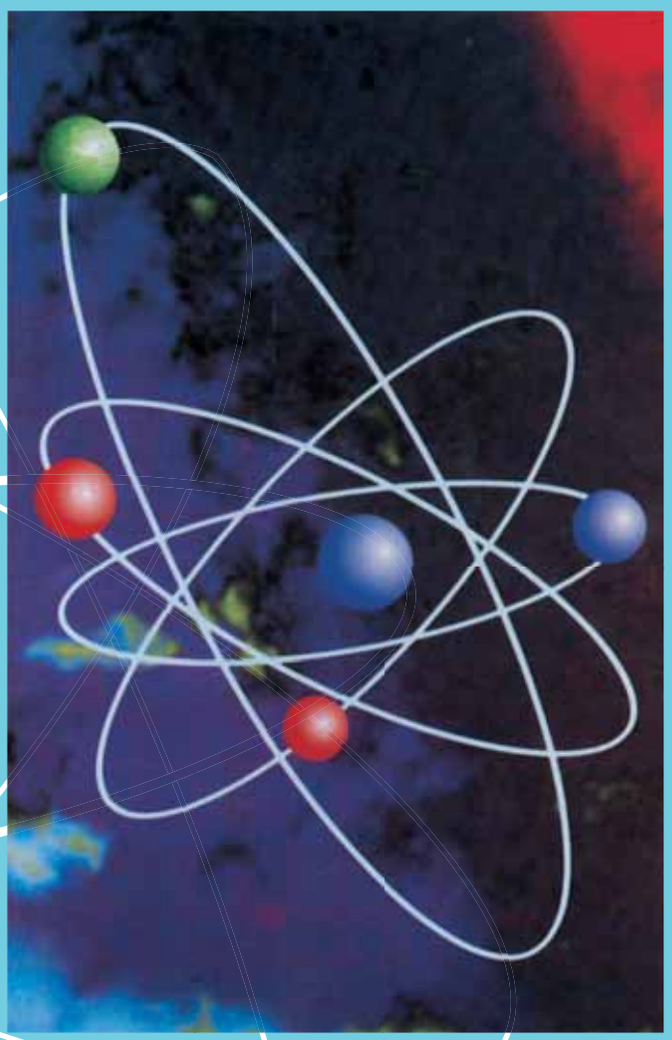
# Annual Report 2007-2008



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GOVERNMENT OF INDIA

ATOMIC ENERGY REGULATORY BOARD MUMBAI

# ATOMIC ENERGY REGULATORY BOARD

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

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

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

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

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

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


GOVERNMENT OF INDIA

# ANNUAL REPORT 2007-2008

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

## THE FUNCTIONS OF THE ATOMIC ENERGY REGULATORY BOARD

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

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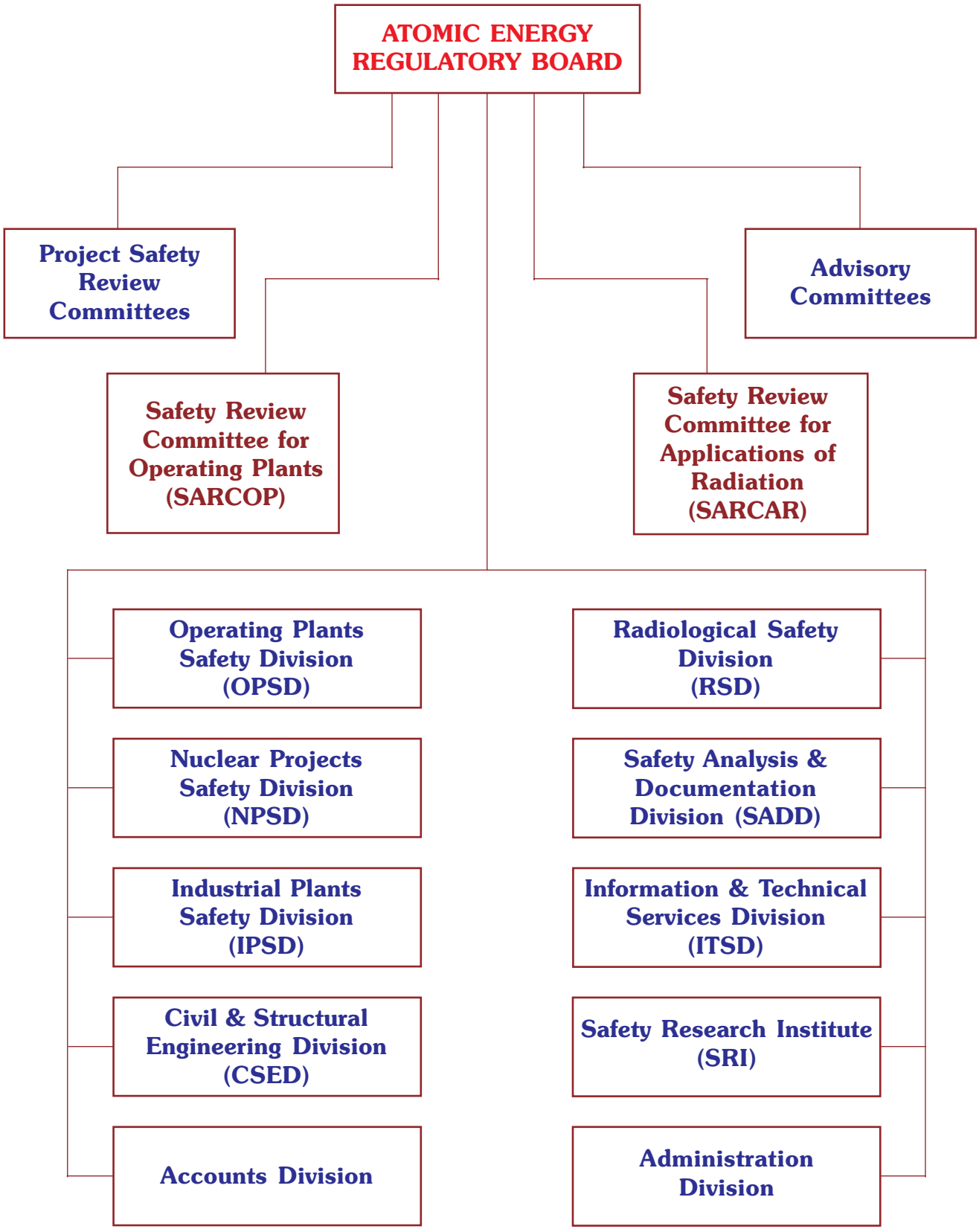
| 2. | Shri S.K. Chande, AERB<br>Chairman, SARCOP | … | Member (Ex-Officio) |
| 3. | Dr. K.V. Raghavan<br>Chairman,<br>Recruitment & Assessment Centre,<br>Defence Research & Development Organisation,<br>Ministry of Defence, Delhi | … | Member |
| 4. | Prof. J.B. Joshi<br>Professor and Director,<br>University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

## 1.2 ORGANISATION CHART OF AERB



## 1.3 SUMMARY

A large number of nuclear and radiation facilities in operation and projects under construction in India are under the regulatory purview of AERB. Presently, there are 17 nuclear power units in operation, 2 units under commissioning and 4 units under construction. The operating fuel cycle facilities and research centers are: 7 Heavy Water Plants, 4 Rare Earths Plants, 3 Research Facilities (Indira Gandhi Centre for Atomic Research (IGCAR), Raja Ramanna Centre for Advanced Technology (RRCAT) and Variable Energy Cyclotron Centre (VECC)), Nuclear Fuel complex (NFC), 5 Uranium Mines and 2 Uranium Mills. Zirconium Complex at Pazhayakayal, Uranium Mill at Tummalapalle and 2 plants for extraction of Uranium from secondary sources are under construction and 4 new Uranium Mines are in the development stage.

Two nuclear power plants, KAPP-3&4, each of 700 MWe Pressurized Heavy Water Reactors are planned to be located at Kakrapar and safety review towards issuing consent for the proposed site is nearing completion. Safety review for excavation consent is also in progress for this project. AERB carried out its functions with the support of its secretariat and specialist committees under the guidance of the Board. The Board met three times during the year: on 22nd June 2007 in Mumbai, on 15th October 2007 at Kaiga site and on 1st February 2008 in AERB, Mumbai. During the meeting at Kaiga, the members also visited the Nuclear Power Plants (NPPs) in operation and under construction at the site.

**Shri S.A. Bhardwaj, Director (Technical), NPCIL making a Presentation in Board Meeting at Kaiga**

### Silver Jubilee Year Celebration

As AERB was established on November 15, 1983, the one year period starting November 2007 is the silver jubilee year of AERB. To mark the beginning of the silver jubilee year, a function was organized on Nov. 23, 2007. Dr. Anil Kakodkar, Chairman, AEC was the Chief Guest. All the former Chairmen (except Dr. A. Gopalkrishnan) and former Vice Chairmen of AERB were present as Guests of Honour and spoke on the occasion. Apart from the addresses by the luminaries, the "AERB Code of Ethics" and a "Monograph on Probabilistic Safety Assessment" prepared by AERB staff were released on this occasion. Prof. A.K. De, the first Chairman of AERB, inaugurated the new AERB building, Niyamak Bhavan-B. Another monograph on 'Construction Safety' prepared by AERB staff was released during the 24th DAE Safety, Occupational & Health Professionals Meet held at Rawatbhata, Rajasthan Site during December 2007. A series of events is planned as part of silver jubilee year celebrations.

### India's Participation in the Convention on Nuclear Safety

India presented its national report on the safety of nuclear power plants to the Convention on Nuclear Safety (CNS) and participated in the 4th review meeting of CNS in Vienna in April 2008. The Indian delegation comprised of experts from AERB, NPCIL and BARC and was led by Shri S. K . Sharma, Chairman, AERB. There are 61 Contracting Parties to the Convention which include all the 30 countries which operate nuclear power plants. In the previous meeting held in 2005, the Indian delegation had participated as observer. The CNS is an incentive convention that seeks to maintain a high level of safety in nuclear powe plants world wide through exhaustive peer review process conducted every three years.

A total of 143 questions were raised on the Indian report, which was posted to CNS members before the meeting and detailed response of these were provided. In the review meeting, the national report was orally presented whereafter there was a discussion on the presentation. The contracting parties appreciated the effective regulatory review structure, the strong R & D support available for nuclear safety from BARC and IGGAR and the excellent safety status of nuclear power plants in India. They also commended the several good safety practices that are followed in India. Some areas identified for the future were 'Extended work on probabilistic safety analysis' and 'Development of severe accident management guidelines for nuclear power plants.'

### Safety Review of Nuclear Projects

For the nuclear power plants under construction/commissioning, authorization was issued to operate Kaiga Generating Station unit-3 (KGS-3) upto 90 % Full Power (FP). Authorizations were issued for hot conditioning of Primary Heat Transport (PHT) system and light water commissioning of KGS-4 and Rajasthan Atomic Power Project unit-5. Clearances were given for erection of major equipment for Kudankulam Nuclear Power Project unit-2 and for erection of safety vessel in the reactor vault and construction of upper lateral for Prototype Fast Breeder Reactor.

### Safety Review of Operating Plants and Fuel Cycle Facilities

All NPPs and research reactors functioned safely. The important authorizations/ clearances issued for NPPs are: Renewal of Authorization for Operation of KGS-1&2 and RAPS-3&4, Permission for En-masse replacement of PHT feeders in RAPS-2, Permission for Restart of NAPS-1 after En-masse Coolant Channels Replacement (EMCCR) and Authorization for Regular Operation of TAPS-3&4 at rated power.

The Front-End Fuel Cycle Facilities functioned safely. HWP-Tuticorin has suspended operations due to non-availability of synthesis gas from the fertilizer plant of M/s SPIC from February 2007. The authorizations issued in Nuclear Fuel Cycle Facilities include: Construction of Heavy Water Clean-Up facility at HWP, Kota; Siting and Construction of Versatile Solvent Production Plant at HWP, Talcher; Commissioning of Boron Enrichment Exchange Distillation facilities at HWP, Talcher; Construction of 10,000 tpa Monazite Processing Plant, Orissa Sands Complex (OSCOM), Operation of Thorium Retrieval Uranium Recovery and Storage (THRUST-II) for uranium recovery at Indian Rare Earths Limited (IREL), Orissa Sands Complex (OSCOM) and Udyogamandal. respectively; Development of Mohuldih underground mine of Uranium Corporation of India Ltd. (UCIL) in Sarikela district of Jharkhand and Siting of Mill and Development of Mine of UCIL located at Tummalapalle in Cuddapah district of Andhra Pradesh.

In R&D units, authorization was granted for the regular operation of Indus-1 and for the trial operation of 750 KeV DC accelerator at Raja Ramanna Centre for Advanced Technology (RRCAT).

### Safety Surveillance of Radiation Facilities

A total of 150 devices were issued Type Approval, 3 medical cyclotrons and 2 industrial gamma processing plants were issued license for operation and 384 Radiological Safety Officers were licensed. Over 2300 licenses were issued for procurement of radiation sources and over 208 authorizations were issued for export and disposal of sources. A total of 195 certificates of registration were issued to diagnostic X-ray installations. One Type-B package certificate was renewed. Regulatory Inspections were conducted in various radiation facilities and 5 unusual occurrences related to loss or misplacement of radiation sources were investigated.

### Industrial Safety

There were two fatal accidents at one of the Nuclear Power Project construction sites. These accidents were investigated and remedial measures were taken. Conduct of monthly inspections at all construction sites was continued.

Various new project proposals, safety related documents, safety related unusual occurrences, dangerous occurrences and fire incidents that occurred at different units were reviewed for rectification of the deficiencies. Regulatory inspections for industrial and fire safety aspects were strengthened at various projects for effective monitoring and

rectification of 'unsafe acts & unsafe conditions'. The minimum safety requirements, Job Hazard Analysis (JHA), preparation of safe working procedures and use of field check list on JHA were made mandatory for all the hazardous works at sites. Eighty-Seven persons were given approval as competent persons under various sections of the Factories Act, 1948.

### Regulatory Inspections

A total of 23 inspections were undertaken, of which 2 were special inspections. The special inspections were conducted for NAPS-1 to investigate one overexposure incident and checking the preparedness of the unit for startup after EMCCR outage. In nuclear projects, a total of 17 inspections were carried out. The inspections of operating power plants and projects included the industrial and fire safety as well as civil engineering aspects also.

About 67 inspections were carried out in other nuclear facilities (Heavy Water Plants, Nuclear Fuel Fabrication plants, Uranium mines and mills, thorium mines and mills, etc) including beach sand mineral industries and research facilities (RRCAT & VECC). Of these, 27 inspections were periodic safety inspections covering process safety, radiological safety, waste management and industrial and fire safety aspects. 40 special inspections were conducted with emphasis on industrial safety aspects at construction sites of nuclear power projects, Zirconium complex, Pazhayakayal and UCIL Mill at Turamdih. Five special inspections were also carried out on civil engineering aspects for nuclear projects as well as operating power plants.

### Regulatory Documents and Safety Studies

A total of 14 new safety documents were published. With this, the total number of safety documents published so far is 134. Safety studies were conducted at AERB, Mumbai and at the Safety Research Institute, Kalpakkam in the areas of event analysis of Indian PHWRs and VVER-1000, Probabilistic Safety Assessment, Reactor Physics, Radiological Safety and Environmental Safety.

### International Cooperation

Under the Indo-French Nuclear Safety Co-operation, a seminar on Pressurized Water Reactors was held in Mumbai during May 8-9, 2007. The 9th nuclear safety cooperation meeting with USNRC was held at AERB during February 25-28, 2008. A workshop on 'Information Exchange on Nuclear Safety' between AERB and Rostekhnadzor, the Nuclear Regulatory Body of Russian Federation, was held during March 25-27, 2008 at Mumbai. AERB Staff also participated in activities of IAEA like Tsunami Hazard Assessment, Seismic Safety of Existing Facilities, Incident Reporting System, International Nuclear Event Scale based reporting of events, Commission on Safety Standards and Coordinated Research Programs.

### Training/Workshops/Seminars

An In-house Orientation Training Programme was conducted for directly inducted and other personnel of AERB. Two training programs were organized for diagnostic radiology professionals. Workshops/Seminars/Discussion meetings were organized on topics of Fire Modeling, Analysis and Management of Severe Accidents in Indian Nuclear Power Plants, New Horizons in Nuclear Reactor Thermal Hydraulics, Ground Water Modeling and Internal Radiation Dosimetry. A One-day radiation safety awareness programme for Indian Customs was conducted at Jawaharlal Nehru Customs House, Nhava Sheva.

### Public Information

Information on major activities of AERB was disseminated through Annual Reports, Newsletters and Press Releases and by posting information on AERB website. Required measures were taken to implement the 'Right To Information Act-2005'.

### ISO Certification

AERB obtained ISO 9001-2000 certification in 2006 for Quality Management System (QMS) for its core activities related to Consenting, Regulatory Inspections of Nuclear and Radiation facilities and Development of Safety Documents. Necessary steps were taken to implement the AERB-QMS for continual improvement in safety regulation of nuclear and radiation facilities.

# CHAPTER 2

# SAFETY SURVEILLANCE OF NUCLEAR FACILITIES

## 2.1 NUCLEAR POWER PROJECTS

### 2.1.1 Project Safety Review

Kaiga Generating Station (KGS-3) had achieved criticality on February 27, 2007 and then Phase-B physics tests were completed. Subsequently, the plant was synchronized to the grid on April 11, 2007 and it was operated upto 50 % FP in line with AERB authorization. Based on satisfactory review of commissioning data and test results at 50 %FP, AERB granted authorization for operating the unit upto 90%FP. KGS-3 was declared commercial on May 6, 2007. KGS-4 and RAPP-5 are under commissioning. Four units, i.e., RAPP-6 (220 MWe PHWR), 2 Units (KK-NPP-1&2) each of 1000 MWe capacity VVER type and 1 unit of liquid sodium cooled PFBR of 500 MWe capacity are under construction. Though the design of VVER type reactors is proven in Russian Federation and some other countries, this is for the first time that reactors of this type are being constructed and reviewed in India.

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

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

The safety review of three nuclear fuel cycle facilities, namely, Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP), Interim Fuel sub-assembly Storage Building (IFSB) and Fast Reactor Fuel Cycle Facility (FRFCF) designed by IGCAR continued during the year.

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

**Table 2.1: Safety Review Committee Meetings of Power Projects**

| Project Safety Committee | Number of Meetings |
|---|---|
| ACPSR-LWR | 4 |
| ACPSR-PHWR | 2 |
| ACPSR-FBR | 1 |
| PDSC-KGS-3&4 and RAPP-5&6 | 16 |
| PDSC-KAPP-3&4 | 6 |
| PDSC-PFBR | 11 |
| PDSC-DFRP | 3 |
| PDSC-IFSB | 1 |
| PDSC-FRFCF | 1 |
| CESC | 9 |

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

#### KGS-3&4 and RAPP-5&6

KGS-3&4 and RAPP-5&6 are "Repeat Designs" of KGS-1&2 and RAPS-3&4 respectively with certain differences in plant layout and control and instrumentation aspects. Safety review process continued on topics related to commissioning data/results of KGS-3, identification and repair of light water leak through tri-junction weld joint in south end shield into the annulus between coolant tube and calandria tube region for lattice position O-10; commissioning of KGS-4 and RAPP-5, resolution of pending design issues, salient observations made during RIs, etc.

#### KGS-3

KGS-3 had achieved criticality on February 27, 2007. Based on the review of various commissioning reports related to First Approach to Criticality (FAC) and Phase-B physics tests, AERB granted consent for synchronization of the KGS-3 to the power grid and operation of the reactor

up to 50 % FP on March 26, 2007. The unit was synchronized to the grid for the first time on April 11, 2007. Subsequently, based on satisfactory review of commissioning data and test results, AERB granted authorization for raising reactor power up to 90 % FP on May 3, 2007 and KGS-3 was declared commercial on May 6, 2007.

Some of the important observations made during safety review, commissioning and the review of incidents observed in KGS-3 are given below.

- Rising trend of dew point temperature of $CO_2$ gas recirculated through annulus between coolant tube and calandria tube by Annulus Gas Monitoring System (AGMS) and subsequent investigations indicated light water ingress into the annulus of lattice position O-10 from south end shield. Water was found to be leaking through tri-junction weld joint. Leak rectification techniques using specially developed gadgets for carrying out precise machining and weld deposition was initially tested on mock-up and then these were implemented. Elaborate safety review at each important sub-stage of the above incident was carried out.
- The unit was tripped manually on tripping of generator on stator fault. This occurred as teflon tubes of stator water coolant circuit developed leak inside the generator. The cause for teflon tube failure has been attributed to impact of flying off of block of insulating material, from the rotor due to failure of its fixing bolt. The Turbine Generator (TG) set did not trip on stator water low flow, as required by thedesign intent. The reason for this was traced to be due to fault in the software installed in the programmablelogic controller. The rectification measures were worked out and implemented.
- Opening of Condenser Steam Dump Valves (CSDVs) has been interlocked with some additional parameters (e.g., pressure of de-superheating water, temperature of injection water at the down stream of CSDVs, etc.) in comparison to logics provided in earlier 220 MWe PHWRs. CSDVs have failed to open on demand, on certain occasions due to these additional logics. The CSDV logics have been suitably modified.
- Most of the commissioning tests which are recommended to be performed at about 90 % FP have been carried out and the results were reviewed and found satisfactory.
- The modified design of power supply scheme for Automatic Voltage Regulator (AVR) for Diesel Generator (DG) sets has been tested and found satisfactory. The modified design was reviewed and will be implemented for all the DG sets of KGS-3&4 and RAPP-5&6 progressively. Temporary modifications done for DG sets of KGS-3 for supply of power to AVR through inverter fed from class-I buses, to avoid tripping of DG set on starting of high capacity motor, would be reverted back.
- The ejector based passive system developed by the DG supplier for maintaining sub-atmospheric pressure in the crankcase was reviewed. This change would also be implemented in all the DG sets of all the units and crank case exhaust fans would be eliminated to improve the reliability.
- Reactor tripped once on low moderator level, though there was no change in actual level. The level instruments readings had come down during make up of helium cover gas for the moderator system. The event was investigated and reviewed in detail. It was noted that Pressure Relief Valve (PRV) in the helium make up circuit was defective and was set at higher pressure and calibration of triplicated level instrument was not proper. Corrective measures were implemented.
- The repair scheme for sub-soil seepage, which was noticed earlier through rock-anchors of the raft portion in the annulus between primary and secondary containments, was reviewed and then implemented at site. The seepages have been arrested.

