Breeder Fuel Processing Plant
FRTG : Fast Reactor Technology group
GAN : GOSATOMNADZOR
GDWP : Gravity Driven Water Pool
GIS : Geographic Information System
HWB : Heavy Water Board
HWP : Heavy Water Plant
HFU : Horizontal Flux Units
HOY : Hot Operating Years
IAEA : International Atomic Energy Agency
I &C : Instrumentation & Control
ICRP : International Commission on Radiological Protection
ICS : Inner Containment Structure
IFSB : Interim Fuel sub-assembly Storage Building
IFTM : Inclined Fuel Transfer Machine
IGCAR : Indira Gandhi Centre for Atomic Research
INES : International Nuclear Event Scale
IREL : Indian Rare Earths Limited
IRLL : Irrational Low Limit
IRMRA : Indian Rubber Manufacturers Research Association
IRPF : Industrial Radiation Processing Facility
IRS : Incident Reporting System
ISI : In-Service Inspection
ISRO : Indian Space Research Organisation
IV &V : Independent Verification & Validation
JHA : Job Hazard Analysis
KAPS : Kakrapar Atomic Power Station
KARP : Kalpakkam Reprocessing Plant
KGS : Kaiga Generating Station
KK-NPP : Kudankulam Nuclear Power Project
LBB : Leak Before Break
LCO : Limiting Condition for Operation
LCW : Low Conductivity Water
LMC : Lead Mini Cell
LOCA : Loss of Coolant Accident
LSSS : Limiting Safety System Settings
LTTM : Low Trajectory Turbine Missile
LWR : Light Water Reactor
LZCS : Liquid Zone Control System
MAPS : Madras Atomic Power Station
MCNP : Monte Carlo N-Particle
MoU : Memorandum of Understanding
MSL : Mean Sea Level
NAPS : Narora Atomic Power Station
NFC : Nuclear Fuel Complex
NICB : Nuclear Island Connected Building
NOC : No-Objection Certificate
NORM : Naturally Occurring Radioactive Material
NPCIL : Nuclear Power Corporation of India Limited
NPP : Nuclear Power Plant
NTC : Nuclear Training Centre
NUOFP : New Uranium Oxide Fabrication Plant
OBE : Operating Basis Earthquake
OGDHRS : Operational Grade Decay Heat Removal System
OLIC : Official Language Implementation Committee
O&M : Operation and Maintenance
OSCOM : Orissa Sand Complex
OSEE : Off-site Emergency Exercises
ONERS : On-Line Emergency Response System
PDSC : Project Design Safety Committee
PEE : Plant Emergency Exercises
PEFHI : Preventive Efforts and Fire Hazard Index
PFBR : Prototype Fast Breeder Reactor
PHT : Primary Heat Transport
PHWR : Pressurised Heavy Water Reactor
PIE : Post Irradiation Examination
PLDSC : Pre-Licensing Design Safety Committee
PSAR : Preliminary Safety Analysis Report
PSHA : Probabilistic Seismic Hazard Analysis
PSR : Periodic Safety Review
PSS : Primary Shutdown System
PT : Pressure Tube

PWR	:	Pressurised Water Reactor
QA	:	Quality Assurance
RAPP	:	Rajasthan Atomic Power Project
RAPPCOF	:	Rajasthan Atomic Power Project Cobalt Facility
RAPS	:	Rajasthan Atomic Power Station
RCB	:	Reactor Containment Building
RCL	:	Radio Chemistry laboratory
RI	:	Regulatory Inspection
RPAD	:	Radiological Physics & Advisory Division
RPN	:	Risk Priority Number
RPV	:	Reactor Pressure Vessel
RRCAT	:	Raja Ramanna Centre for Advanced Technology
RRS	:	Reactor Regulating System
RRSSC	:	Regional Remote Sensing Service Centre
RS	:	Remote Sensing
RSO	:	Radiological Safety Officer
RV	:	Reactor Vault
RWB	:	Radioactive Waste building
SAC	:	Space Application Centre
SARCAR	:	Safety Review Committee for Applications of Radiation
SARCOP	:	Safety Review Committee for Operating Plants
SAS	:	Site Assembly Shop
SC	:	Safety Committee
SC	:	Secondary Containment
SCHWOP	:	Safety Committee for Heavy Water Operating Plants
SCNORM	:	Safety Committee on Naturally Occurring Radioactive Material
SCR	:	Supplementary Control Room
SCRSD	:	Standing Committee on AERB's Radiation Safety Documents
SSC	:	Systems, Structures and Components
SCURF	:	Standing Committee for Investigation of Unusual Occurrences in Radiation Facilities
SDDP	:	Safety Document Development Proposal
SDS	:	Shutdown Systems
SEE	:	Site Emergency Exercise
SER	:	Significant Event Report
SFSB	:	Spent Fuel Storage Bay
SFTD	:	Spent Fuel Transfer Duct
SG	:	Steam Generator
SGB	:	Steam Generator Buildings
SGDHRS	:	Safety Grade Decay Heat Removal System
SGTF	:	Steam Generator Test Facility
SLHS	:	Small Leak Handling System
SPND	:	Self Powered Neutron Detector
SRI	:	Safety Research Institute
SS	:	Stainless Steel
SSE	:	Safe Shutdown Earthquake
SSP	:	Secondary Sodium Pump
S.R	:	Severity Rate
SSS	:	Secondary Shut down System
SSSB	:	Spent Subassembly Storage Bay
SSSF	:	Solid Storage Surveillance Facility
SV	:	Safety Vessel
SW	:	Steam Water
TAPS	:	Tarapur Atomic Power Station
TAPP	:	Tarapur Atomic Power Project
Type B (U)	:	Type B (Unilateral)
UCIL	:	Uranium Corporation of India Limited
VECC	:	Variable Energy Cyclotron Centre
VSP	:	Vapour Suppression Pool
VVER	:	Water Water Energy Reactor
USNRC	:	United States Nuclear Regulatory Commission
WIP	:	Waste Immobilisation Plant
ZCC	:	Zone Control Compartment
ZSP	:	Zirconium Sponge Plant

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