## KGS-4

Construction activities of KGS-4 have almost been completed. Pre-commissioning checks and individual system commissioning is in progress. Construction Completion Certificates (CCC) of civil engineering structures were audited. ILRT and proof test of containment were carried out and the results are satisfactory. Hot conditioning of PHT system has been completed. Light water commissioning tests are nearing completion.

## RAPP- 5&6

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


***Shri C. P. Jhamb, Site Director, RAPP Site, welcoming the Project Design Safety Committee of Kaiga-3&4 and RAPP-5&6 at RAPP Site***

For RAPP-5, Hot conditioning of PHT system has been completed. Since some of the results of light water commissioning tests were not meeting the design intent/ acceptance criteria; the hot run was repeated based on recommendations of safety review committees. Light water commissioning tests related to moderator and cover gas systems are nearing completion. The audit of Construction Completion Certificates pertaining to civil engineering structures of RAPP-5 was carried out prior to starting of Proof Test and Integrated Leak Rate Test (ILRT) for primary containment.

Construction and erection activities for RAPP-6 are in progress.

### KK-NPP-1&2

ACPSR-LWR held 4 meetings and reviewed status of construction and erection activities, problems observed in polar crane erection and implementation of corrective measures, pre-stressing system for Primary Containment (PC) and results of related mock-ups, preparedness for commissioning approach proposed for Independent Verification and Validation (IV&V) of computer based systems, Level-1 PSA report, industrial safety, etc.

During August 2006, clearance for erection of major equipment for unit-1 was issued. To keep various construction activities going on in parallel, permission for installation of pressurizer for unit-2 was granted, after satisfactory review of all the connected issues by a separate TF. Clearance for erection of major equipment for Unit-2 was granted on June 22, 2007.

**Erection of Pressurizer of Unit-2 of KK-NPP in Progress**

Civil construction activities and erection of equipment are in progress for both the units. Pre-commissioning activities of unit-1 are planned by the end of year 2008. The training simulator has been commissioned at site and is being extensively used for the training of Operation and Maintenance (O&M) staff.

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

- NPCIL proposal for installation of pressurizer for unit-2 with a revised scheme using DEMAG crawler crane prior to erection of metallic liner of IC dome was reviewed and permission was granted for its erection with certain stipulations. The pressurizer has been installed in its cavity.
- With regard to qualification and licensing of O&M personnel, present status and the methodology to be adopted was asked to be submitted for review.
- Site was asked to submit document detailing the special commissioning requirements for all first-of-a-kind systems along with their acceptance criteria.
- During commissioning, it is essential to monitor the behaviour of certain systems/components using special gadgets/ instruments (e.g., vibration monitoring of reactor internals) to collect the required baseline data. Action has been initiated in this regard by NPCIL.
- The original scheme of plant water supply from Pechiparai dam located about 70 km from KK-NPP site has been changed and in lieu desalination plants are installed at site. This change is under review.
- Probabilistic Safety Assessment (PSA) has been performed only for internal events with reactor at high power (>2 % FP) and for two events in shutdown condition. External events and events at low power and other events of shutdown conditions are not considered in the PSA. Considering large uncertainties in external event PSA, and the fact that present PSA report is being used as a tool to support design, it was recommended that issues related to present PSA (Level-1) report be resolved on priority.
- Required mock-ups were carried out prior to grouting of ducts housing vertical pre-stressing cables. Based on the review of the outcome of mock-ups, grouting proceedures were revised and used in actual grouting.

### PFBR

Design safety review was carried out for variety of topics such as design safety limits for fuel, clad and coolant, temperature evolution in roof slab during pre-heating and loss of cooling, 3-D hydraulic analysis of grid plate under primary pipe rupture condition, transient analysis for primary pipe rupture event, Leak Before Break (LBB) analysis for main vessel, allowable external pressure on main vessel, diverse shut-off rods drive mechanism and core-subassembly components, biological shield cooling system, reactivity oscillations during seismic events, seismic analysis of reactor assembly, seismic analysis of decay heat exchangers, procedures for erection of safety vessel, load combination for reactor assembly components, design changes in the under vessel neutron detectors, complementary shielding over roof slab, etc. PSAR chapters on 'Conduct of Operations' and 'Initial test programme' were briefly discussed.

AERB had granted clearance for construction of

Reactor Vault (RV) upto +26.715 m elevation and Spent Sub-assembly Storage Bay (SSSB) in May 2006. The RV inner wall concreting has been completed upto 26.715 m elevation and outer wall upto 26.0 m elevation. Fabrication of Safety Vessel (SV) has been completed. Fabrication of Main Vessel, Inner Vessel, Roof Slab, SV closure cover, etc. are in progress. After satisfactory review of relevant documents, clearance for installation of SV and construction of upper lateral upto 31.5 m elevation was granted on February 4, 2008.

Important observations/recommendations made during the review are given below.

- For neutronic transients, the actuation of SDS-2 will also be incorporated in addition to actuation of SDS-1 on high differential temperature across fuel sub-assembly.
- It was recommended to provide indication of Diverse Shut-down System Rods (DSR) - "DSR- Fully In" and measurement of DSR travel time. The development work on this is in progress.
- It was observed that experimentally measured heat flux past the insulation on SV is 230 W/m$^2$ in comparison to the design value of 200 W/m$^2$. Based on the revised heat flux value, Biological Shield Cooling (BSC) water flow is to be doubled to keep the Reactor Vessel concrete temperature within limits. The design has been modified accordingly.
- It was recommended to provide containment isolation in case the activity in the stack release increases more than the pre-set value. For this purpose, in-duct monitors will be incorporated in the exhaust duct of reactor building.
- For many design basis events, SCRAM action is considered as a means of reactor shutdown. Justification has been asked on the time availability for crediting operator action and specify the parameters on which manual SCRAM action would be taken.
- The designers were asked to study and report the effect of instrument air failure on the plant.
- Modifications were made in the Neutron Detector Box (NDB) based on observed accumulation of seepage water due to choking of upper level drain lines during construction stage. The designers have been asked to work out alternate neutron flux monitoring system in case the present design of NDB and associated detectors do not perform as per the design intent.
- Complementary shielding needs to be provided over roof-slab as per design to reduce the radiation due to direct streaming along the various penetrations in the slab. It was recommended that adequate space and loading requirements on the roof slab are to be taken care of for complementary shielding.
- It was recommended that a full scale mock up of transport, lifting and placing SV in reactor vault be done (by appropriate dummy considering both size and weight) prior to installation of SV. Some of the mock-ups have been carried out and many improvements have been incorporated in the handling procedures and equipment for the same.

**Mock Up of Upper Lateral of Prototype Fast Breeder Reactor**

- Bharatiya Vidyut Nigam (BHAVINI) has been asked to ensure that no choking/blocking of sub-circuits of biological shield cooling pipes, which are embedded in the reactor vault, occurred during construction activities completed so far.
- During safety review by CESC, it was pointed out that certain areas around the SV support location could have difficulty in proper concreting essentially due to congestion of re-bars. Mock-ups to demonstrate the concretability were carried out and related issues were reviewed and resolved.
- AERB accepted a proposal for use of Fe-500 grade reinforcement in place of Fe-415 grade, owing to its non-availability in the market, after appropriate design check.

### KAPP-3&4

Site Evaluation Committee (SEC) has completed review of application seeking consent for siting of KAPP-3&4. Review for siting consent and associated documents is in progress by ACPSR-PHWR. The safety review for excavation consent is also under progress. The review of plant layout, design basis ground motion, geotechnical aspects, site flooding aspects, design basis for safety related civil engineering structures and issues related to use of Fe-500 grade reinforcement and fusion bonded epoxy coating for reinforcement is in progress.

Some of the salient observations/recommendations

made during the safety review are given below.

- The safe grade elevation for all the buildings/structures for KAPP-3 & 4 has been fixed at +51.0 m RL (Reference Level) and this has been arrived at based on a detailed assessment of all possible combinations of flooding as per the relevant AERB Safety Guide. It is seen that for the postulated worst possible scenario of Ukai dam break coincident with maximum precipitation (rainfall), the maximum water level that can be reached at Site has been calculated to be +50.68 m RL. This has been arrived at by Central Water Power Research Station (CWPRS), Pune based on a flooding analysis carried out by them. In order to restrict the water level rise at Site,CWPRS has also suggested certain flood protection measures. The details of the flooding analysis and the protection measures are under review to confirm their adequacy.
- Contractors would undertake extensive radiography jobs during construction phase of KAPP-3&4. Therefore, it was emphasized that comprehensive action plan to handle situations pertaining to radiological incidents during construction phase should be prepared and made available for review.
- Since the estimated source strength, neutron and gamma dose rates would be higher for the end-shield of 700 MWe compared to 540 MWe PHWRs, these dose rates at surface of end-shields (fuelling machine vault side) and at 1 m away from surface need to be estimated. NPCIL was asked to provide the basis for proposed reduction in end-shield thickness vis-à-vis increased source strength.
- Detailed review of the plant layout was done and NPCIL was asked to clarify on various observations made with respect to ISI, maintainability, material handling requirements, Low Trajectory Turbine Missile (LTTM) zone, radiation zoning, etc.
- NPCIL was asked to study and report the aspects related to internal flooding due to equipment/ tank/ piping failures and corresponding safety implications and protection measures.
- It is recommended that preliminary Fire Hazard Analysis (FHA) should be done at Preliminary Safety Analysis Report (PSAR) stage itself before finalizing the plant layout to ensure that fire barriers areadequate for segregation of safety related items (fire containment approach), equipment layout ensures the passive fire protection by distance (fire influence approach) and adequate number of fire doors and emergency exits are provided.
- Safety review of aspects such as design basis ground motion, geotechnical studies, design basis for safety related civil engineering structures, specifications for re-bars etc. has also been started.

## DFRP

IGCAR is setting up DFRP to process spent fuels of FBTR and PFBR. This is a forerunner of the reprocessing facility in FRFCF to be setup at Kalpakkam. It is divided into 2 concrete cell facilities called Head End Facility (HEF) and Process Plant Facility (PPF). Most of the civil construction and installation of equipment and piping for the PPF have been completed at the time of construction of Kalpakkam Reprocessing Plant (KARP). Civil construction of HEF is in progress.

In depth review of aspects related to i) Mechanical systems, Head End Systems and Remote Handling; ii) Process System; iii) Waste Management; iv) Off Gas and Ventilation; v) Re-conversion and Analytical Labs; vi) Radiological, Criticality and Environmental Safety; and vii) Utilities and Instrumentation Control etc. is in progress. Issues pertaining to water seepage in Waste Tank Farm (WTF) area, seepage of water into the concrete pipe trench, design features of the Stainless Steel (SS) box around the waste transfer lines, seismic analysis of the off gas header and adequacy of supports, feasibility to carryout maintenance/ replacement of equipment inside the process cells etc., were discussed in detail in safety committees.

## IFSB

AERB granted clearance for construction for IFSB in August 2006. Excavation up to 12 m depth was completed and post-geo-technical confirmatory investigations are in progress. Safety review activities were mainly on topics, viz., construction schedule, impact of failure of shared facilities with Fast Breeder Test Reactor (FBTR), handling & storage of pin magazines and subassemblies, alcohol cleaning & vacuum drying facility, instrumentation system for interim storage building, electrical power supply system, radiation monitoring and health physics programme, design of ventilation and auxiliary systems, etc.

Based on recommendation during review, an opening made in the western side random rouble wall of FBTR and IFSB construction site is cordoned off completely from FBTR for man and material movement to avoid unauthorised entry into FBTR premises. IGCAR has planned to almost double the pin magazine storage capacity in line with AERB recommendations.

## FRFCF

FRFCF is being built to meet the fuel reload requirement for PFBR and for closing the fast reactor fuel cycle. The design of the facility is under progress. The safety review of application for seeking construction clearance is in progress. The review covered site activities, site characteristics, reactor physics aspects of the PFBR fuel, red-oil explosions in process industries, design basis flood level, revised layouts, 'Fish-bone' type of glove box arrangement in Fuel Fabrication Plant (FFP) in place of the

row-type glove box trains, site characteristics vis-à-vis flooding potential, etc. Many observations/recommendations have been made by PDSC and associated WGs during the review, these are being addressed progressively.

### 2.1.2 Authorizations/Clearances/ Permissions Issued

- Authorization for operation upto 90 % Full Power of KGS-3 (May 03, 2007).
- Authorization for Hot Conditioning of PHT System and Light Water Commissioning of KGS-4 (February 19, 2008).
- Suspension of Construction Consents for RAPP-5&6 (June 29, 2007).
- Revoking suspension of construction consents for RAPP-5&6 (July 05, 2007).
- Authorization for Hot Conditioning of PHT System and Light Water Commissioning for RAPP-5 (October 12, 2007).
- Permission for Erection of Pressuriser of unit-2 of KK-NPP (May 23, 2007).
- Clearance for Erection of Major Equipment for KK-NPP unit-2 (June 22, 2007).
- Clearance for installation of SV in the reactor vault and construction of upper lateral upto 31.5 m elevation for PFBR (February 4, 2008).

### 2.1.3 Regulatory Inspections of Projects

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

**Table 2.2: Regulatory Inspections of Nuclear Projects**

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

In addition to these planned inspections, AERB representatives visited KGS-3&4 and RAPP-5&6 to observe certain important commissioning tests and/or to assess the preparedness of site for certain sub-phases of commissioning. Special inspections of project sites were also carried out, as necessary, exclusively by experts in civil engineering and industrial safety.

Methodology has been worked out to bring uniformity, to the extent feasible, in maintaining database of observations/recommendations made during regulatory inspections of all nuclear projects and for subsequent follow-up and this is suitably implemented.

Some of the important observations/ recommendations made by RI teams are given below. These recommendations would be checked for their compliance during the follow-up regulatory inspections.

#### KGS-3&4

- Fire water system capability test to meet Station Black Out (SBO) condition was performed and firewater pressure obtained in pump room of RB unit-3 was found to be adequate. Regarding ensuring firewater pressure of 3.5 kg/cm2 at the hydraulically farthest point, it was recommended that since RB of unit-4 is farther than RB of unit-3 from Fire Water Pump House (FWPH), the fire water system capability test during commissioning of unit-4 should be performed.
- The openings between hydrogen addition area and Main Oil Tank for TG set were asked to be sealed to prevent potential fire spread from one fire hazard area to the other.
- As per Fire Hazard Analysis report, provision of curb walls around the Primary Coolant Pumps (PCPs) and Oil Supply Units (OSUs) of PCPs and covering of openings besides OSUs to prevent possible fire spread from 107 m El to the lower elevation were to be done. In field visit, it was observed that these safety provisions have not been made. Site has agreed that these improvements would be implemented in the long shutdown.
- For Regulating Rod, R2, error was noticed in setting of low flow alarm. Subsequently, it was corrected. High Flow Alarm was found to have not been incorporated as per the design intent, the same was implemented subsequently.
- For many contamination monitors (e.g. QT-2 at final exit point), 'Counter Failed' indication was persisting even if the monitors were in working condition. Site informed that this was due to low background readings. It was recommended that the problem be resolved to ensure that the alarm comes only for genuine failure.
- Source calibration checks on Ventilation Duct Radiation Monitors (VDRMs) (QT-58 & QT-59) revealed that the observed values of radiation fields displayed by those monitors were less than expected by about 24 %. It was recommended that the discrepancy should be rectified.
- During source calibration checks on process water and steam line activity monitors, it was observed that Radiation Data Acquisition System (RADAS) reading differed largely from monitor reading. The problem was subsequently rectified.

- According to the procedure, for all four Steam Generators (SG) of KGS-4 the required SG elevation, verticality and blue matching area were 114998 mm, 2.5 mm in 12.5 m and 80 % minimum respectively. In all the SGs, the observed elevation was higher than the required elevation by 1.0 - 6.0 mm. Observed verticality in SG-2 was 5.0 mm against required 2.5 mm. At some places blue matching area observed was 70 % against required 80 % minimum. Site responded that Design Concession Reports (DCR)would be raised after erection and alignment of nozzle bearing support of all SGs.
- Failure of any tower supporting 220 kV feeders as well as 400 kV system can lead to power supply unavailability to the respective startup power supply of each unit of KGS-3&4. This violates the requirements stipulated in clause 0803 of AERB code on 'Design for safety in pressurized heavy water based nuclear power plants and clause 2.2.2 of AERB guide on "Emergency Electric Power supplies". The issue was discussed in detail. Appropriate Technical Specifications for Operation have been incorporated to meet the safety requirement.
- Seismic analysis/qualification of the engineering console for Programmable Logic Controllers (PLCs) has not been carried out. It is recommended that the functional performance of the PLC panels in case of seismic event should be evaluated either by simulation or qualification.
- There was discrepancy in Radiological Work Permits (RWP) that have been issued by Shift Health Physicist (SHP) and surrendered back to SHP. It was recommended that strict account should be maintained for RWP.
- The deviation observed in top elevation of stand pipes for 10 Primary Shutdown System (PSS) rods will be taken care during in-situ qualification of PSS drive mechanism and the total stroke length will be maintained as per the specification.

### RAPP-5&6

- In history dockets, records on environmental qualification (temperature, humidity, fire, radiation etc.) were not traceable. Site was asked to confirm that environmental qualification including radiation qualification has been ensured by appropriate tests for all safety related structures/systems/components as per the design intents.
- Contingency plan was not existing in the Main Control Room (MCR) for handling flood, cyclone, earthquake, sabotage, etc. Site was asked to finalize the contingency plans prior to fuel loading in the core.
- For RAPP-6, it was observed from the field records that helium Leak rate for 34 north side coolant tube rolled joints is higher than the specified limit. Corrective actions have been initiated.
- For RAPP-5, DG-1 and DG-2 were tested for 24 cold starts and one hot start. It was observed that the test lacked compliance with commissioning procedure. It was recommended that the tests be carried out as per procedure and submit compliance report to AERB.
- For power UPS of RAPP-5, as per the procedure step load change test should be done by putting on 0 to 100 % load and load throw off to verify that dip/ overshoot in the voltage is within the acceptable limit. It was observed that test intent was not met in totality. It was recommended to repeat the test.
- In RB and Control Building of RAPP-5, at certain locations, it was observed that safety related cables were running above non-safety related cables and in few places mixing with each other. It was recommended that site should ensure compliance of safety practices in this regard and take necessary corrective actions.
- During Emergency Core Cooling System (ECCS) Integrated Test time recorded for open/close timing of a few valves were observed to be not reasonable (of the order of few milliseconds). Site informed that there is software problem for testing of some valves. Calibration reports for ECCS instruments were checked and records were found incomplete. It was recommended that the deficiencies be corrected.
- During the field visit it was observed that in certain safety related areas, fire detectors were located away from the exhaust route. It was recommended that efficacy to detect smoke/fire should be verified. Site has planned corrective actions in consultation with the designers.

### KK NPP-1&2

- In respect of ECCS accumulator, it was noted from the passport that there are 3 pipes penetrating the bottom of the accumulator for 3 stepwise discharge flows depending upon the height of the pipes to cater to extended blow down during SBO. This was in variance to the design. Justification was sought for this design change in the engineered safety system configuration.
- As per the joint protocol between Site and Russians, a decision was taken to temporarily limit the maximum load capacity of the polar crane up to 332 Te due to tilting of main hoist fork under 350 Te load. Subsequently, static load test was conducted at 100 % and 125 % of the revised maximum load of 332 Te. Dynamic test was also conducted at 110 % of the revised maximum load. Observed deflection/tilts in both the tests were within the acceptable value. The polar crane was then released for erection of SG, RPV and

PRZ, etc for unit-1. Suitable modifications were incorporated to eliminate the problem subsequently.

- Some base metal defects and weld defects were observed at site for polar crane for unit-2, which were not observed in the manufacturing plant. These defects were rectified at site.
- Crown portion of containment dome liner was observed to have large amount of water accumulation on it. Site was asked to maintain dry condition on the liner.

### PFBR

- Deposition of dust on biological shield cooling pipes and rusting of pipes especially around bend and weld a portion was observed. It was recommended to prepare preservation procedures for all items, under fabrication or already installed taking into consideration designers/manufacturers recommendations.
- After sodium filling in the main vessel, thermal deflection may cause reduction in the gap between main vessel and safety vessel and also tilting of centerline. This may pose difficulty during installation of necessary Instrumentation and Control (I&C) components and insertion of tooling for In Service Inspection (ISI). Designers were asked to examine the requirement of measurement of deflection and provide necessary instrumentation towards this.
- The full scale model base frame of SV was tested with 125 % of maximum load. During the testing, the deflection observed in base frame was found to be more than 25 mm. Base frame design was subsequently modified to limit the deflection and the base frame was retested for 125 % of load.
- Channels of 10 mm OD and 7 mm ID are provided in the RV and SV to introduce Extended Electrode Leak Detectors (EELD) and Mutual Inductance type Leak Detector (MILD). It was recommended that the procedure for replacement of detectors be prepared and mock-up should be performed simulating the site conditions to check the adequacy of the procedure and design.

### DFRP

- Several equipment/piping were installed a few years back. It was recommended to check the healthiness of these installed items.
- Liners, provided to various concrete process cells, do not have leak detection system. It was recommended that site should clarify how the leak would be detected and how ingress/seepage of active fluids in the sub-soil would be prevented.
- It was observed that the off-gas header lines have been blinded abruptly without smoothening the ends, which could result in accumulation of radioactivity at the blind end portion. Necessary action in this regard was recommended.
- Profuse water leakage in the WTF through the wall of the waste vault at -7.5 m elevation was observed. A large water sump has been constructed to collect this water and a pump installed for regular dewatering. Corrective actions to stop seepage/leakage of water in the area were recommended.
- The project authorities were asked to establish mechanism for conducting internal audits periodically as per AERB/SC/QA.

### IFSB

- IFSB is cordoned off from FBTR by use of metal corrugated sheets. One security person has been posted at the entrance. The security person was checking for vehicle movement only. It was recommended to strengthen security checks for the persons entering IFSB site and to maintain the head count of the people present at site.
- It was recommended that IFSB should include addendum in the emergency preparedness manual of FBTR with emphasis on emergency preparedness plan for the construction site and identify emergency shelters for workers at IFSB site. The recommendation has been implemented.

## 2.2 NUCLEAR POWER PLANTS AND RESEARCH REACTORS

The Operating Plants Safety Division (OPSD) of AERB carries out 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 20 meetings during the calendar year 2007. 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 safety committees during 2007 is given in Table 2.3.

**Table 2.3: Meetings of Safety Committees**

| Name of the Safety Committee | No. of Meetings |
|---|---|
| SARCOP | 20 |
| TAPS-1&2 Safety Committee | 6 |
| TAPS-3&4 Safety Committee | 16 |
| RAPS - MAPS Safety Committee | 6 |
| NAPS - KAPS Safety Committee | 16 |
| KGS -1&2 and RAPS - 3 & 4 Safety Committee | 18 |
| IGCAR Safety Committee | 3 |
| CESCOP | 2 |

All the NPPs and Research Reactors operated safely. During the year, a number of applications from the utilities were reviewed and several authorizations/clearances were issued. Important among them are:

1. Permission for operation of TAPS-3&4 up to 100% FP (May 11, 2007).
2. Renewal of authorization for operation of KGS-1&2 (May 29, 2007).
3. Permission for taking up En-masse replacement of PHT feeders in RAPS-2 (September 5, 2007).
4. Renewal of authorization for operation of RAPS-3&4 (January 2, 2008).
5. Permission for restart of NAPS-1, after EMCCR and safety upgradations (November 31, 2007).
6. Authorization for regular operation of TAPS-3&4 (January 1, 2008).

Detailed reviews of the events / incidents that occurred in the units were carried out. Important among these are:

1. Incident of leakage from the PHT feeder in RAPS-2.
2. Incident of spread of radioactive contamination and unplanned radiation exposures to personnel beyond the regulatory limit, at NAPS-1.
3. Anomalies observed during restart of NAPS unit-1 after EMCCR.

The following restrictions were imposed on the operation of NAPS-1 based on safety reviews:

- Suspension of activities related to restart of NAPS-1 after EMCCR (December 2007), following certain anomalies indicating deficiencies in quality assurance and work practices.

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

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

#### TAPS -1&2

TAPS-1&2 were operational up to a power level of 160 MWe. TAPS-2 remained shutdown for refueling and ISI from September 23, 2007 to October 26, 2007.

#### TAPS-3&4

TAPS-3&4 were operational. The maximum power level achieved by TAPS-3 was 540 MWe (100 % FP) and by TAPS-4 was 470 MWe (85% FP). TAPS-4 remained shut down from June 25, 2007 to August 26, 2007, for carrying out maintenance, ISI and surveillance activities. Presently these units are operational up to 270 MWe (50 % FP).

#### Authorization for Operation

TAPS-3&4 were commissioned in 2005-06. Pending completion of certain commissioning tests, these units were permitted to operate up to 85% FP and 90% FP respectively. The remaining commissioning tests (Net Load Rejection Test and the test to demonstrate residual heat removal from the reactor core by Thermo-Siphoning) were completed by February 2007. The results of these tests were reviewed and found satisfactory. The investigations and analysis of the problem of instabilities observed in the Reactor Regulating System (RRS), resulting in oscillations in reactor power, were completed and corrective actions involving modifications in the RRS were implemented after regulatory review. Subsequent steady operation of the units indicated that the problems in the RRS have been addressed satisfactorily. After review of the results of the commissioning tests and the status of resolution of problems in RRS, the operation of the units up to 100 % FP was permitted.

After demonstrating sustained operation of the units up to 100% FP and complying with the prerequisites, viz., (i) submission of final safety analysis report, (ii) regulatory review and approval of the Technical Specifications revised on the basis of experience during commissioning and initial operation of the units and (iii) regulatory review of the status of implementation of regulatory recommendations from the previous clearance stages, the authorization for regular operation of the units up to August 2011, i.e., up to five years from start of commercial operation was granted.

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

#### RAPS-1&2

RAPS-1 continues to remain shutdown since October 2004. RAPS-2 is undergoing a campaign of en-masse replacement of feeder pipes in the PHT system. This involved prolonged shutdown and draining of the reactor coolant, removal of nuclear fuel from the reactor core. As some of the fuel bundles removed had seen irradiation only to a limited extent, these fuel bundles could be reused in the reactor again for power generation. Therefore, NPCIL proposed reuse of these fuel bundles in RAPS-2 after it gets back on line after the current outage. However, as this required storage of fuel bundles in a safe location with reliable cooling, NPCIL also proposed to transfer and store the fuel bundles in the reactor core of RAPS-1. The PHT system of this reactor is operational. After a detailed review of the safety implications, AERB accepted the proposal. The reuse of these fuel bundles in RAPS-2 will be subject to a detailed safety review, including aspects related to qualification of the fuel transfer/handling systems and the fuel bundles for reuse.

#### En-masse Replacement of Feeders of RAPS- 2

As brought out in the previous annual reports, thinning of elbows in the feeder pipes in the PHT system, due to flow induced erosion / corrosion has been one of the issues being closely monitored by AERB for the all Indian PHWRs. The concern is more pronounced in the older operating reactors, viz., RAPS-2, MAPS and NAPS. To address this problem, a programme involving periodic ISI of vulnerable feeders and health assessment based on the inspection results is being followed for ensuring fitness of the feeders for service. As a long-term solution to the

problem, NPCIL had recently undertaken en-masse replacement of PHT feeders in MAPS-1 and NAPS-1, during their respective long outages for EMCCR. On similar lines, replacement of feeders was also planned for RAPS-2 and NAPS-2 reactors and based on ISI and health assessment, AERB had permitted operation of the unit up to November 2007, after which the unit was to undergo en-masse replacement of feeders. However on June 28, 2007, while restarting the unit, after a shutdown, a minor leak of heavy water from the feeders of PHT system was detected. Inspections done on some of the other feeders also indicated wall thinning at the elbows. As a result of this, NPCIL decided to undertake en-masse replacement of feeders, ahead of the earlier plan of November 2007. After detailed review of the NPCIL proposal in this regard, the clearance for en-masse feeder replacement in the unit-2 was granted. The existing feeders are being replaced with feeders of material having better resistance to flow induced erosion / corrosion, as was done in the case of MAPS-2 and NAPS-1 reactors. The replacement of feeders is presently in an advanced stage.

Restart of the unit after the replacement of feeders will be subject to the process of extensive safety review and renewal of authorization as per the established regulatory practice.

### Renewal of Authorization for Operation of RAPS-3&4

The authorization for operation of RAPS-3&4 was valid till October 31, 2007. As per AERB requirement, the Application for Renewal of Authorization (ARA) for operation of RAPS-3&4 was submitted for a further period of five years. The ARA was reviewed in detail by OPSD, Kaiga-RAPS-3&4 Safety Committee and SARCOP. The aspects reviewed included operational performance, significant events, radiological safety performance, status of in-service inspection of plant systems and environmental discharges. The reviews carried out indicated that the performance and safety status of the units during the current authorization period has been satisfactory. Based on this and review of ARA, the authorization for operation of RAPS-3&4 was renewed, for a further period of five years, i.e., till October 31, 2012.

### 2.2.3 MAPS-1&2

Both the units operated normally during the year.

### 2.2.4 NAPS-1&2

As brought out in the previous annual reports, NAPS-1 remained shutdown since November 1, 2005, for EMCCR and PHT feeders replacement and for certain upgradations. After completion of these jobs, the restart of the unit was permitted on November 30, 2007. During restart of the unit some problems were encountered (discussed later). After resolving these, the unit was synchronized to grid on February 25, 2008. The unit is under normal operation since then.

NAPS-2 operated normally, till the unit was shutdown on December 18, 2007 for taking up EMCCR and PHT feeder replacement jobs.

### EMCCR in NAPS-1

As mentioned above, NAPS-1 was shutdown on November 1, 2005 for EMCCR and other upgradation jobs. During this outage, the old Zircaloy -2 pressure tubes with two loose garter springs were replaced by coolant channels having Zirconium Niobium pressure tubes with four tight fit garter springs. The new coolant channels will have a much longer life span as compared to the lifespan of the Zircaloy-2 channels, owing to lower hydrogen pick up during reactor operation and reduced possibility of movement of the garter spring spacers from their design locations. Taking advantage of this long shutdown, all the feeder pipes of the PHT system were also replaced. Also a number of upgradation jobs were also carried out, which will help in enhancing the safety and availability of the units and reduce the collective doses. The activities related to EMCCR, feeder replacement, the upgradations and results of inspection of plant systems were closely reviewed and monitored by a special review group of AERB.

### Restart of NAPS-1

The reactor restart sequence after EMCCR followed for NAPS-1 involved some differences as compared to that followed earlier in MAPS-1&2 and RAPS-2. Important among these was the proposal to undertake fuel loading in the reactor core, with the calandria remaining filled with moderator. This required in-depth review of safety aspects and additional requirements were imposed with respect to (a) availability of a reliable neutron monitoring system, (b) availability of shutdown systems and (c) sub-criticality margin, as prerequisites before undertaking fuel loading. Additionally, the initial fuel-loading pattern proposed for NAPS-1 involved a larger proportion of depleted and deeply depleted uranium fuel. These issues required extensive reviews and assessments within NPCIL, AERB and the associated expert committees and safety committees. Based on the reviews and assessments, the fuel loading and heavy water addition to PHT system of the unit was permitted, in August 2007.

While installing the in-core neutron detectors in the central thimble of the reactor, an event of personnel contamination and unplanned radiation exposures took place on September 3, 2007. During this event, presence of water with cobalt contamination was discovered inside central thimble assembly. The reason for cobalt contamination was apparently due to disintegration of some of the cobalt SPNDs (Self Powered Neutron Detector), which were left inside at the time of the initial commissioning of the unit. Presence of such highly active cobalt SPNDs inside central thimble had made it unfit for installing the start up instrumentation.

To facilitate reactor start-up, NPCIL proposed to

utilise one of the adjuster rod locations, away from the central thimble, for installing the in-core start-up instrumentation. After extensive review of the reactor physics and safety implications in the Standing Committee on Reactor Physics and NAPS-KAPS Safety Committee and SARCOP, the proposal was accepted. A special regulatory inspection was also conducted for assessing the status of the plant systems and preparedness for restart of the unit. After in-depth reviews and satisfactory resolution of the issues related to restart of the unit, clearance for restart of NAPS unit-1 was accorded on November 30, 2007. Following this, the unit was made critical on December 2, 2007.

During the FAC and low power physics experiments of the unit, a few anomalies were observed. These were with respect to (i) difference between the predicted and observed critical boron concentration (ii) non-availability of out-of core calandria vault neutron counters connected to reactor protection system and (iii) non-availability of two regulating rods. Taking serious view of these anomalies, which were apparently caused by lapses in maintenance, commissioning and quality assurance, the activities related to restart of the unit were suspended. Subsequently, after detailed investigations and identification of corrective actions by NPCIL and detailed review of status and action plans for resolution of the anomalies, which involved steps to strengthen quality assurance practices at NAPS, resumption of activities related to restart of NAPS-1 was permitted on January 2, 2008.

During subsequent restart of the unit, an internal electrical fault occurred in Generator Transformer (GT) and its winding got damaged. The station then replaced the damaged GT with GT of the unit-2, which was in shutdown state for EMCCR. After replacement and commissioning of the GT, NAPS-1 was restarted and connected to the grid on February 25, 2008.

**Life Management of Coolant Channels in NAPS-2 and KAPS-1**

NAPS-2 and KAPS-1 also have pressure tubes made of Zircaloy-2, which have a limited life span. AERB had earlier given permission for operation of these units upto 11.5 Hot Operating Years (HOYs). An extensive campaign of ISI and balance life assessment of coolant channels was carried out in these units during January-May 2007 and July to September 2007 respectively. The results of the inspections carried out earlier in other units using similar pressure tubes were also used for balance life assessment of coolant channels in these units. Based on the results of these assessments, NPCIL proposed to operate NAPS-2 and KAPS-1 upto 12 HOYs. After an extensive safety review of the proposals, which indicated no undue reduction in the safety margins, AERB accepted the NCPIL proposal for operation of these units up to 12 HOYs. Subsequently, NAPS-2 was shutdown on December 18, 2007 for EMCCR. KAPS-2 will also be shutdown for EMCCR after completion of 12 HOYs which is expected to be reached in June 2008.

### 2.2.5 KAPS-1&2

Both the units of KAPS operated normally during the year.

### 2.2.6 KGS-1&2

Both the units of KGS operated normally during the year.

**Renewal of Authorization for Operation**

The authorization for operation of KGS-1&2 was valid till May 31, 2007. As per AERB requirement, KGS had submitted the ARA for operation of the units for a period of five years from June 1, 2007. As done for other plants, the ARA was reviewed in detail by OPSD, Kaiga-RAPS - 3&4 Safety Committee and SARCOP. The aspects reviewed again included operational performance, significant events, radiological safety performance, status of in-service inspection of plant systems & environmental discharges. The reviews carried out indicated that the performance and safety status of the unit during the current authorization period has been satisfactory. Based on this and review of ARA, the authorization for operation of RAPS-3&4 was renewed, for a further period of five years, i.e., till May 31, 2012.

### 2.2.7 Indira Gandhi Center for Atomic Research

**FBTR**

FBTR operated at 16.6 MWt (max.) to facilitate the completion of identified experiments.

**KAMINI**

KAMINI reactor remained operational for conducting various irradiation and neutron radiography experiments.

**Reactor Fuel Reprocessing Group**

FBTR fuel reprocessing is being carried out in the Compact Reprocessing of Advanced Fuels in Lead Cells (CORAL) Facility (earlier known as the Lead Mini Cell Facility), which is a pilot plant set up in Reprocessing Development Laboratory of IGCAR. The objective of CORAL is mainly to validate the process and equipment developed for reprocessing of the fast reactor fuel. As brought out in the earlier annual reports, AERB had given authorizations for taking up campaigns for reprocessing of FBTR fuel pins in the CORAL Facility. Since then, IGCAR has completed these campaigns successfully and sought authorization for taking up further reprocessing campaigns. After review of the safety aspects and the performance during the previous reprocessing campaigns, IGCAR was authorized to take up reprocessing of fuel pins irradiated up to 155 GWd/t in the CORAL facility.

### 2.2.8 Regulatory Inspections

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

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

The RIs are conducted following the guidelines specified in AERB Safety Guide, AERB/SG/G-4 on 'Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities' and AERB Safety Manual, AERB/NPP&RR/SM/G-1, 'Regulatory Inspection and Enforcement in Nuclear Power Plants and Research Reactors'. A total of 21 routine RIs were carried out once in six months for nuclear power plants and once in a year for research facilities. In addition, two special inspections were carried out; one during the outage of NAPS-1 for EMCCR and up-gradation activities in view of the overexposure incident while carrying out jobs related to installation of start-up counters in the central thimble and the other to check the preparation of the station for restart of the unit after EMCCR outage.

The observations during the inspections are summarized into 5 different groups depending upon their significance, as given below. Category wise distribution of observations in different plants is given in Table 2.4.

| | |
|---|---|
| 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-I observation in RAPS-1&2 was with respect to restart of RAPS-2 from shutdown with one of the Class-II Motor Generator Set being unavailable, which is in deviation from the technical specification requirements. At NAPS, the compliance with respect to submission of bioassay samples for assessment of tritium uptakes by the workers was found to be poor. AERB has taken up the issue of improving compliance to bioassay requirements with NPCIL and NAPS management. At MAPS, the average in core fuel burnup exceeded the specified limits. This issue is presently under consideration of AERB.

### 2.2.9 Licensing of Operating Staff

The number of operating personnel, who were licensed from various power plants during the calendar year 2007, is tabulated in Table 2.5.

**Table: 2.4 Categorisation of Deficiencies observed during RI (2007)**

| Unit | Number of Inspections | | Cat.-I | Cat.-II | Cat.-III | Cat.-IV | Cat.-V |
|---|---|---|---|---|---|---|---|
| | Planned | Special | | | | | |
| TAPS-1&2 | 2 | 0 | 0 | 8 | 0 | 41 | 4 |
| TAPS-3&4 | 2 | 0 | 0 | 4 | 4 | 76 | 3 |
| RAPS-1&2 | 2 | 0 | 1 | 1 | 14 | 25 | 2 |
| RAPS-3&4 | 2 | 0 | 0 | 4 | 1 | 32 | 9 |
| MAPS-1&2 | 2 | 0 | 1 | 3 | 11 | 37 | 6 |
| NAPS-1&2 | 1 | 2 | 1 | 3 | 3 | 26 | 0 |
| KAPS-1&2 | 2 | 0 | 0 | 4 | 8 | 45 | 1 |
| KGS -1&2 | 2 | 0 | 0 | 3 | 9 | 43 | 4 |
| RAPPCOF | 1 | 0 | 0 | 0 | 2 | 5 | 0 |
| FBTR & KAMINI | 1 | 0 | 0 | 0 | 6 | 18 | 11 |
| Radio Chemistry Lab | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Radio Metallurgy | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| LEAD MINI CELL A,B,C | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| FRTG NO | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 21 | 2 | 3 | 30 | 58 | 348 | 40 |

The Control Engineers (CE) licensed for TAPS-3&4 operations included the three engineers of AERB who were deputed at TAPS-3&4 for gaining experience in plant operations.

In addition to the above, for the operation of FBTR, one person was licensed for the position of Engineer In-charge (Operations) (Level-I), 2 persons were licensed for the position of Senior Shift Engineer (Level-II), 1 person was licensed for the position of Senior Fuel Handling Engineer (Level-II), 4 persons were licensed for the position of Shift Engineer (Level-III) and 6 persons were licensed for the position of Control Room Assistant / Field Supervisor (Level-IV). Another person was licensed for the position of Shift-in -Charge, KAMINI.

**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 | 8 | 3 | - | 3 | - | 2 |
| TAPS-3&4 | 6 | 7 | 1 | 10 | 2 | 2 |
| RAPS-1&2 | 4 | 4 | 1 | 2 | 0 | 2 |
| RAPS-3&4 | 6 | 3 | 3 | 10 | 4 | 3 |
| MAPS-1&2 | 4 | 4 | 2 | 7 | 5 | 2 |
| NAPS-1&2 | 6 | 2 | 1 | 8 | 3 | 2 |
| KAPS-1&2 | 2 | 4 | 2 | 6 | 0 | 2 |
| KGS-1&2 | 4 | 3 | 5 | 4 | 1 | 2 |
| KGS-3&4 | 6 | 6 | 2 | 13 | 2 | 3 |
| Total | 46 | 36 | 17 | 63 | 17 | 20 |

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 the Regulatory Body, 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 categorization depends on the safety significance and importance to operational safety experience feedback. Based on the reporting criteria, Event Reports (ER) and Significant Event Reports (SER) are submitted to AERB.

The SERs received from the operating NPPs are also rated on the International Nuclear Event Scale (INES). The INES system of the International Atomic Energy Agency (IAEA) rates events at seven levels (1 to 7) depending on their safety significance. Events rated at level 4 and above are termed as Accidents. Events rated at level 2 and 3 are called Incidents. An event at level 1 is an anomaly. Events at level 0 or below are called deviations. The IAEA-INES scale is depicted at the end of the report.

The number of SERs for the last five years and their ratings on INES are given in Table 2.6. The classification of SERs for the year 2007 on INES scale is given in Table 2.7. A total of 36 events were reported in the year 2007. Eight events were rated at level 1 on INES and the rest were rated at level 0. The system wise classification of SERs in NPPs is given in Fig: 2.1.

#### Important Events at NPPs

Three events at RAPS-1&2 and three events at NAPS were rated level 1 on INES because of overexposure of plant and temporary workers beyond their respective annual radiation exposure limits. At RAPS-1&2, the events occurred during En-masse Feeder Replacement (EMFR) campaign. Seven temporary workers received radiation exposure, ranging from 16.92 mSv to 26.73 mSv beyond their annual radiation exposure limit of 15 mSv in these events. At NAPS, events of radiation exposure occurred during EMCCR or subsequent unit startup activities in NAPS-1. During these events, three temporary workers received radiation exposure of 15.88 mSv, 18.63 mSv and 18.02 mSv. Also, two plant personnel received radiation exposure of 43.75 mSv and 41.29 mSv that was beyond the limit of 30 mSv prescribed by AERB for the occupational worker.

In a fuel-handling event at TAPS-3, human error during fuel transfer resulted in falling of pair of spent fuel bundles from a height of 0.9 meter on spent fuel receiving bay floor. About 11 fuel pins (out of 37) of one spent fuel bundle got detached and the other spent fuel bundle

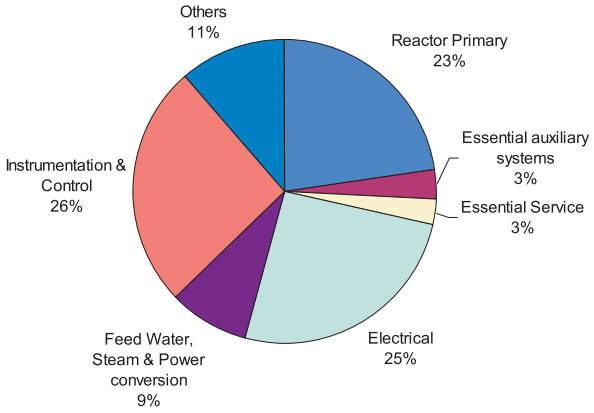
**Table 2.6: Classification of SERs in NPPs as rated on INES**

| INES Levels | April-Dec 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| Out of Scale | 0 | 0 | 0 | 0 | 0 |
| 0 | 21 | 39 | 26 | 34 | 28 |
| 1 | 10 | 4 | 2 | 5 | 8 |
| 2 | 0 | 1 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 |
| >3 | 0 | 0 | 0 | 0 | 0 |
| Total | 31 | 44 | 28 | 39 | 36 |

**Table 2.7: Classification of SERs in individual NPPs (2007)**

| Plant Name | Out of Scale | International Nuclear Event Scale | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | > 3 | Total |
| TAPS-1&2 | | 1 | 0 | 0 | 0 | 0 | 1 |
| RAPS-1&2 | | 5 | 3 | 0 | 0 | 0 | 8 |
| MAPS-1&2 | | 5 | 0 | 0 | 0 | 0 | 5 |
| NAPS-1&2 | | 5 | 3 | 0 | 0 | 0 | 8 |
| KAPS-1&2 | | 0 | 1 | 0 | 0 | 0 | 1 |
| KAIGA | | 0 | 0 | 0 | 0 | 0 | 0 |
| RAPS-3&4 | | 6 | 0 | 0 | 0 | 0 | 6 |
| TAPS-3&4 | | 6 | 1 | 0 | 0 | 0 | 7 |
| Total | 0 | 28 | 8 | 0 | 0 | 0 | 36 |

**Fig. 2.1 : System wise classification of SERs in NPP**




remained intact. There was no breach in fuel pins clad of fallen spent fuel bundles during the event. Event was rated at level 1 on INES.

In a significant event at KAPS-2, 240 V AC Class-II uninterrupted control power supply got affected and reactor tripped automatically. The cause of the event was attributed to deficient design of electrical system that resulted in common mode failure of control power supply. Event was rated at level 1 on INES.

Out of the 28 significant events of level 0 reported in year 2007, an important event was at RAPS-2 on July 2, 2007 where pin-hole leak in one of the PHT system feeders resulted in increase in fuelling machine vault dryer collection and tritium DAC. The core cooling was not affected during this incident. Reason for the leak was identified as substantial reduction in wall thickness due to

flow induced erosion / corrosion. After this incident, the unit was taken under long shutdown for en-masse replacement of primary system feeders, which was earlier planned from November 2007.

## 2.3 FUEL CYCLE FACILITIES

Review and monitoring of safety status of fuel cycle facilities and other nuclear facilities is carried out by IPSD of AERB and SARCOP. A three-tier review process is followed for granting consent for major stages for hazardous facilities of nuclear fuel cycle. For less hazardous facilities, a two-tier review process is followed with first review being conducted by Unit Safety Committee (USC) of the facility/ Design Safety Review Committee (DSRC) for diversified projects or uranium extraction projects. The nuclear fuel cycle facilities of the following organizations are covered.

- Nuclear Fuel Complex (NFC), Hyderabad and Zirconium Complex, Pazhayakayal.
- Heavy Water Plants (HWP), Baroda, Talcher, Thal, Hazira, Manuguru, Tuticorin and Kota.
- Uranium Corporation of India Ltd (UCIL), Jaduguda.
- Indian Rare Earths Research Centre, Kollam, Indian Rare Earths Ltd. (IREL), Udyogamandal, OSCOM, Chavara and Manavalakurichi.
- Atomic Mineral Directorate for Exploration and Research (AMD), Hyderabad.

Highlights on safety status and reviews, regulatory inspections and licensing of personnel carried out with respect to the above facilities are given below. The industrial safety aspects of these facilities are discussed in Chapter 4.

### 2.3.1 Nuclear Fuel Complex

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

- The modification of layout and relocation of equipment for Ceramic Fuel Fabrication Plant Assembly.
- The application for renewal of license for operation of 18 plants/facilities. The application for renewal of license of Uranium Oxide Plant and revised technical specifications of some facilities, are under review.
- Wet processing of sintered Depleted Uranium (DU) pellets, which are not qualified.

### 2.3.2 Heavy Water Plants

The HWPs at Thal, Baroda, Hazira, Kota, Manuguru and solvent facilities at Talcher operated normally during the year. HWP-Tuticorin is under shutdown due to non-availability of synthesis gas supply from SPIC.

The following important proposals/ safety issues were discussed in the Heavy Water Plants Safety Committee (HWP-SC), Design Safety Review Committee for Diversified Projects (DSRC-DP), Uranium Extraction Project (DSRC-UEP), Advisory Committee for Project Safety Review for Fuel Cycle Facilities (ACPSR-FCF) and SARCOP and after ensuring satisfactory compliance to the safety requirements, the following clearances/authorizations/approvals were granted/given.

1. Construction of Heavy Water Clean Up facility (HEWAC) at HWP-Kota

This facility is being set up to clean up the heavy water from primary heat transport system and moderator circuit of nuclear power plants which would help in reducing the tritium concentration in heavy water and thereby the internal dosage of occupational workers of the nuclear power plants.

2. Siting and construction of Versatile Solvent Production Plant (VSPP) at HWP, Talcher

The VSPP will produce various organo phosphorous solvents, namely, Di-2 Ethyle Hexyl Phosphoric Acid (D2EHPA), Tri-Alkyl Phosphine Oxide (TAPO), Tri-Octyle Phosphate Oxide (TOPO) and Di-Nonyl Phenyl Phosphoric Acid (DNPPA).

3. The revised technical specifications of HWP, Kota

4. The proposals for siting and construction clearance for elemental boron facility and boron carbide pelletising unit at HWP-Manuguru and Tri Butyl Phosphate plant at HWP, Baroda are under review.

5. Commissioning of Boron Enrichment Exchange Distillation (BEXD) facility at HWP, Talcher. The facility is designed for production of enriched boron for control rods and neutron detectors.

The revised technical specifications of ammonia based HWPs, namely, Thal, Hazira, Baroda and Tuticorin are under review.

The important incidents that took place in the plants are discussed below.

- An incident of failure of uninterrupted power supply to the Distributed Control System (DCS) panels occurred at HWP, Thal leading to the DCS blackout. Subsequent to this both UPS-1 and UPS-2 failed to supply power. Coincidently, even the DG set tripped on earth fault protection while starting, resulting in non-availability of Class III power supply to the critical loads. The panic lighting was also not available. Necessary actions for safe shutdown of the plant were taken by the field operation staff. DCS supply was restored after 45 minutes. After review of the incident, measures to prevent recurrence of such incidents in future were recommended.

- An incident of over traveling of 100 ton E.O.T. crane hook took place at HWP, Thal. The incident occurred due to simultaneous operation of 100 tons hoist and 15-ton hoist and non-availability of limit switch interlock to limit the over travel. In this process, the hoist rope got cut near the pulleys above the hook, but the rope did not snap completely. Safety Committee, after thorough discussion on the incident, recommended measures to prevent recurrence of such incidents.
- An incident of tilting of a 40 ton crane on a 33/66.6 KVA transformer (which was under maintenance) occurred at HWP, Manuguru. The crane was being used for first time after procurement and was deployed for fixing a LT Bus duct on the transformer. The crane was positioned on main road at a distance of 24 m from the transformer and the crane boom was rotated by 90o. During the extension of the boom to 21 m, the crane got tilted with boom resting on transformer. No personnel were injured due to the incident. The Safety Committee, after thorough discussion on the incident, recommended measures to prevent reoccurrence of such incidents in future.
- An Incident of a contractor's bus hitting and damaging the Reinforced Cement Concrete (RCC) column supporting the cable rack on south side of East Substation occurred at HWP, Manuguru. The column got bent at the bottom portion due to high impact load. Safety Committee, after thorough discussion on the incident recommended measures to prevent reoccurrence of such incidents.

### 2.3.3 Uranium Corporation of India Ltd.

Jaduguda, Bhatin, Narwapahar, Turamdih, Banduhurang mines and Jaduguda mill of UCIL operated normally during the year. UCIL-Turamdih Mill construction activities have been completed and cold commissioning run of Turamdih ore processing plant with inactive material have been started. Development work of Bagjata Mine has been in progress and ventilation circuit is being established.

In the USC/ DSRC-UEP/ ACPSR-FCF/ SARCOP, after ensuring satisfactory compliance to the safety requirements, the following decisions were taken.

- No-Objection Certificate (NOC) was granted for issuing license to Tummalapalle mine.
- Authorization was granted for processing of uranium ore and production of Sodium Di-Uranate (SDU) at site for Tummalapalle Process Plant (Mill) in Vemula Mandal of Cuddapah district; Andhra Pradesh.
- Authorizations were granted for mine development of Mohuldih mine in Sarikela district of Jharkhand and Tummalapalle mine in Cuddapah district of Andhra Pradesh.
- Permission was granted for cold commissioning run of Turamdih ore processing plant with inactive material. The cold commissioning trials have been completed. The proposal for commissioning and operation of Turamdih ore processing plant is under review.
- Two safety related unusual occurrences of leakage through breach in discharge pipeline of tailings were discussed. The root cause of the incident was external damage of the metal portion of pipeline along with damage of internal rubber lining. The measures to minimize the possibility of such incidents in future were recommended.
- As part of decommissioning of Jaduguda Tailings Pond Stage II, proposal for soil capping on the pond to reduce the emanation of radon gas was reviewed. The detailed decommissioning plan of the pond will also be reviewed.
- Technical Specifications of Narwapahar and Bhatin mine have been approved with respect to radiological aspects.
- The authorization for safe disposal of radioactive liquid wastes with enhanced limit from Jaduguda mill was approved.

### 2.3.4 Indian Rare Earths Limited

The mineral separation plants at the IREL Chavara, Manavalakurichi and OSCOM, IREL Udyogamandal and thorium plant at OSCOM operated normally. THRUST Phase-II, i.e., retrieval and processing of thorium oxalate from the silos 4, 5 & 6 for uranium recovery at Udyogamandal has been started. Capacity expansion at IREL, Chavara for enhancing the annual production capacity of Ilmenite, Rutile, Zircon, Illuminite and Monazite concentrates has been completed.

The Safety Committee for IREL plants IRESC, DSRC-UEP, ACPSR-FCF and SARCOP reviewed radiological safety status of the following proposals of the IREL plants for clearance and took appropriate decisions.

- Authorization was granted for construction of 10,000 tpa Monazite Processing Plant for recovery of uranium at IREL, OSCOM.
- The review of the proposal for authorization for siting and construction of Phosphatic Rare Element Extraction project is under review.
- The proposal for THRUST PHASE-II operation at IREL, Udyogamandal was reviewed and after ensuring satisfactory compliance with safety requirements agreed to permit its operation. The revised road map for long-term storage of thorium oxalate from THRUST project along with shielding design was also discussed and accepted.

- The proposal for the construction of underground RCC trenches at OSCOM for storing 3200 t of Thorium Oxalate generated from THRUST project in slurry form was reviewed and the construction clearance was granted. The proposal for construction of underground RCC trenches for storage of solid wastes generated from Thorium Plant, OSCOM (without the chemical barrier and increasing the clay barrier thickness) was also reviewed and accepted.
- The revised SER received from NFC for processing of Uranyl Nitrate Raffinate Cake at Udyogamandal was discussed. On the disposal of the empty drums, it was decided that either the empty drums be sent back to NFC or procedure/scheme for their decontamination and disposal be worked out and submitted for review.
- The proposal for processing of 5 t monazite using sulphuric acid route at Udyogamandal was reviewed and it was recommended to carry out a heat balance and safety analysis of the process and mechanical aspects.
- The revised technical specifications for operation of IREL Udyogamandal and IREL Manavalakurichi were reviewed for approval.

### 2.3.5 Atomic Minerals Directorate for Exploration and Research

- AMD has applied for authorization for exploratory mine development of Gogi mine in Gulbarga district, Karnataka. The exploratory mining project is planned with two levels at 65 m and 120 m from surface and would produce about 1200 tons of uranium ore. After the review of the above proposal, authorization for exploratory mine development of Gogi underground uranium mine was granted.

### 2.3.6 Regulatory Inspections

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

#### (i) Fuel Cycle Facilities

- NFC should establish the reasons for the higher uranium levels in the new settling tanks and take corrective actions to ensure that the uranium level is within the prescribed limits. NFC should also ensure that all drums containing radioactive material are stored in a separate shed so that radiation exposure can be prevented to workers handling inactive material kept inside storage.
- At IREL, Manavalakurichi, the ventilation in the HT platform, rutile and monazite sections of MSP areas should be improved to bring down the Th-232 air activity levels below 0.1 DAC. The radiation level of the monazite pits (I - IV) should be reduced close to the background radiation level. The dose records of contract workers employed for work in radioactive areas should be maintained.
- Any inadvertent discharge of radioactivity by UCIL mines and mills through routes other than authorized routes should be informed to Health Physics Unit (HPU) at UCIL and reported to AERB.
- At IREL, Chavara, spillage of monazite-enriched non-conducting fraction from the rutile circuit should be removed regularly.
- At IREL, OSCOM, solid waste trenches should be tendered well in advance and temporary stacking of solid waste in the stacking yard should not elevate the background radiation level. Any dealing with private parties with respect to the handling of monazite-enriched tailings should be reported to AERB.
- The quarterly records of the personnel dose of the employees at VECC, Kolkata should be made available and maintained properly.

#### (ii) Beach Sand Minerals Industries

M/s V.V.Mineral, M/s Tisaiyanvilai, M/s Beach Sand Minerals Company Pvt. Ltd., Tirunelveli, M/s Dhrangadhra Chemicals Works Ltd., Tuticorin. M/s Cochin Minerals & Rutile Ltd., Alwaye and M/s Kerala Minerals & Metals Ltd., Chavara were inspected during the period. Some of the recommendations were:

- The monazite-enriched waste should be measured and in case monazite fraction is much higher than the raw material feed, it should be mixed with the silica tailings from the heavies upgradation plant prior to backfilling the mined out sites. While doing so, care to be taken that the background radiation levels do not get elevated.
- Mineralogical analysis of monazite content in the feed and tailings from Ilmenite purification plant should be done periodically.
- The monazite-enriched tailings should not be dumped into the sea.
- Radiation caution board should be displayed conspicuously near the waste disposal area to avoid unnecessary occupancy in the area.
- Certified Radiological Safety Officer (RSO) should be appointed.
- Ambient dosimetry should be practiced for the estimation of external dose received by the workers.
- Fencing should be provided around monazite enriched tailings disposal area.
- Periodic radiation survey of the workplace should be done and records maintained.

### 2.3.7 Licensing of Plant Personnel

Licensing Committee for licensing of operating personnel for HWPs met at HWP, Kota, Thal, Hazira, Manuguru and authorised/re-authorised the license of 27 operation personnel.

## 2.4 Variable Energy Cyclotron Centre (VECC)

The existing cyclotron (K-130) was under shutdown for up-gradation and commissioning of RF system. In Radioactive Ion Beam (RIB) facility, phase wise testing of stable beam operation was in progress. The VECC and RRCAT Safety Committee (VRSC) reviewed the concerned reports/issues and took the following decisions.

- The radiation monitoring data of radioactive ion beam facility along with the compliance status of recommendations made during the regulatory inspections should be included in the quarterly progress report sent to AERB.
- Magnet energisation of the super-conducting cyclotron has been completed and commissioning of RF system is in progress. The commissioning status of the super-conducting cyclotron is being reviewed.
- A medical cyclotron facility will be set up at Chakgaria, which will have five beam lines of which, three will be used for radio pharmaceuticals production by Board of Radiation and Isotope Technology (BRIT), fourth and fifth will be used for materials science experiments and for experiments on liquid metal targets respectively. Siting and construction authorization of the facility has been issued.

## 2.5 Raja Ramanna Centre for Advanced Technology (RRCAT)

Indus-1 was operating producing synchrotron 450 MeV beam energy and 100 mA current. Indus 2 has commissioned Stage-3 (i.e., injection of the beam into Indus-2 storage ring at 2 GeV energy and 10 mA current). RRCAT has applied for Stage-4 clearance of Indus-2 and clearance for 2 beam lines along with the necessary documents. LINAC facility was operating at 10 MeV energy level. 15 MeV Free Electron Linear Accelerator (LINAC) was under shutdown. The authorizations for regular operation of Indus-1 and trial operation of 750 keV DC Accelerator were issued after review of the relevant proposals.

# CHAPTER 3

## SAFETY SURVEILLANCE OF RADIATION FACILITIES

### 3.1 SAFETY REVIEW OF RADIATION FACILITIES AND APPROVAL OF SAFETY PERSONNEL

The radiation facilities in India can be broadly classified as Medical, Industrial and Research facilities. Medical facilities include diagnostic X-ray machines, Telegamma units, LINACs, Brachytherapy units using manual and remote after-loading techniques and Nuclear Medicine Centres practicing diagnosis and therapy. Industrial installations include gamma and X-ray radiography equipment, gamma radiation processing plants, ionizing radiation gauging devices (nucleonic gauges) including well-logging devices and manufacturers of certain 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, 2008, is given in Table 3.1.

**Table 3.1: Radiation Installations Regulated by AERB**

| S.No. | Type of Application | Number of Devices in use | Number of institutions |
|---|---|---|---|
| 1 | Diagnostic X-ray | ~ 50,000 | ~ 40,000 |
| 2 | Radiotherapy | | 239 |
| ● | Teletherapy | Telecobalt 280<br>Telecesium 2<br>Accelerators 110<br>Gamma Knife 4<br>Tomotherapy 1 | |
| ● | Brachytherapy | High Dose Rate 112<br>Low Dose Rate 30<br>Manual (Intracavitary) 90<br>Manual (Interstitial) 34<br>Opthalmic (90Sr) 20<br>Opthalmic (125I) 4<br>Opthalmic (106Ru) 2 | |
| 3 | Nuclear Medicine | | |
| | ● RIA Centres | Not applicable | 400 |
| | ● Diagnostic & low dose therapy | | 145 |
| | ● Diagnostic low & high dose therapy | | 35 |
| 4 | Research | Not applicable | 500 |
| 5 | Industrial Radiography | | |
| | ● Radiography Cameras | 1416 | 486 |
| | ● X-ray units | 228 | |
| | ● Accelerators | 12 | |
| 6 | Gamma Irradiators | 12 | 12 |
| 7 | Nucleonic Gauges | 7850 | 1475 |
| 8 | Consumer Products | | |
| | ● Gas Mantle | | 65 |
| | ● Lamp starters | | 20 |
| | ● Smoke Detectors | Not applicable | 102 |
| | ● Electron Capture Detectors (ECD) | - | 585 |

### 3.1.1 Type Approvals

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

**Table 3.2: Type Approvals Granted**

(Radiation Generating Equipment and Equipments Containing Radioactive Material)

**A. NOCs Issued**

| Sr. No. | Type of Equipment | Number of Approvals Issued |
|---|---|---|
| 1. | Med ical Diagnostic X-ray Units | 38 |
| 2. | Computed Tomography Units | 6 |
| 3. | Radiotherapy Simulators | 1 |
| 4. | Patient Positioning Systems | 2 |
| 5. | Tele Cobalt Units | 2 |
| 6. | Gamma Knife Units | 2 |
| 7. | CyberKnife Unit (Robotic Radiosurgery System) | 1 |
| 8. | Medical Linear Accelerators | 1 |
| 9. | Remote Controlled Afterloading Brachytherapy Units | 5 |
| 10. | Integrated Brachytherapy Units | 1 |
| 11. | Industrial Radiography Exposure Devices | 2 |
| 12. | Portable X-ray Betatron | 1 |
| 13. | Industrial Radiation Gauging Device | 1 |
| 14. | Relocatable X-ray based Container Scanner System | 1 |
| 15. | Radio Surgery Treatment System | 1 |
| 16. | Medical Cyclotron | 1 |
| 17. | Industrial Linear Accelerators | 2 |

**B. Type Approvals**

| Sr. No. | Type of Equipment | Number of Models Type approved |
|---|---|---|
| 1 | Medical Diagnostic X-ray units | 95 |
| 2 | Computed Tomography (CT) Units | 15 |
| 3 | Radiotherapy Simulators | 2 |
| 5 | Tele Cobalt Units | 2 |
| 6 | Medical Linear Accelerators | 6 |
| 7 | Remote Controlled After-loading Brachytherapy Units | 5 |
| 8 | Industrial Radiation Gauging Devices | 21 |
| 9 | Type B(U) Package | 1 |
| 10 | X-ray Baggage Inspection Systems | 2 |
| 11 | Ionization Chamber Smoke Detector | 1 |

**C. Consents**

| Sr. No. | Type of Facilities | Permission Granted |
|---|---|---|
| 1 | Site Approval for installation of new Gamma Radiation Processing Plants | 3 |
| 2 | Design and Construction Approval for Gamma Radiation Processing Plants | 4 |
| 3 | Design and Construction Approval for Integrated Facility for Radiation Technology | 1 |
| 4 | Regulatory Consent for routine operation for Gamma Radiation Processing Plant | 1 |
| 5 | Certificate of Approval for radiation processing of Food products | 2 |
| 6 | Design and Construction Approval of Medical Cyclotron | 1 |
| 7 | Commissioning Approval for Medical Cyclotrons | 2 |
| 8 | Regulatory Consent for operation of Industrial Accelerators | 4 |
| 9 | Site Approval for installation of fixed X-ray based Container Scanner | 1 |

### 3.1.2 Approval of Radiological Safety Officers

The approval certificates issued to Radiological Safety Officers (RSOs) are given in Table 3.3.

**Table 3.3: Approval Certificates Issued to RSOs**

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

### 3.1.3 Approval of Packages for Transport of Radioactive Material

As per AERB regulations, Type-A packages, which are permitted to transport radioactive material of activity not exceeding the specified limits, need to be registered with AERB. All Type-B packages are subjected to a stringent approval procedure and are required to fulfill the regulatory standards. One validity certificate of approval of design of Type-B package was renewed.

## 3.2 LICENSING / AUTHORISATION AND REGULATORY INSPECTIONS

### 3.2.1 Licensing / Authorization

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

AERB issued 195 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 during the year 2007-08 for procurement and disposal of radioactive sources, are given in Table 3.4.

**Table 3.4: Licences / NOCs Issued**
**A. Procurement of source**

| Sr. No. | Type of application | Regulatory licences / NOC issued in 2007 | |
|---|---|---|---|
| | | Local | Import |
| 1 | **Radiotherapy** | | |
| | ● Telecobalt | 28 | 12 |
| | ● Telecaesium | - | - |
| | ● Accelerators | 1 | 30 |
| | ● Gamma Knife | - | 1 |
| | **Brachytherapy** | | |
| | ● HDR | 4 | 158 |
| | ● LDR | 4 | - |
| | ● Manual (Intracavity & Interstitial) | 4 | - |
| | ● Opthalmic Sr-90 | - | - |
| | ● Opthalmic I-125 | - | - |
| | ● Ophthalmic Ru-106 | 1 | - |
| 2. | **Nuclear Medicine** | | |
| | ● RIA facilities | 1 | 115 |
| | ● Diagnostic & Therapeutic | 143 | 95 |
| | ● Research | 36 | 191 |
| 3. | Industrial Gamma Radiography Exposure Devices | 822 | 50 |

| | | | |
|---|---|---|---|
| 4. | Gamma Irradiators (Category-IV) | 11 | 0 |
| | Gamma Irradiators (Category-I) | 3 | 1 |
| 5. | Nucleonic Gauges | 49 | 187 |
| 6. | Diagnostic X-ray (Registered) | 195 | 0 |
| 7. | **Consumer Products** | | |
| | ● Gas Mantles | 45 | - |
| | ● Lamp starters | 2 | - |
| | ● Electron Capture Devices | - | 104 |
| | ● Smoke detectors | - | 12 |
| | ● Explosive detectors | - | 22 |

### B. Authorizations for Export and Disposal of Sources

| Export | | Disposal of sources | | | |
|---|---|---|---|---|---|
| **By BRIT & IRE (Sale)** | **By other users** | **Authorisations** | **No. of Sources disposed Off** | | |
| 61 | 102 | 106 | At BRIT | At WMD, BARC & CWMF Kalpakkam | Returned to original supplier abroad |
| | | | 130 | 80 (ICSD),229 & 225 kg(DU) | 258 |

### 3.2.2 Shipments Approved

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

### 3.2.3 Regulatory Inspections

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

**Table 3.5: Regulatory Inspections**

| Sr. No. | Facilities | No. of Institutions | No. of Inspections |
|---|---|---|---|
| 1 | Diagnostic X-ray | ~ 40,000 | 80 |
| 2 | Radiotherapy | 230 | 07 |
| 3 | Nuclear Medicine | 145 | 40 |
| | ● Diagnostic & low dose therapy | 110 | |
| | ● Diagnostic, Low dose therapy & Ca thyroid treatment centres | 35 | |
| 4 | Research | 500 | |
| 5 | Industrial Radiography | 486 | 42 |
| 6 | Gamma Irradiators | 12 | 12 |
| 7 | Nucleonic Gauges | 1464 | 18 |

## 3.3 RADIOLOGICAL SAFETY SURVEILLANCE

### 3.3.1 Radiation Diagnostic and Therapy Facilities

On the basis of pre-commissioning safety evaluation, AERB issued authorizations for the commissioning of 22 Teletherapy units (11 Telecobalt units and 11 Medical LINAC) and 7 remote after-loading Brachytherapy units, and for the decommissioning of 1 Teletherapy unit during the year. Permissions were accorded for re-starting 12 Telecobalt units after source replacement and 13 new radiotherapy centres. Forty nuclear medicine facilities were inspected. AERB reviewed annual safety status reports received from the licensees and inspected 80 medical X-ray diagnostic installations. Deviations and violations of regulatory requirements were taken up with the users. In some cases, AERB initiated appropriate regulatory actions such as suspension of license.

### 3.3.2 High Intensity Gamma Irradiation Facilities

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

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

The quarterly safety status reports were received from all the operating gamma radiation-processing facilities. The occupational exposures of any worker 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. Five proposals for the loading/ replenishment of Cobalt-60 sources from such facilities were reviewed and clearances were issued. The pre-commissioning testing and inspection was carried out for one gamma irradiation facility.

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

### 3.3.3 Industrial Radiography

There are 486 industrial radiography institutions in India. The total number of industrial gamma radiography exposure devices deployed for radiography work is 1416. There are 228 Industrial X-ray units and 12 industrial accelerator facilities. During the year, AERB carried out announced as well as unannounced inspections of 42 industrial radiography sites and installations. The monthly safety status reports received from radiography institutions were reviewed to ensure availability of safety infrastructure and inventory of radiography devices/sources. Type approval applications for new models of radiography devices were reviewed and approved.

### 3.3.4 Nucleonic Gauging

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

### 3.3.5 Transport of Radioactive Materials

Thirty four permissions for transport of radioactive material were issued, while 246 packages were inspected in 3 regulatory inspections. AERB communicates regularly with other government authorities for the safe transport of radioactive material in and out of the country. The concerned nodal and other agencies are Director General of Civil Aviation (DGCA), New Delhi, Port Trusts, Indian Railways, Airport Authority of India and Customs.

### 3.3.6 Disposal of Radioactive Materials

The users send decayed radioactive materials from medical, industrial and research institutions for safe disposal to the original supplier or to one of the approved radioactive waste disposal facilities in India. The number of authorizations issued for export to original supplier abroad was 102. The number of authorizations for transfer to domestic supplier and waste management agencies was 106.

Before the authorization for disposal of the material is issued, safety assessment of the disused sources is done by physical inspection, correspondence with the waste generator and the authorized waste management agency. A total of 129 such assessments were done during the year. One such safety assessment of the disused sources was carried out physically at a big steel plant in the country by a team of officers from AERB and Central Waste Management Facility (CWMF). Altogether 228 transport containers were identified containing 268 nos. of radioactive

sources. The gauges were old and mostly supplied by Russia. Four gauges were found in damaged condition and particularly one gauge containing Cs-137 source lost all shielding resulting in the radiation level on the surface of the container showing up to 22 R/h. The other three gauges were showing up to 1.2 R/h on the surface. The diagram of the source containers and source retrieval procedures for the gauges were not available. The plant authority was advised to pack these gauges in specially designed containers for disposal. It was told to the plant authority that they should get the clearance from the Kalpakkam Committee to dispose off this large voluminous radioactive waste and contact AERB for obtaining the clearance for transport of the radioactive waste from the plant site to Kalpakkam.

## 3.4 UNUSUAL OCCURRENCES

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

### 3.4.1 Industrial Radiography

**Case 1:** A 50 Ci Ir-192 industrial radiography source contained in Gammarid Radiography camera Sr.No. 216 was reported to be stolen from the source storage pit during midnight between 01:00 to 05:00 hrs on 25-04-07 at Indo Gulf Fertilizer Ltd. (IGFL) site, Jagadishpur located about 90 km from Lucknow. FIR was lodged with local police. AERB expert team made an extensive search at all probable locations including metal scrap dealers in that area. But the source could not be traced. Police is still working on this case. Radiography agency and IGFL were directed by AERB to enhance security measures at their premises and make Standard Operating Procedures (SOP) for implementation with immediate effect to prevent recurrence of such incidents in future. The device has adequate shielding with proper locking mechanisms to prevent inadvertent removal of the radioactive source from the device. No radiation injury has been reported. Since the radiography source is safely contained inside Industrial Radiography Exposure Device (IGRED), it is not expected to cause any significant radiological hazard to the members of the public

**Case 2:** IGRED model Gammarid, Sr. No. 63 with 0.6 TBq (15 Ci) Ir-192 industrial radiography source, belonging to M/s General Industrial Inspection Bureau (GIIB), Jamshedpur was reported to be stolen from the source storage pit of M/s TISCO Jamshedpur. FIR was lodged with local police at Bistupur Police Station, Jamshedpur on 27-08-07 by M/s GIIB, Jamshedpur. Search operations were launched with the help of Police. Radiation detection surveys were carried out at various locations near the incident site. The source could not be recovered inspite of extensive search operations by using high sensitivity radiation survey instruments. The device has adequate shielding with proper locking mechanisms to prevent inadvertent removal of the radioactive source from the device. No radiation injury has been reported. Since the radiography source is safely contained inside IGRED, it is not expected to cause any significant radiological hazard to the members of the public.

**Table 3.6: Unusual Occurrences (2007)**

| Application | Number of Institutes | Type of Violations/ Cause of Occurrence |
|---|---|---|
| Industrial Radiography | 2 | Theft of radiography sources |
| Nucleonic Gauges | 1 | Sources getting stuck up during well logging operation |

### 3.4.2 Nucleonic Gauges

Oil well logging tool containing Am-Be (20Ci) and Cs-137 2Ci was stuck on 3/6/2007 into the well at a depth of 1938.5 m. The well belongs to M/s ONGC, Mehsana. The 241Am-Be sources have been fished out successfully, however Cs-137 source was abandoned inside the well with adequate concrete plugging.

### 3.4.3 Transport

There was an incident of non-compliance with regulatory requirements during transport of radioactive material by a hospital to CWMF, Kalpakkam, for safe disposal. The major non-compliances included (i) improper marking and labeling of the package, (ii) non declaration of radioactive consignment in the transport document and (iii) transport documents were not provided to the transporter. The non-compliances were observed by CWMF. The matter was reported to AERB. A show cause notice was issued to the hospital. The management of the hospital felt extremely sorry and committed that they would take utmost care in future to avoid such non-compliances of regulatory requirements.

### 3.4.4 Radioactive Contamination in Steel Products

Radioactive contamination was reported in steel products exported to UK and US. It was noted that all the shipment of contaminated steel products originated from Kolkata. AERB conducted inspection of 24 factories manufacturing engineering products at Kolkata for detection of radioactive contamination in the steel products on the request of Engineering Export Promotion Council, Eastern Region, Kolkata and some of the manufacturing companies. Some radioactive contaminated items were located in six factories and safe disposal of the same was arranged. The manufacturing units and exporters of steel products have

been advised to use the radiation monitoring equipment for detection of radioactive contamination. AERB is in the process of accreditation of some laboratories to give radiation free certification for steel items.

## 3.5 OTHER ACTIVITIES

### 3.5.1 Response to Seizure of Material Falsely Claimed to be Uranium

AERB officer acted as first responder to the seizure of material claimed to be uranium by Lucknow police. However, preliminary testing showed that material was not uranium and subsequent laboratory testing confirmed that the material was organic ion-exchange resin.

### 3.5.2 Inspection of the Ship, Blue Lady, at Alang Ship Breaking Yard

Inspection of the Blue Lady, passenger ship at Alang, Bhanvnagar, was carried out for checking presence of any radioactive material on board the ship as per the directive from the Hon'ble Supreme Court. The ship was inspected by a team of officers from AERB and Gujarat Maritime Board (GMB). During the inspection it was found that the ship had no radioactive material on board except a few ionization based smoke detectors. These detectors were removed from the ship and handed over to the ship breaker company and advised for safe disposal at BARC through AERB.

### 3.5.3 Joint Inspection with IMO Team

A joint team of AERB and International Maritime Organisation (IMO) also visited Alang Ship Breaking Yard, Alang, as a part of the programme of the National Workshop on Recycling held in Mumbai, organized by Director General of Shipping, Government of India, under the sponsorship of IMO. The main aim of the visit by the IMO team to Alang was to have first hand knowledge of the ship breaking activities going on at Alang and to assess the safety of the workers involved in the ship recycling industry at Alang. Altogether there were 13 foreign delegates in the team. The visit of the AERB representative was to address the issue concerning presence of the radioactive material in the ship due for breaking.

### 3.5.4 Accreditation of Laboratories

- Performance assessment of the low level counting laboratory at Health Physics Division, Inter University Accelerator Centre, New Delhi was carried out and the Accreditation Certificate was issued by Chairman, AERB to the laboratory for measurement of radionuclide content in commodities.
- As per the requirements given in the AERB Booklet on the implementation of the AERB Program for Accreditation of Bio-dosimetry Laboratories for Assessment of Personnel Radiation Exposures, applications were received from one private institution and one laboratory of the DAE for obtaining accreditation/certificate. A team of AERB representatives inspected the laboratories to verify compliance with the requirements of the booklet. Based on the recommendations of the team, accreditation certificates have been issued by Chairman, AERB to the two laboratories for assessment of personnel radiation exposures by biodosimetry techniques.

### 3.5.5 Formation of Directorate of Radiation Safety (DRS) in various States

Some of the State Governments such as Goa, Andaman Nicobar, Nagaland, Tripura, Assam have issued the notification regarding the formation of DRS in their respective States as per the directives of Supreme Court.

An officer from AERB participated in the review committee meeting of DRS, Kerala on 26-9-2007 at Thiruvananthapuram. The renewal of authorization to DRS by competent authority will be issued after they get the new space for their office and employing four radiation safety inspectors as detailed in the original authorization.

Government of Karnataka had shown keen interest in the formation of DRS. AERB had a meeting with Additional Chief Secretary & Principal Secretary, Health & Family Welfare Department, Government of Karnataka and their team on Oct. 29, 2007 and briefed them about the duties and responsibilities of DRS for effective functioning of DRS.

### 3.5.6 Training Activities

- Training programmes were conducted for medical physicist-cum-RSO in radiation therapy facilities, technicians for radiotherapy and radiographers in DAE hospitals and for qualifying persons as RSOs for gamma radiation processing facilities and nuclear medicine centres. In addition, AERB personnel participated in training rogrammes for medical physicist-cum-RSO in radiation therapy facilities and for qualifying persons as RSOs for gamma radiation processing facilities and nuclear medicine centres.With this effort, the number of trained manpower for radiological safety function has increased substantially and will contribute to improved radiological safety in radiation facilities.
- AERB officers served as faculty for Diploma courses in Radiological Physics and other courses conducted by BARC.
- RSD participated in the appraisal program carried out on "Radiation Safety Aspects in Handling of Nucleonic Gauges" at M/s Bongaigaon Refinery & Petrochemicals Ltd., Bongaigaon, Assam during May 3 & 4, 2007.
- A one-day radiation safety awareness programme for Indian Customs was arranged at Jawaharlal Nehru Customs House, Nhava Sheva. The programme was arranged for the personnel involved with the operation of container scanner installed at Jawaharlal Nehru Port Trust.

# CHAPTER 4

## INDUSTRIAL SAFETY

### 4.1 INTRODUCTION

AERB carries out review and monitoring of industrial safety status in nuclear power plants/projects, nuclear fuel cycle and associated facilities of DAE. Licenses are issued/renewed and regulatory inspections on industrial and fire safety aspects are carried out under the Factories Act 1948 and the Atomic Energy (Factories) Rules, 1996.

There have been 2 fatalities during the year (April 2007- March 2008) due to industrial accidents at RAPP-5&6 construction site. These accidents were investigated to arrive at the root cause and remedial measures were suggested to the site to prevent recurrences of such accidents. Table 4.1 gives the brief details of the accidents and recommendations made by the Fatal Accident Assessment Committee. After the fatal accident in June 2007 the construction consent issued to RAPP-5&6 was suspended for a period of about one week till implementation of corrective actions and the recommendations made by AERB was completed. Subsequently, AERB lifted the suspension order after the verification of the implementation of the measures taken by NPCIL to prevent recurrences of such incidents.

**Table 4.1 Fatal Accidents**

| Sr. No. | Date | Unit | Event | Recommendations made by the Fatal Accident Assessment Committee |
|---|---|---|---|---|
| 1 | 06.04.07 | RAPP-5&6 | ● Fall from height (through a hatch opening) | ● All weak barricades should be strengthened and minimum safety requirements for work at height should be maintained as per notification by Chairman, AERB.<br>● Proper identification and accounting of openings with drawings should be done. |
| 2 | 26.06.07 | RAPP-5&6 | ● Fall from height (through an opening) | ● Area in-charge/contractor's supervisor should identify hazards/openings before start of the jobs in the morning hours and apprise the workers.<br>● Every opening in the floor of a building shall be pro vided with suitable means to prevent fall of persons / materials. |

In order to enhance industrial safety at construction sites, AERB decided to conduct "Special Monthly Inspections" at all Nuclear Power Project sites and other front-end fuel cycle construction sites with respect to industrial safety focusing on work at height. Special monthly/ quarterly inspections were carried out at RAPP-5&6, KK-NPP, Kaiga-3&4, DFRP, BHAVINI, Turamdih mills, Zirconium Complex, Pazhakayal, HEWAC facility at HWP-Kota, VSPP site at HWP-Talcher, boron enrichment plant and elemental boron plant at HWP-Manuguru. It was emphasised that minimum safety requirements, JHA, preparation of safe working procedures and use of field check list on JHA, that are mandatory for all hazardous works at sites, should be strictly enforced.

### 4.2 LICENSES/APPROVALS

The following licenses and approvals for operation were renewed/issued to various DAE units under the Factories Act, 1948:

**Licenses**

- License for IREL-OSCOM thorium plant for a period of five years on April.24, 2007.
- License for TAPP- 3&4 for a period of five years on May 18, 2007.
- License for RAPS- 3&4 for a period of five years on September 24,2007.
- License for KGS -1&2 for a period of five years on December 5,2007.

**Approvals**

- Twelve officers from IGCAR.
- Three officers from HWP-Tuticorin.
- Fifteen officers from RAPS-1& 2.
- Twenty officers from TAPS-3&4.
- Seventeen officers from NFC, Hyderabad.

- Seven officers from HWP, Hazira.
- One officer from HWP, Talcher.
- One officer from KAPS.
- Three officers from NAPS.
- Eight officers from RAPP-5&6.

## 4.3 REGULATORY INSPECTIONS

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

During the year, 46 regular inspections, 34 monthly inspections at construction sites of nuclear power projects and operating plants of DAE to ensure minimum safety requirements (with emphasis on safety in work at height) and 6 special inspections (to check compliance status of recommendations made by SARCOP, pre-start-up of NAPS-1 after EMCCR etc.) were carried out at various operating plants of DAE. During these inspections, the inspectors enforced immediate rectification of the unsafe conditions observed. JHA preparation of safe working procedure and use of field checklist based on the JHA were made mandatory for all hazardous works at the project sites. Based on the findings of these inspections and AERB directives, AERB, NPCIL, HWB, UCIL and BHAVINI have issued notifications empowering the Head (Industrial and Fire Safety) of the concerned project site to stop work in case of observing any safety related deficiencies at their project sites and instructed the project directors to ensure proper supervision, use of Personnel Protective Equipment (PPE) especially during work at height, implementation of work permit system, JHA for hazardous activities, etc. Some of the recommendations that emerged from the inspections of different units are given below.

### 4.3.1 Important Recommendations

- Audiometry test should be conducted for the identified persons working in the noisy area (> 85 dBA) irrespective of time of exposure. (All operating plants)
- Periodic examination and testing of lifting machines and lifting appliances should be done once in a year as per rule No.35 of Atomic Energy (Factories) Rules 1996. (NFC, UCIL, RRCAT)
- Accidents should be reported as per the procedure of Notification of accidents specified in Rule 89 of the Atomic Energy (Factories) Rules, 1996. (HWP, UCIL)
- All the open sides of a structure and floor openings should be barricaded or suitably covered to prevent fall of a person from height. (Nuclear Power Projects)
- ISI of main and mini cracker unit should be done as specified in the revised ISI code. (NH3 based Heavy Water Plants)
- Sectional level safety committee meeting should be conducted once in a month as per rule 44 (2) of Atomic Energy (Factories) Rule, 1996. (Nuclear Power Plants)
- Hydrostatic testing of the pressure vessels should be done as per Rule 36 of the Atomic Energy (Factories) Rules, 1996. (VECC)
- Periodic functional checks should be done of the interlocks, scram switches, alarms in different accelerators. (RRCAT)
- Safety work permit system should be implemented for carrying out hot work jobs and working on electrical installations. (ECIL)

## 4.4 PROMOTION OF INDUSTRIAL SAFETY

### 4.4.1 DAE Safety and Occupational Health Professionals Meet

The 24th DAE Safety and Occupational Health Professional Meet was held at Rawatbhata site, Rajasthan during December 29-31, 2007. The meet was organized jointly by AERB and RAPP-5&6. The theme of the meet was "Construction Safety and Medical Management of Industrial Accidents". Around 225 delegates and invited speakers participated in this meet. There were plenary and parallel sessions and one poster session apart from the inaugural and valedictory sessions. The topics included construction safety, innovation in construction safety, medical management of industrial accidents, occupational health, injury and occupational health statistics and fatal accidents. AERB's Green Site Award for the year 2006 was won by IREL-OSCOM and KAPS and was presented on this occasion. Dr. S.K.Jain, CMD, NPCIL delivered endowment lecture and released the AERB Monograph on "Construction Safety". This professional meet is organized every year and is serving as a forum where the experts in industrial safety exchange their experience.

**Release of Monograph on Construction Safety at the 24th Annual Meeting of DAE Safety & Occupational Health Professionals at RAPP Site**

*(L to R: Shri C.P.Jhamb,Site Director, RAPP-5&6, Shri S.A. Bhardwaj, Director (Technical), NPCIL, Shri S.K. Jain, CMD, NPCIL, Dr. Anil Kakodkar, Chairman, AEC& Secretary, DAE , Shri S.K. Sharma, Chairman, AERB and Shri R. Bhattacharya, Head, IPSD, AERB)*

### 4.4.2 Industrial Safety Statistics

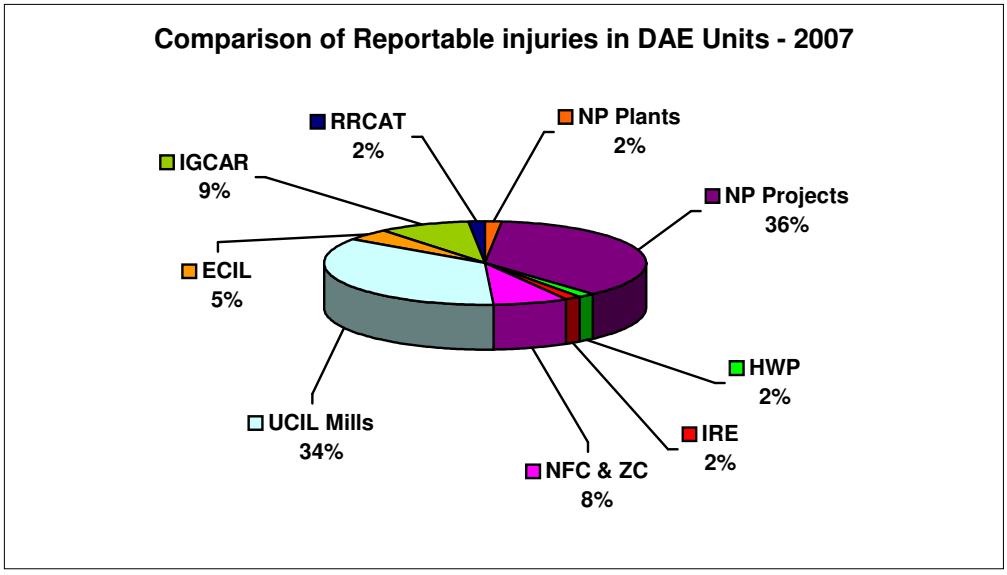
The compilation of Industrial Safety Statistics-2007 of DAE (other than BARC facilities and mines) provides the information on data on accidents and analysis of number of injuries and man-days loss caused by various factors.

There were 65 reportable injuries including 5 fatalities (during the calendar year 2007) and 4 amputations (on fingers), which contributed to 33,234 man-days loss in DAE units in the year 2007, compared to 43 reportable injuries including 4 fatal accidents and 26,106 man-days loss in the year 2006 in DAE units. Out of the 33,234 man-days loss, 225 are due to the accidents occurred in the year 2006. The total man-hours worked in 2007 were 135 millions compared to that of 161millions in 2006. No case of occupational disease was reported for the year 2007 in the DAE units. Fig. 4.1 gives the distribution of reportable injuries among DAE units and Fig. 4.2 gives the distribution of man-days lost with respect to type of accidents in DAE units.

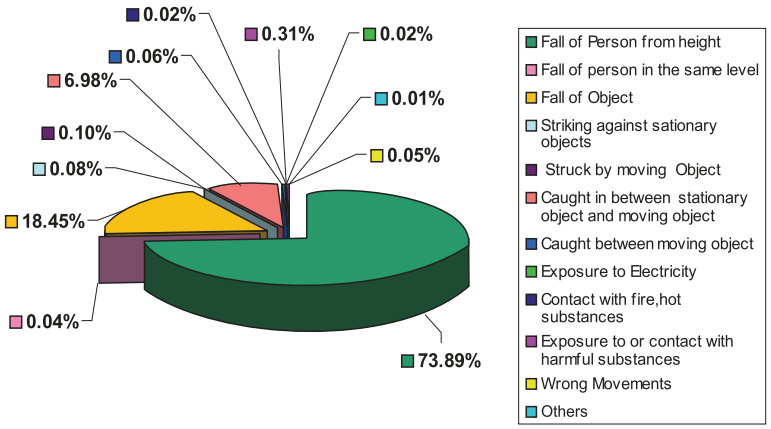
The data was compared with similar units outside DAE in India. It was observed that industrial safety performance of DAE units is better than other similar industries in the country. Table 4.2 gives the comparison of incidence rates in some DAE units with other similar industries in the country. Unit-wise comparison of injury Frequency Rate (F.R) and Severity Rate (S.R) are given in Figs. 4.3 and 4.4 respectively. In Figs 4.5 to 4.7 distribution of injuries caused due to unsafe acts, man-days lost due to unsafe conditions and injuries with respect to the nature of injury in DAE units are reported respectively.

In the year 2007, reporting of near miss accidents has been implemented from different units of DAE. Statistical analysis shows, 39 % of the reported near miss accidents were in the category of "fall of objects". The other frequent types of near miss accidents were "struck by moving object", "exposure to electricity", "fall/slip of person in the same level" and "fall of person from height".

**Fig 4.1: Distribution of Reportable Injuries in DAE Units (2007)**



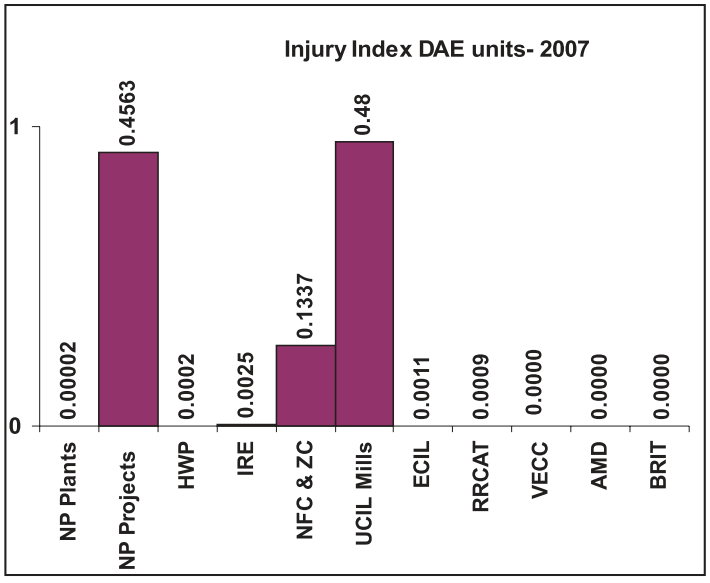
## Fig.4.2: Distribution of Man-days Loss in DAE Units (2007)



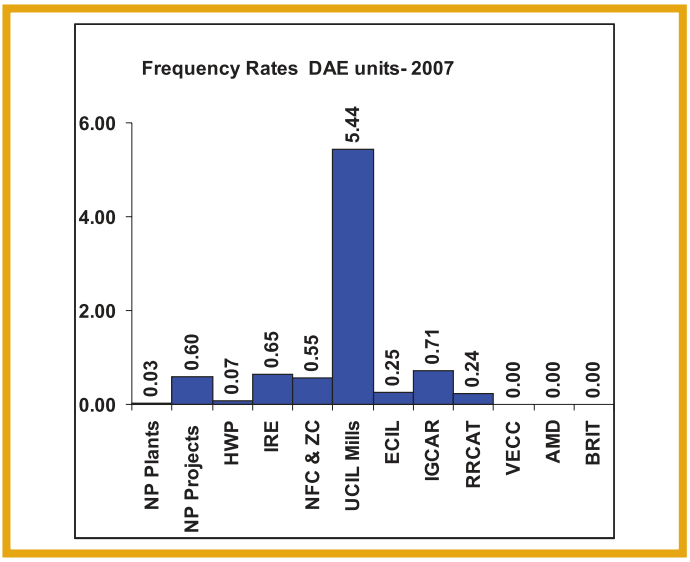

## Table 4.2: Comparison of Incidence Rates of DAE Operating Units with Equivalent Non-DAE Industries (2007) in India

| Industry Type | Incidence Rate | |
|---|---|---|
| | Fatal | Non-Fatal |
| Heavy Water Plants (2007) | 0 | 0.18 |
| Manufacture of Chemicals & Chemicals products (2002) | 0.23 | 2.64 |
| Nuclear Fuel Complex (2007) | 0 | 1.15 |
| Manufacture of Fabricated Metal Products except Machinery and Equipment (2002) | 0.10 | 4.95 |
| Nuclear Power Plants (2007) | 0 | 0.07 |
| Electricity, Gas, Steam and Hot Water Supply (2002) | 0.47 | 5.07 |

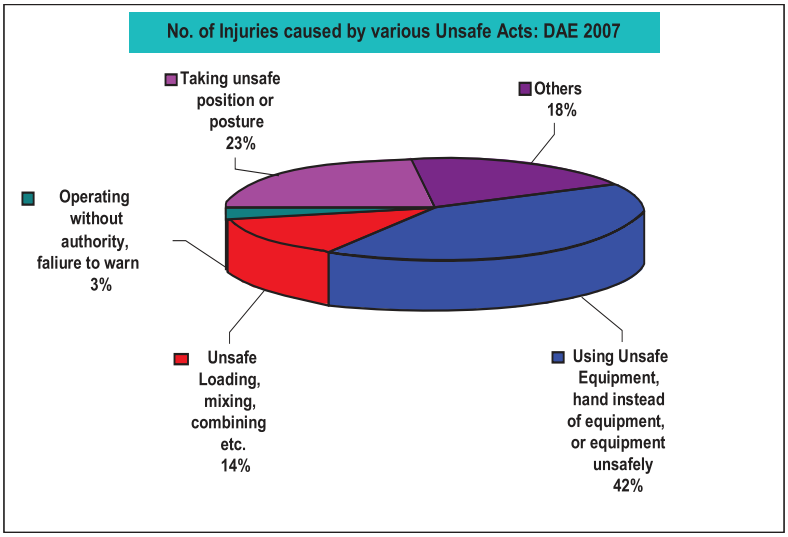
## Fig. 4.3: Injury Index of DAE Units (2007)



## Fig. 4.4: Frequency Rates in DAE Units (2007)




## Fig. 4.5: Distribution of Injuries caused due to Unsafe Acts in DAE Units (2007)




## Fig 4.6: Distribution of Man-Days lost due to Unsafe Conditions in DAE Units (2007)

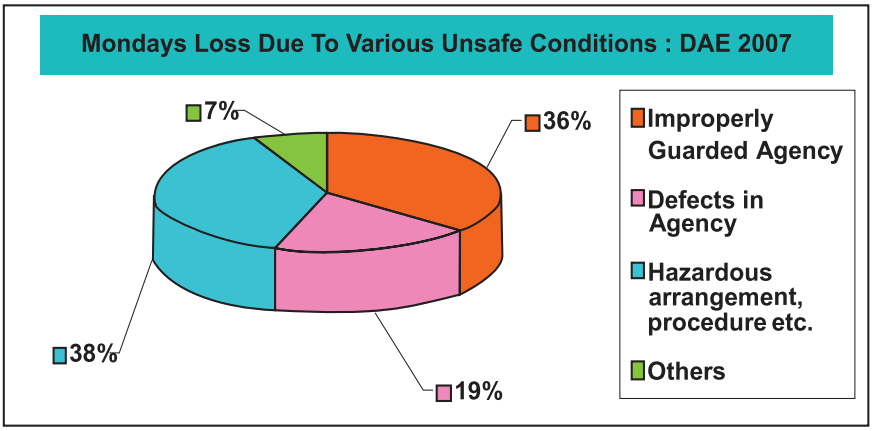
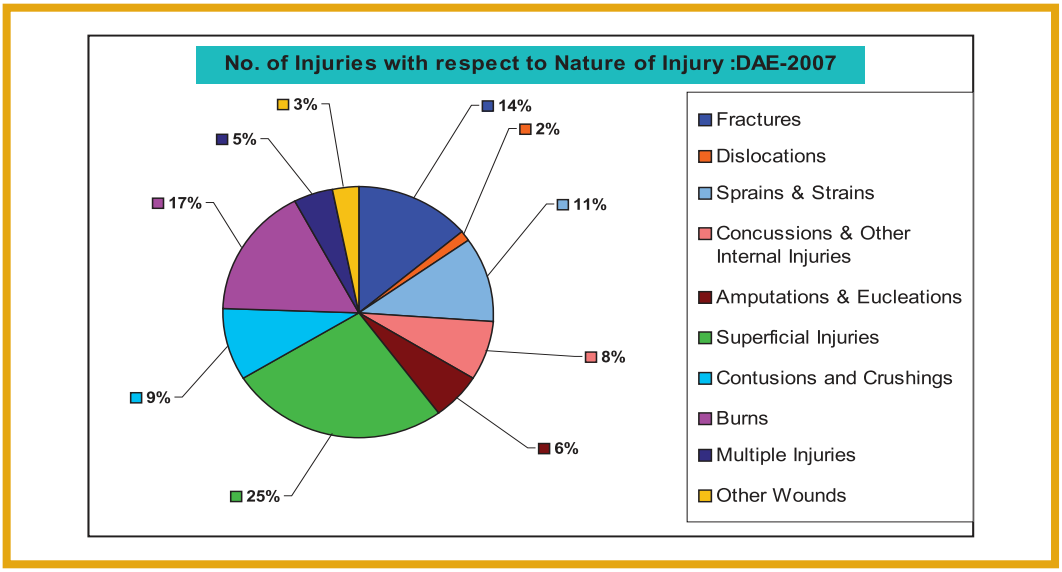


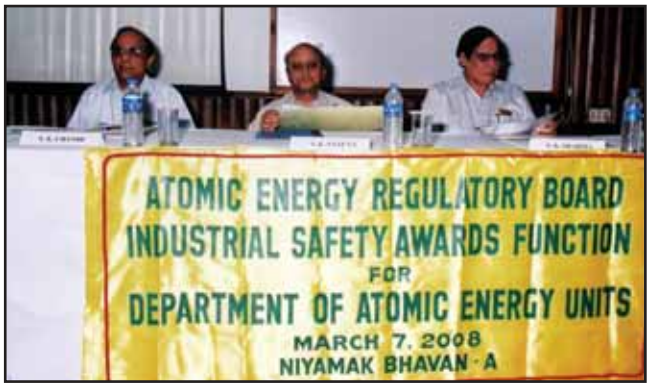
**Fig 4.7: Distribution of injuries with respect to the Nature of Injury in DAE Units (2007)**




### 4.4.3 Industrial Safety Awards

The annual Industrial Safety Awards function of AERB for the year 2007 was held on March 7, 2008. The assessment of the plants for the awards is based on a set of parameters that include number of reportable injuries and their severity, longest accident free periods, safety training imparted to personnel and efforts made by plants towards improving safety.

Shri S.K. Saxena, Director General, Directorate General Factory Advice Service & Labour Institutes (DGFASLI), Mumbai presented the Safety Awards for the year 2007 to the award winning units namely, KGS-1&2 and thorium plant-IREL-OSCOM in the production units group, KK-NPP in the construction group and VECC in research units group for attaining high levels of Industrial Safety. A compilation entitled "Industrial Safety Statistics-2007 of the DAE units" was also released during this function.




**Inauguration of AERB Industrial Safety Award Function**
*(L to R: Shri S. K. Chande, Vice-Chairman, AERB, Shri S.K. Saxena, Director General, DGFASLI and Shri S.K. Sharma, Chairman, AERB)*

### 4.4.4 Green Site Award

The Green Site Award for the year 2006 was given to winning units during the 24th DAE Safety & Occupational Health Professional Meet held at Rawatbhata site, Rajasthan during December 29-31, 2007. The award was based on the highest value of Greenery (G) of the site. Greenery of the site is the product of existing greenery area (E) and efforts made for green site (T). In the calculation of efforts made for green site, weighing factor for terrain conditions of the site and effective site area is taken into consideration. The DAE units are divided in two categories based on the total area of the plant including housing colony site (X) namely, Category-A (X < = 350 hectares) and Category-B (X > 350 hectares). Based on these criteria, in Category-A, IREL-OSCOM was the winner and in Category-B, KAPS-1&2 was the winner.

### 4.4.5 Fire Safety Awards

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

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

Deshmukh, Director-Fire & Emergency Services, Government of Maharashtra presented the awards to the winning units.

### 4.4.6 Amendment of Atomic Energy (Factories) Rules, 1996

Advisory Committee on Industrial and Fire Safety (ACI & FS) has taken up the task of amendment of the Atomic Energy (Factories) Rules, 1996 and constituted subcommittees to review the various changes suggested. Further work is in progress.

### 4.4.7 Fire Standard Revision

ACIFS discussed on the "Revised Standard for Fire Protection Systems for Nuclear Facilities" and the views presented by DAE units. The document is in final stage of approval.

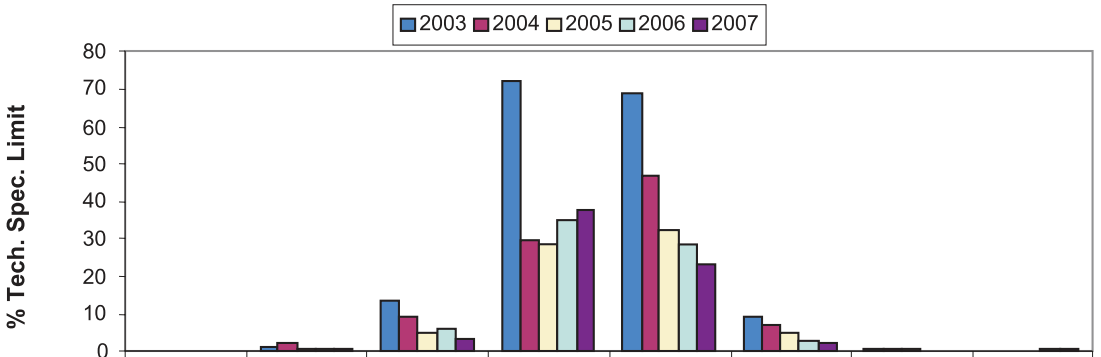
# CHAPTER 5

## ENVIRONMENTAL SAFETY AND OCCUPATIONAL HEALTH AND SAFETY

### 5.1 ENVIRONMENTAL SAFETY

The Environmental Survey Laboratories (ESL) of the Health, Safety and Environment Group, BARC carry out environmental surveillance at all the operating nuclear power plants at sites. The liquid and gaseous waste discharged to the environment during the year 2007 from the operating units was only a small fraction of the limits specified in the Technical Specifications. Figs. 5.1a - 5.1e show the liquid and gaseous discharges from the plants for the years 2003, 2004, 2005, 2006 and 2007 as percentage of Technical Specification limits. Figs. 5.2a and 5.2b show the committed dose to the members of public due to release of radioactive effluents from the plants. Radiation dose to members of the public near the operating 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 NPP sites, the effective dose to public is far less than the specified annual dose limit of 1 mSv.

**Fig 5.1a: Liquid Waste Discharge from NPPs (Tritium)**




| | TAPS-1&2 | RAPS-1&2 | MAPS | NAPS | KAPS | KGS | RAPS-3&4 | TAPS-3&4 |
|---|---|---|---|---|---|---|---|---|
| 2003 | 0.00 | 1.49 | 13.31 | 72.29 | 68.88 | 9.67 | 0.71 | 0.00 |
| 2004 | 0.00 | 2.08 | 8.90 | 29.48 | 46.79 | 7.32 | 0.35 | 0.00 |
| 2005 | 0.00 | 0.77 | 5.21 | 28.68 | 32.45 | 5.10 | 0.29 | 0.00 |
| 2006 | 0.00 | 0.91 | 5.81 | 34.91 | 28.32 | 3.07 | 0.18 | 0.58 |
| 2007 | 0.00 | 0.32 | 3.50 | 37.83 | 23.28 | 2.12 | 0.19 | 0.87 |

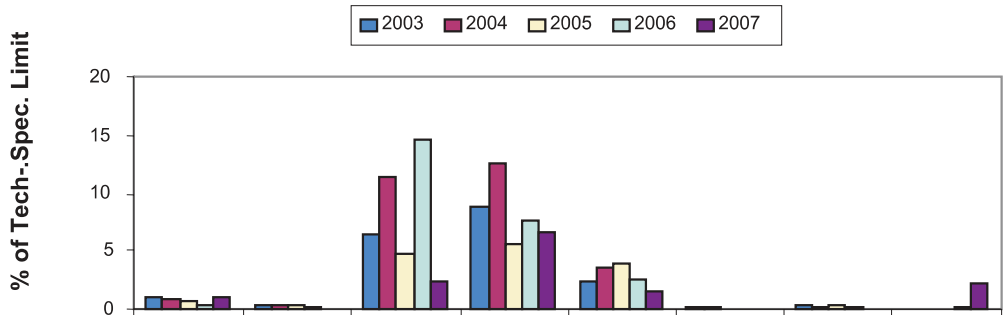
**Note:**

1) TAPS-1&2 is a Boiling Water Reactor. Hence, there is no generation / discharge of Tritium.

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

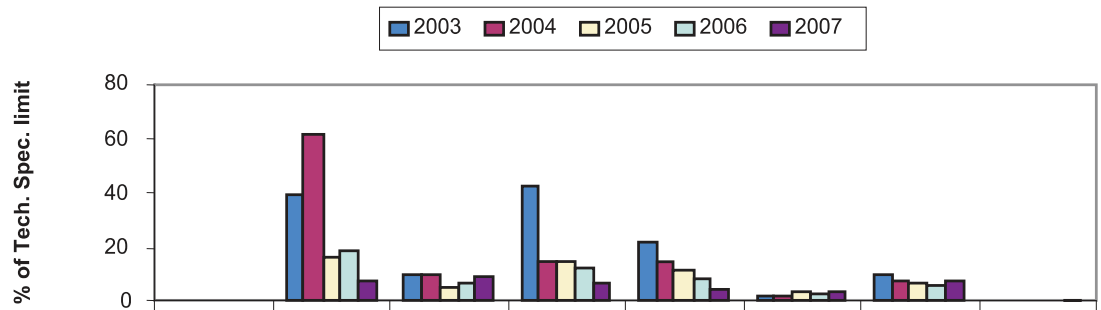
3) The release from the NAPS and KAPS were high in 2003 due to steam generator leak.

## 5.1b : Liquid Waste Discharges from NPPs (Gross Beta)




| | TAPS-1&2 | RAPS-1&2 | MAPS | NAPS | KAPS | KGS | RAPS-3&4 | TAPS-3&4 |
|---|---|---|---|---|---|---|---|---|
| 2003 | 1.14 | 0.30 | 6.57 | 8.84 | 2.44 | 0.09 | 0.47 | 0.00 |
| 2004 | 0.88 | 0.34 | 11.46 | 12.59 | 3.58 | 0.11 | 0.15 | 0.00 |
| 2005 | 0.62 | 0.30 | 4.70 | 5.61 | 4.01 | 0.01 | 0.34 | 0.00 |
| 2006 | 0.37 | 0.07 | 14.49 | 7.67 | 2.56 | 0.00 | 0.08 | 0.12 |
| 2007 | 0.96 | 0.01 | 2.29 | 6.65 | 1.44 | 0.00 | 0.06 | 2.16 |

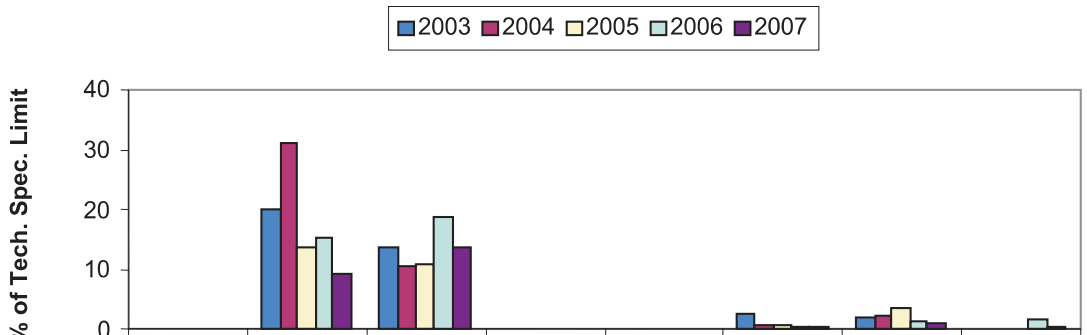
## Fig. 5.1c :Gaseous Waste Discharges From NPPs (Tritium )




| | TAPS-1&2 | RAPS - 1&2 | MAPS | NAPS | KAPS | KGS | RAPS-3&4 | TAPS-3&4 |
|---|---|---|---|---|---|---|---|---|
| 2003 | | 39.11 | 9.85 | 42.29 | 21.75 | 1.93 | 9.83 | 0.00 |
| 2004 | | 61.29 | 9.40 | 14.68 | 14.53 | 1.73 | 7.70 | 0.00 |
| 2005 | | 16.80 | 4.78 | 14.51 | 11.24 | 3.15 | 6.82 | 0.00 |
| 2006 | | 18.65 | 7.18 | 12.16 | 8.07 | 2.27 | 5.88 | 0.14 |
| 2007 | | 7.89 | 9.17 | 6.70 | 4.47 | 2.98 | 7.64 | 0.41 |

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

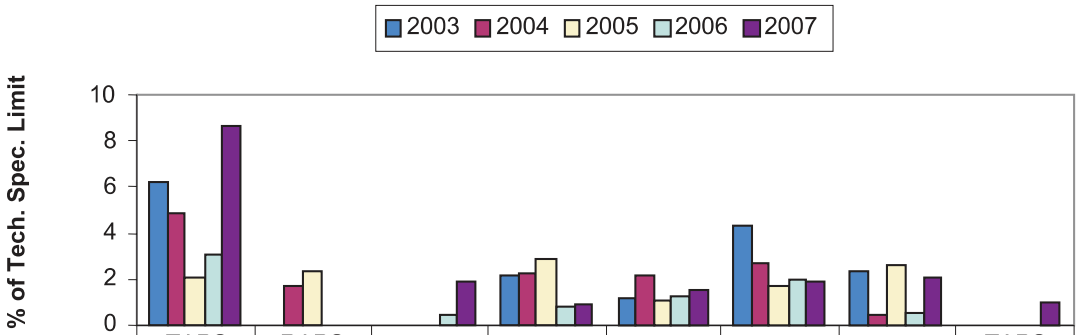
## Fig. 5.1d Gaseous Waste Discharges from NPPs (Argon-41)




| | TAPS-1&2 | RAPS-1&2 | MAPS | NAPS | KAPS | KGS | RAPS-3&4 | TAPS-3&4 |
|---|---|---|---|---|---|---|---|---|
| 2003 | 0.00 | 19.97 | 13.54 | | | 2.76 | 2.26 | 0.00 |
| 2004 | 0.00 | 31.10 | 10.47 | | | 1.00 | 2.40 | 0.00 |
| 2005 | 0.00 | 13.75 | 10.94 | | | 1.02 | 3.51 | 0.00 |
| 2006 | 0.00 | 15.45 | 18.65 | | | 0.34 | 1.66 | 1.97 |
| 2007 | 0.00 | 9.52 | 13.77 | | | 0.73 | 1.13 | 0.32 |

**Note:** At present there is no separate Tech. Spec. Limit for release of Ar-41 from NAPS and KAPS.

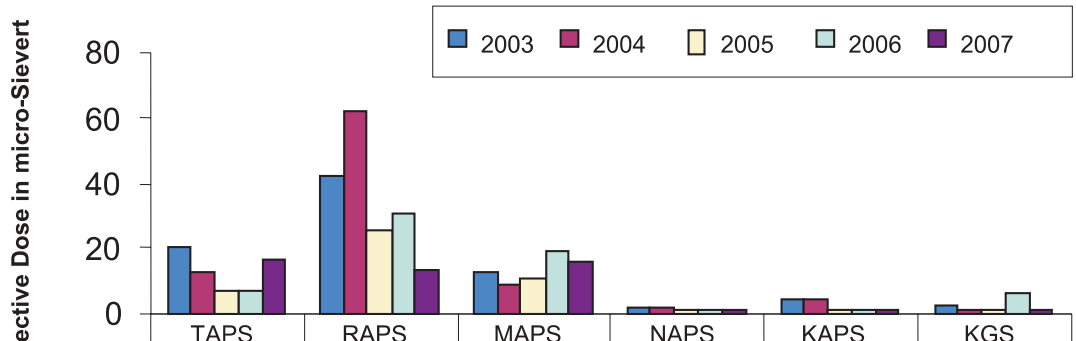
## Fig 5.1e: Gaseous Waste Discharges from NPPs (Fission Product Noble Gases)




| | TAPS-1&2 | RAPS-1&2 | MAPS | NAPS | KAPS | KGS | RAPS-3&4 | TAPS-3&4 |
|---|---|---|---|---|---|---|---|---|
| 2003 | 6.26 | 0.00 | 0.00 | 2.20 | 1.10 | 4.38 | 2.34 | 0.00 |
| 2004 | 4.89 | 1.64 | 0.00 | 2.28 | 2.20 | 2.67 | 0.41 | 0.00 |
| 2005 | 2.11 | 2.37 | 0.02 | 2.83 | 1.04 | 1.65 | 2.57 | 0.00 |
| 2006 | 3.04 | 0.00 | 0.40 | 0.77 | 1.20 | 2.00 | 0.50 | 0.00 |
| 2007 | 8.71 | 0.00 | 1.95 | 0.84 | 1.47 | 1.92 | 2.12 | 1.00 |

**Fig 5.2 a : Public Dose at 1.6 km Distance from NPPs**

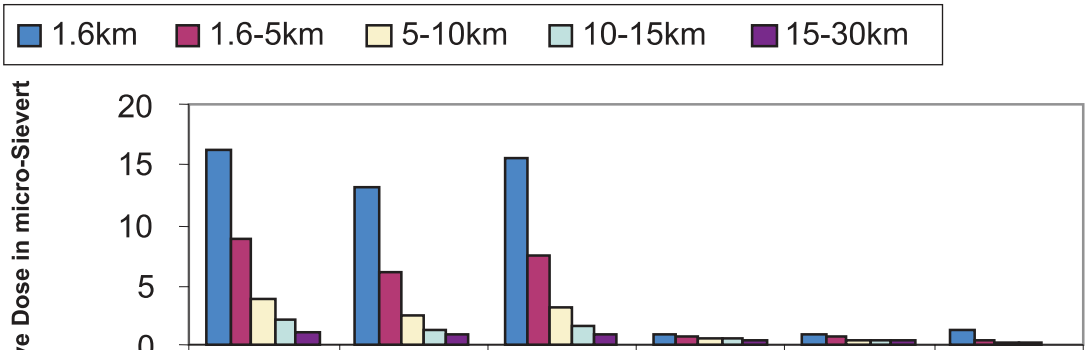
**(AERB Prescribed Annual Limit is 1000 micro-Sievert)**




| | TAPS | RAPS | MAPS | NAPS | KAPS | KGS |
|---|---|---|---|---|---|---|
| 2003 | 20.44 | 42.2 | 13.0 | 2.03 | 4.02 | 2.39 |
| 2004 | 12.75 | 61.4 | 9.3 | 1.69 | 4.06 | 1.06 |
| 2005 | 7.12 | 25.43 | 11.0 | 1.24 | 1.36 | 1.30 |
| 2006 | 7.21 | 30.40 | 18.7 | 1.18 | 1.12 | 6.91 |
| 2007 | 16.25 | 13.30 | 15.6 | 1.05 | 1.00 | 1.26 |

**Fig 5.2b : Total Effective Dose in Different Zones**

**(AERB Prescribed Annual Limit is 1000 micro-Sv)**




| | TAPS | RAPS | MAPS | NAPS | KAPS | KGS |
|---|---|---|---|---|---|---|
| 1.6km | 16.25 | 13.3 | 15.6 | 1.05 | 1 | 1.26 |
| 1.6-5km | 8.71 | 6.1 | 7.4 | 0.7 | 0.71 | 0.32 |
| 5-10km | 3.73 | 2.5 | 3.15 | 0.56 | 0.36 | 0.15 |
| 10-15km | 2.13 | 1.3 | 1.68 | 0.48 | 0.29 | 0.09 |
| 15-30km | 1.09 | 0.8 | 0.81 | 0.37 | 0.27 | 0.06 |

## 5.2 OCCUPATIONAL EXPOSURES

No worker in the Front-end fuel cycle facilities of DAE units [IREL (Udyogamandal, Chavara, Manavalakurichi, OSCOM); UCIL (Jaudguda, Bhatin, Narwapahar, Turamdih); NFC-Hyderabad] received radiation dose greater than the annual dose limit of 30 mSv during the year 2007. Number of workers of these facilities who received radiation doses between 20 mSv (Investigation Limit) and 30 mSv (Annual Limit) during the period 2003-2007 is given in Table 5.1.

**Table 5.1: Number of Workers Exposed between 20 mSv and 30 mSv (Front End Fuel Cycle Facilities)**

| Organisation | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| IRE-Udyogamandal | 4 | 0 | 1 | 0 | 0 |
| IRE-Manavalakurichi | 0 | 0 | 0 | 0 | 0 |
| NFC | 1 | 0 | 0 | 0 | 0 |
| All other Industrial Plants | 0 | 0 | 0 | 0 | 0 |

The number of workers who received radiation doses between 20 mSv and 30 mSv during the years 2003-2007 in NPPs is given Table 5.2 a. Details of radiation doses received by workers in medical, industrial and research institutions are given in Table 5.2 b.

**Table 5.2 a: Number of Workers Exposed between 20 mSv and 30 mSv and > 30 mSv (Nuclear Power Plants)**

| Year | 2003 | | 2004 | | 2005 | | 2006 | | 2007 | |
|---|---|---|---|---|---|---|---|---|---|---|
| NPP | 20-30 mSv | >30 mSv | 20-30 mSv | >30 mSv | 20-30 mSv | >30 mSv | 20-30 mSv | >30 mSv | 20-30 mSv | >30 mSv |
| TAPS-1&2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RAPS-1&2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MAPS-1&2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| NAPS-1&2 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 3 | 2 |
| KAPS-1&2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KGS-1&2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RAPS-3&4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TAPS-3&4 | | | | | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 5.2 b: Radiation Doses Received by Workers in Medical, Industrial and Research Institutions (2007)**

| Category of Radiation Worker | Number of Monitored persons | Average Dose for Monitored Persons (mSv) | No. of Exposed Persons | Average Dose for Exposed Persons (mSv) | Number of Workers Receiving Annual Individual Dose Excluding Zero Dose, D (mSv) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0 < D | 20 < D ≤20 | 30 < D ≤ 40 | 40 < D ≤ 50 | D > 50 |
| Diagnostic X-rays | 21517 | 0.34 | 7990 | 0.92 | 7979 | 3 | 2 | 6 | 9 |
| Radiation Therapy | 5270 | 0.23 | 2005 | 0.61 | 2002 | 1 | 2 | - | - |
| Nuclear Medicine | 1095 | 0.39 | 480 | 1.89 | 480 | - | - | - | - |
| Industrial Radiography & Radiation Processing | 4814 | 0.80 | 1541 | 2.48 | 1533 | 7 | 4 | 2 | 6 |
| Research | 3039 | 0.06 | 618 | 0.32 | 618 | - | - | - | - |

From Table 5.2 b, the number of radiation workers who received >30 mSv were: 8 out of 21517 in diagnostic X-ray installations, 2 out of 5270 in radiation therapy installations and 3 out of 4814 in industrial radiation installations. The reason for the higher doses is attributed to wrong work practices by the radiation workers, which were brought out during investigations to avoid recurrence.

## 5.3 OCCUPATIONAL HEALTH AND SAFETY

### 5.3.1 Advisory Committee on Occupational Health

Two meetings of the Advisory Committee on Occupational Health (ACOH) and Certifying Surgeons were held during the year. The committee suggested annual audiometry examination for all the workers exposed to noise level of above 85 dB in the regular work areas during the course of their employment, irrespective of the use of personal protective equipment and time of exposure.

# CHAPTER 6

## 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. Off-site exercises involve station authorities, district administration, and the members of public. Plant Emergency Exercises (PEE) are carried out once in a quarter, Site Emergency Exercises (SEE) once in a year and Off-site Emergency Exercises (OSEE) once in 2 years in operating nuclear power plants.

During the year 2007, the number of emergency exercises carried out in NPPs is as given in Table 6.1.

**Table 6.1: Number of Emergency Exercises in NPPs**

| PLANT | PEE | SEE | OSEE |
|---|---|---|---|
| TAPS-1&2 | 4 | 1 | 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-3&4 | 4 | 1 | 1 |

PEE and OSEE were also carried out at hydrogen sulphide based HWPs at Manuguru and Kota. SEEs, Periodic Emergency Exercises and Fire drills are carried out at ammonia based HWPs at Baroda, Thal, Hazira and Tuticorin. PEEs are carried out once in a quarter and fire drills are carried out once in 2 months. SEEs are carried out once in 6 months and OSEEs once in a year. The site emergency preparedness plans for HWP-Hazira and Manuguru were reviewed in detail and approved by AERB. AERB officials witnessed the actual SEE and OSEE exercises at some of the HWP sites.

The response of the plant personnel, officials and public involved in the exercise and general level of the awareness amongst the public were satisfactory.

# CHAPTER 7
# DEVELOPMENT OF SAFETY DOCUMENTS

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

## 7.1 NEW SAFETY DOCUMENTS PUBLISHED

1. Atmospheric Dispersion and Modelling (AERB/NF/SG/S-1).
2. Containment System Design for Pressurized Heavy Water Reactors (AERB/NPP-PHWR/SG/D-21).
3. Probabilistic Safety Assessment for Nuclear Power Plants and Research Reactors (AERB/NPP&RR/SM/O-1).
4. Human Reliability Analysis: A Compendium of Methods, Data and Event Studies for Nuclear Power Plants (AERB/NPP/TD/O-2).
5. Geotechnical Aspects and Safety of Foundation for Buildings and Structures Important to Safety of Nuclear Power Plants (AERB/NPP/SG/CSE-2).
6. Management of Radioactive Waste (AERB/NRF/SC/RW).
7. Predisposal Management of Low and Intermediate Level Radioactive Waste (AERB/NRF/SG/RW-2).
8. Management of Radioactive Waste from Mining and Milling of Uranium and Thorium (AERB/NF/SG/RW-5).
9. Management of Spent Radioactive Sources and Radioactive Waste Arising from the Use of Radio nuclides in Medicine, Industry and Research, including Decommissioning of such Facilities (AERB/RF/SG/RW-6).
10. Regulatory Inspection and Enforcement in Nuclear Fuel Cycle Facilities and Related Industrial Facilities other than Nuclear Power Plants and Research Reactors (AERB/NF/SM/G-2).
11. Radiological Safety in Uranium Mining and Milling (AERB/FE-FCF/SG-2).
12. Industrial Gamma Radiography Exposure Devices and Source Changers (AERB/SS-1/Rev.1).
13. Land-based Stationary Gamma Irradiators (AERB/SS-6/Rev.1).
14. Security of Radioactive Material during Transport (AERB/NRF-TS/SG-10).

## 7.2 SAFETY DOCUMENTS UNDER REVISION

1. Code of Practice on Safety in Nuclear Power Plant Siting (AERB/NPP/SC/S) published in 1990.
2. Code of Practice on Design for Safety in Pressurized Heavy Water Based Nuclear Power Plants (AERB/NPP/SC/D) published in 1989.
3. Code of Practice on Safety in Nuclear Power Plant Operation (AERB/NPP/SC/O) published in 1989.
4. Code of Practice on Quality Assurance for Safety in Nuclear Power Plants (AERB/NPP/SC/QA) published in 1988.

## 7.3 SAFETY DOCUMENTS TRANSLATED AND PUBLISHED IN HINDI

Four safety documents were translated and published in Hindi. Hindi titles of the translated documents together with the titles of corresponding documents that were earlier published in English are given below.

1. दाबित भारी पानी रिएक्टर से संबंधित अभिकल्पन आधार घटनाएं (एईआरबी/एसजी/डी-5;2000).

   Design Basis Events for Pressurized Heavy Water Reactors (AERB/SG/D-5; 2000).

2. दाबित भारी पानी रिएक्टर आधारित नाभिकीय बिजलीघर में द्रव एवं ठोस रेडियोसक्रिय अपरशिष्ट प्रबंधन (एईआरबी/एनपीपी-पीएचडब्लूयूआर/एसजी/डी-13; 2002).

   Liquid and Solid Radwaste Management in Pressurized Heavy Water Reactor Based Nuclear Power Plants (AERB/NPP-PHWR/SG/D-13; 2002).

3. नाभिकीय ऊर्जा संयंत्रों से संबंधित सामग्री एवं सेवाओं के प्रापण में गुणवत्ता आश्वासन (एईआरबी/एसजी/क्यूए-2; 1998).

   Quality Assurance in the Procurement of Items and Services for Nuclear Power Plants (AERB/SG/QA-2; 1998).

4. नाभिकीय एवं विकिरण सुविधाओं में आपातस्थिति अनुक्रिया एवं आपातस्थिति से निपटने की तैयारी में नियामक संस्था की भूमिका (एईआरबी/एसजी/जी-5; 2000).

   Role of Regulatory Body with Respect to Emergency Response and Preparedness at Nuclear and Radiation Facilities (AERB/SG/G-5; 2000).

## 7.4 SAFETY DOCUMENTS UNDER DEVELOPMENT

1. Extreme Values of Meteorological parameters (AERB/SG/S-3).
2. Seismic Qualification of Structures, Systems and

Components of Pressurized Heavy Water Reactor (AERB/NPP-PHWR/SG/D-23).

3. Computer Based Systems of Pressurized Heavy Water Reactors (AERB/SG/D-25).
4. Commissioning of Pressurized Water Reactors (AERB/NPP-PWR/SG/O-16).
5. Predisposal Management of High Level Radioactive Waste (AERB/SG/RW-3).
6. Decommissioning of Nuclear Fuel Cycle Facilities other than Reactors (AERB/SG/RW-7).
7. Decommissioning of Nuclear Power Plants and Research Reactors (AERB/SG/RW-8).
8. Design of Nuclear Power Plant Concrete Containment Structures (AERB/NPP/SS/CSE-3).
9. Consenting Process for Radiation Facilities (AERB/SG/G-3).
10. Safety in Uranium Fuel Fabrication Facilities (AERB/FE-FCF/SG-3).
11. Nuclear Medicine Facilities (AERB/RF-MED/SC-6/Rev.2).
12. Radiation Therapy Sources, Equipment and Installations (AERB/RF-MED/SC-9).

At the end of the year 2007, AERB has published 134 safety documents and 16 safety documents are under development or revision. 32 documents have been translated and published in Hindi also.

# CHAPTER 8
# SAFETY STUDIES

## 8.1 SAFETY ANALYSIS

### 8.1.1 Analysis of Hydrogen Distribution in Containment of TAPS-3&4 using Fire Dynamics Simulator Code, FDS

An analysis was carried out for the assessment of amount of hydrogen in different compartments of the containment of TAPS-3&4 following a Loss of Coolant Accident (LOCA) coincident with failure of ECCS. Computer code, FDS 4.0 was used. For the purpose of analysis, containment was discretized into seven compartments. The steam and hydrogen mixture from the primary heat transport system is discharged into one of the Fuelling Machine Vaults (FMVs). Water in the containment is not modeled. Two cases are analysed. First case is the normal case where hydrogen management feature is not considered. In the second case, a blower is used to blow air from pump room into the FMV to mix the hydrogen with the air. The analysis was carried out for 3600s. It is observed that mass fraction of hydrogen in the dome region increases to 0.63x10-3 kg/kg from 0.48x10-3 kg/kg because of the blower. But the peak mass fraction of hydrogen in FMV during the transient is significantly less in the second case .

### 8.1.2 Standard Problem Exercises

Joint exercise of benchmarking computer codes through analysis of standard problems in thermal hydraulics as part of collaborative work between AERB and USNRC was taken up. The details of the exercise and progress in the bench-marking are given below.

#### (i) Simulation of Experiments Conducted at PANDA Facility using a System Thermal Hydraulics Computer Code

Six sets of experiments (Phase A-F) were carried out at the PANDA test facility in Switzerland to investigate design-basis accident phenomena that might be anticipated for advanced light water reactors. The objective of each set of experiments is as follows: Phase-A: To investigate the startup behavior of a Passive Containment Cooling System (PCCS) when steam is injected into dry well filled with air. Phase-B: To investigate the discharge of cold water from gravity driven cooling system into a saturated pressure vessel and to observe induced phenomena and the system behaviour. Phase-C: To investigate the system response during normal operation of PCCS. Phase-D: To investigate the system response in case of an overload of PCCS at pure steam conditions. Phase-E: To investigate the system behavior when air is fed to the dead-end drywell compartment which is originally at pure steam conditions. Phase-F: To observe the induced phenomena when helium is released into the reactor pressure vessel. Simulation of the test facility and preliminary transient analysis of all the six sets of experiments have been carried out. The analysis results have been compared with the experimental data. For first two and the sixth set of experiments the results show good agreement with the experimental data. For Phase-C, Phase-D and Phase-E, the magnitudes of various system parameters have been predicted accurately. However, the time behavior of these parameters is having significant deviation from the experimental data. The analysis of all the cases is being continued further to enhance understanding and to further improve the results.

#### (ii) Severe Accident Analysis of TMI-2

The accident at TMI-2 occurred on March 28, 1979 and resulted in severe damage to the reactor core and associated structures. For analysis purpose, the accident scenario is divided into four phases. The details of the accident progression analyzed are given below.

**Phase 1 (0 to 100 min):** The accident got initiated with loss of main feed water to both the Once-Through Steam Generators (OTSG) when the main feed water pumps lost suction due to loss of both condensate pumps. Subsequently, the main turbine tripped and the Auxiliary Feed Water Pumps (AFWP) automatically started to operate as expected. However, the auxiliary feed water could not be injected to either of the OTSG because the Auxiliary Feed Water (AFW) system block valves were in closed positions. This resulted in loss of heat sink and led to rapid primary system pressure increase and opening of the pressurizer Pilot Operated Relief Valve (PORV). The high primary system pressure automatically initiated a reactor signal that caused reactor shutdown, which in turn resulted in a rapid reduction in the primary system pressure. The reduction in the primary system pressure should have caused the closure of the PORV; however, this valve failed in a stuck-open position, causing continued loss of coolant inventory. Without AFW, the OTSG's boiled dry in about 1.5 minutes. At 8 minutes the AFW block valves were opened and measurable levels were reestablished in the OTSGs by ~25 minutes. By the time the AFW injection was started, both primary hot legs had reached saturation condition, which continued until about 74 minutes when the B loop Reactor Coolant Pumps (RCPs) were shut down to avoid cavitation. Subsequently, at about 100 minutes, the 'A' loop RCPs were also de-energized to prevent cavitation.

**Phase 2 (100 to 174 min) :** At this time, the primary system inventory got depleted, and shortly after the final RCP trip, both hot leg temperatures increased above saturation that was indicative of steam superheating due to excessive core heat up. At about 139 minutes the PORV block valve was closed and the loss of coolant through this path was terminated.

**Phase 3 (174 to 200 min) :** At 174 minutes, the 2B RCP was started and then stopped at 193 minutes due to low motor current.

**Phase 4 (200 to 300 min) :** At 200 minutes makeup pumps 1A and 1C were both in operation for a short period of time. At about 262 and 267 minutes, make up pumps 1B and 1C were placed into continuous operation.

The accident analysis of the scenario was carried out. The results of the analysis for most of the parameters, including primary pressure, primary level, hydrogen production, primary temperatures, etc. are in good agreement with the measured data for the first two phases of the accident. The trends of the parameters predicted in other two phases, i.e., phase 3 and phase 4 are also in good agreement. However, there are small variations in magnitudes as compared to the plant data. Generally the models used in the computer codes and the measured plant data have uncertainties. The uncertainty analysis is in progress.

### 8.1.3 Thermal Hydraulic Analysis of Large Break LOCA of VVER- 1000

The thermal hydraulic analysis of VVER-1000 was carried out. Two cases were analysed. The first case deals with the thermal hydraulic analysis of double-ended guillotine rupture of one of the cold legs. The second case is an extension of the first one with blockage of 56% in the maximum rated fuel assembly. The other initial conditions, boundary conditions etc. are same as in first case. The predictions are in good agreement with the results predicted by Russian code, DINAMIKA.

### 8.1.4 Computer Code Adoptable Model for Core Disassembly

Computer code adoptable core disassembly model for Indian PHWR was developed which would serve as an input for severe accident management. The severe accident considered in the analysis is LOCA with loss of ECCS coupled with loss of moderator cooling. As the accident progresses calandria tubes get exposed to steam and its temperature increases. Calandria tubes sag and rest on the tube immediately below as the temperature increases. As the accident progresses the calandria tubes pile up and ultimately fail when total strain in calandria tube reaches failure strain. A failure surface is obtained, which may be used for predicting the time available before the collapse of core. A 3-D failure surface is generated which will be useful in assessing the reactor core disassembly status, i.e., the number of channels piled up and the time before the piled up channels fail and form corium at the bottom of the calandria.

### 8.1.5 Thermal Analysis of Central Thimble for NAPS-1

Central thimble assembly of NAPS-1 comprises of two concentric inner Zircaloy tubes. The outer tube is called guide tube assembly and inner tube is called inner tube assembly. The inner tube assembly supports six number of SPND along its length on the outer periphery of the inner tube. Moderator surrounds the outer guide tube. Air is present inside the inner tube and in the annulus of inner and outer tube. Heat is generated in the inner tube, outer tube, and SPND material. An analysis for steady state temperature profile of inner tube, inner tube air, annulus air and SPND has been calculated. The predicted temperatures are within the acceptable limits, and therefore, may not pose any problem to the integrity of inner tube and SPND.

### 8.1.6 Seismic Re-evaluation of FBTR

Seismic re-evaluation of FBTR, which was commissioned in 1985, is being carried out as a joint exercise between AERB/SRI and IGCAR, as it was built adopting seismic standards prevailing during that period. The primary objective of seismic re-evaluation is to review the seismic capacity of safety related Structures, Systems and Components (SSCs) of the plant required to achieve a safe shutdown, maintain the plant in a safe condition, achieve decay heat removal and confine radioactive materials. The re-evaluation programme includes, assessment of the seismic hazard as an external event, safety analysis of the NPP resulting in identification of the selected SSCs, appropriate for dealing with a seismic event and evaluation of the plant specific seismic capacity to withstand the loads generated by such an event, if required.

The document addressing the criteria and methodology for seismic re-evaluation was prepared consistent with current international seismic re-evaluation criteria and practices. The Review Basis Ground Motion (RBGM) parameters were determined by Probabilistic Seismic Hazard Analysis (PSHA). This is the first time in India that PSHA is used to determine the RBGM parameters. For this purpose a list of initiating events for the functions found to be most important for seismic induced core melt were identified. Event trees and corresponding fault trees were developed for these initiating events to determine the SSCs necessary for carrying out the safety functions in the event of an earthquake. A procedure for seismic plant walkdown of FBTR was prepared based on the guidelines provided in the Generic Implementation Procedure of

Department of Energy USA. This procedure was implemented at site during the plant walkdown, wherein around 175 components were walked through and the details required for their qualification using the experience based method were collected. Seismic response analysis of civil engineering structures and mechanical systems is in progress and their capacity assessment adopting both deterministic and probabilistic approaches is planned.

### 8.1.7 Development of Flyash Concrete for NPP Structures

A collaborated R&D program on development of fly ash concrete in NPP structures has been jointly taken up by AERB & NPCIL. The scope of the work includes preparation of consolidated report on the work of fly ash concrete, characterization of fly ash, identification of grades of concrete mixes to be developed with fly ash, and production of fly ash concrete mixes at Laboratory and test for the required properties both at (a) fresh state and (b) hardened state, evaluation of optimum mixing method, field trial of the mixes to ascertain constructability of the designed mixes and identification and working out of special measures, if any, required for construction.

The work of consolidation of the past work of fly ash concrete, characterization of fly ash, identification of grades of concrete mixes and evaluation of optimum mixing methods are completed. The final composition of N35 and N50 grade fly ash concrete has been established. The work on long-term properties of fly ash concrete is under progress.

### 8.1.8 Tsunami Hazard Assessment

Japan Society of Civil Engineers (JSCE) has organized recent findings and progress of technology in the form of a standard assessment method for evaluation of tsunami model for the safety assessment of NPP in Japan. An effort was made to understand critical aspects of this assessment method and implement this for tsunami hazard assessment in the Indian coast. For this purpose, tsunami hazard analysis based on JSCE methodology was carried out for Indian Ocean region. Uncertainty analysis was undertaken for Sumatra earthquake. Main parameters considered for uncertainty analysis were fault position, fault width, depth of rupture, and variation of dip angle. Mariograms were obtained at various places along the east coast of India. The study helped in understanding various aspects of tsunami hazard assessment with Indian perspective.

In view of the hazard caused by tsunami to coastal NPP sites, AERB has undertaken a study of evaluation of tsunami hazard along Indian coast. This includes 1) identification of tsunamigenic sources around Indian peninsula, 2) estimation of source parameters 3) collection of bathymetry data, 4) identification of numerical computation system for simulation, 5) calibration and simulation of the various tsunami scenarios. AERB in coordination with IGCAR identified possible tsunamigenic sources, its dimensions, associated uncertainties, probable earthquake magnitudes etc. An extra budgetary program (EBP), Tsunami and Post Earthquake considerations in the External Zone (TiPEEZ), has been initiated by IAEA and AERB will be a participant on the program.

## 8.2 SAFETY REVIEW

### 8.2.1 Fire Hazard Analysis for Kaiga-3&4

FHA for Kaiga-3&4 was reviewed as per guidance provided in safety guide AERB/SG/D-4 and safety standard AERB/S/IPSD-1. The fire hazard analysis, includes calculating hot gas temperature (unventilated condition and forced ventilated condition), mass lost, smoke generated, oxygen consumed, visibility and ratings of fire barriers during flashover condition.

It was observed that in reactor auxiliary building and control building, the number of detectors mentioned in FHA were less as compared to the requirement mentioned in AERB safety guide. Some other observations regarding $CO_2$ extinguishers and cylinders were also incorporated FHA report.

### 8.2.2 Level-1 PSA of NPP

The reviews of the Level-1 PSA (Internal events) for MAPS-1&2, NAPS-1&2, RAPS-3&4 and KGS-1&2 were carried out. The review reports on MAPS-1&2 and NAPS-1&2 are prepared. Preparation of review report for KGS-1&2 and RAPS-3&4 is in progress. The level-2 (internal events) PSA for KAPS-1&2 has also been reviewed and preparation of review report is in progress.

### 8.2.3 Application for Renewal of Authorization for RAPS- 3&4

The ARA for RAPS-3&4 was reviewed for reliability analysis covering the systems such as primary shut down system, secondary shutdown system, emergency core cooling system, 415 V AC power supply system, 240 V AC control power supply system and 220V DC control power supply system. The main observations include: (i) Common Cause Failure (CCF) treatment not followed uniformly for all systems, (ii) in some cases CCFs not considered for reliability assessment and (iii) system reliability estimates to be re-evaluated.

### 8.2.4 Hydrogen Management Proposal

In PHWRs, the analysis for the postulated accident involving LOCA and ECCS failure indicated that the hydrogen concentration may not reach deflagration levels, if uniform mixing of hydrogen with the air in the entire volume of primary containment is considered. A proposal was submitted to mix hydrogen with containment

atmosphere using a force mixing system. Supporting analysis using PACSR code was also submitted. A task force reviewed the proposal.

The design basis reports and supporting analysis reports were reviewed for large break loss of coolant accident with loss of emergency core cooling system. The review indicated that the proposed system would be able to take care of hydrogen concentration for most of the design basis accidents but would not be able to mitigate the hydrogen risk during some scenarios like in-core LOCA with ECCS failure, as the hydrogen generation would be more. The use of re-combiners, which would remove the hydrogen from the containment atmosphere, is more effective, widely used and preferred solution. However, it is recognized that the in-house development of these is still in progress and would take some more time to develop in a large scale. Present proposal of mixing of containment atmosphere may be used as an interim solution. The monitoring of hydrogen is also important for hydrogen mitigation during the post accident scenario and therefore, it is recommended to implement the hydrogen monitoring system.

### 8.2.5 Evaluation of Responses to PSA Questionnaire

The CANDU Senior Regulator Group (CSRG) countries' responses to PSA questionnaire were reviewed and evaluation report was sent to all participants. The evaluation report covers the similarities and differences in the PSA practices of member countries and identifies the PSA elements that need further discussion among CSRG countries to harmonize the PSA methodologies. The report was discussed in the last CSRG meeting held in November 2007 in Canada and it was decided to obtain additional information for detailed comparison of PSA results. The evaluation of the additional response from the member countries is in progress.

# CHAPTER 9

## SAFETY RESEARCH INSTITUTE

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

- Nuclear Safety Studies.
- Reactor Physics & Radiological Safety Studies.
- Environmental Safety Studies.
- Fire Safety and Thermal hydraulics Studies.

### 9.1 NUCLEAR SAFETY STUDIES

#### 9.1.1 Seismic Re-evaluation of FBTR

Towards seismic reevaluation of FBTR, seismic Structures, Systems and Components (SSC) required to achieve a safe shutdown, maintain the plant in safe condition, achieve decay heat removal and confine radioactive material were identified. These were grouped into three major categories and further sub-grouped based on their physical arrangement (system / panel). For the purpose of identifying seismic qualification methodology, SSC were also categorized into civil structures, electrical & instrumentation and mechanical components and recommended for seismic qualification using General Implementation Procedure (GIP) of Department of Energy (DOE) of USA, testing and analysis as well as a combination of them. The recommended qualification methodology for relays is by testing. Certain components were identified for shake table test in IGCAR. Methodology for arriving at the component fragility has been developed and using the generic data, the plant fragility is being estimated.

#### 9.1.2 Functional Reliability Analysis of Safety Grade Decay Heat Removal System of PFBR

The functional reliability of Safety Grade Decay Heat Removal System (SGDHRS) of PFBR was estimated with response surface and Monte Carlo simulation. When the response surface is linear and if the uncertain variables are independent, the Monte-Carlo sampling could be avoided if we could directly construct the probability density function. Such an approach was developed to construct probability density function with method of moments. The moments method is a simple and computationally efficient compared to Monte-Carlo sampling approach. This approach is applied to SGDHRS and the results are integrated with the classical component reliability analysis to compute the overall decay heat removal system.

### 9.2 REACTOR PHYSICS AND RADIOLOGICAL SAFETY STUDIES

#### 9.2.1 PWR Physics Analysis

Fuel management studies were continued for VVER-1000 type of reactor of Kudankulam project. Fuel assemblies of different enrichment reside in the core for more than one fuel cycle and equilibrium core is formed after four cycles. Assembly wise fuel depletion and fission product build up analysis was carried out using ORIGEN-S module of SCALE code system. Results compare well with EXCEL generated values.

The full core calculations were done using TRIHEX-FA code to study the effect of void and control rods on the thermal and fast neutron flux spectrum at different reactor powers. These results form a part of input information required for transient analysis of the core. After completing the core physics studies for steady state conditions, reactor dynamics studies involving coupling of reactor neutronic code and thermal hydraulics code have been initiated.

Assessment of the suitability of mixed Uranium - Plutonium Oxide (30 % MOX) fuel as an alternate fuel is being made. Core physics parameters for several benchmark problems have been analysed using computer code EXCEL. Assembly level depletion calculations are performed up to a burn-up of 40 MWd/Kg of heavy metal. The k? values versus burn-up showed maximum deviation of -10 mk from the benchmark mean values. It is found that the reactivity worths of Boron, 135Xe and 149Sm are smaller due to hardened neutron spectrum.

VVER-TIC (Temporary International Collective) benchmark problems were analyzed to understand the physics design of water-cooled, water moderated VVER type reactor such as KK-NPP being built at Kudankulam, Tamilnadu. During 1972-1990, a large variety of physics experiments were carried out in ZR-6; a zero power critical facility at Budapest, Hungary. Effective multiplication factor, keff, for critical configurations of fuel assembly was evaluated by solving zero dimensional diffusion equation using a few group homogenized cross sections of the basic lattice cell, as generated by the indigenous lattice burn-up code, EXCEL. Results were quite satisfactory for uniform lattices and regularly perturbed lattices.

#### 9.2.2 Code Development

A computer code, IGSHIELD has been developed. The code is an interactive gamma ray shielding code and is based on point kernel method in Visual Basic-6 language under windows operating system. This code allows variety of multiple sources embedded in a complex geometrical shield media. The code is being evaluated by users for identifying the required improvements. The salient features of the code are the following.

- Multiple volume sources with arbitrary orientation along the geometric axes, can be handled.
- Shield configuration is arbitrary and can be built with 9 different types of geometrical bodies.

- Fission product gamma ray strengths in 6 groups are evaluated for given a burn up and cooling periods for U and Pu fuels.
- Built in Provision is made for estimation of activity of activation products which emit gamma rays.
- Most commonly sought after utilities like activation cross-sections, isotopic library, build up factors and gamma ray cross section exist.
- User-friendly interactive features to prepare error free input and to display geometry in 3D with arbitrary rotation, cut view of the geometry in plane exist.

### 9.2.3 Simulations of Dosimetric Parameters of Brachytherapy sources using IGSHIELD Code

In order to check the utility of IGSHIELD code in extended medical applications such as brachytherapy sources, computations have been done for dose distributions around the ADVANTAGETM Pd-103 located at the centre of 30 x 30 x 30 cm3 water phantom cube. The calculated dose distributions by IGSHIELD were compared with the results obtained using the Monte Carlo code. The IGSHIELD results agreed quite well with the Monte Carlo results, confirming the suitability of IGSHIELD code on the facilities for medical applications.

## 9.3 ENVIRONMENTAL SAFETY STUDIES

### 9.3.1 Remote Sensing (RS)- Geographical Information System (GIS) Studies

#### (i) RS and GIS Applications

Spatial data base on the buildings, roads, power lines, etc. were generated for Kalpakkam and Anupuram townships of Kalpakkam site of DAE by employing GIS software. This database is required for planning emergency preparedness steps to be taken.

High resolution Digital Elevation Model (DEM) has been created for plant site area as well as DAE townships, namely Kalpakkam and Anupuram. Land survey data was digitized by employing GIS software. The high resolution DEM was created using image-processing software. These data have centimeter accuracy in elevation. The DEM of Anupuram Township is shown in Fig. 9.1.

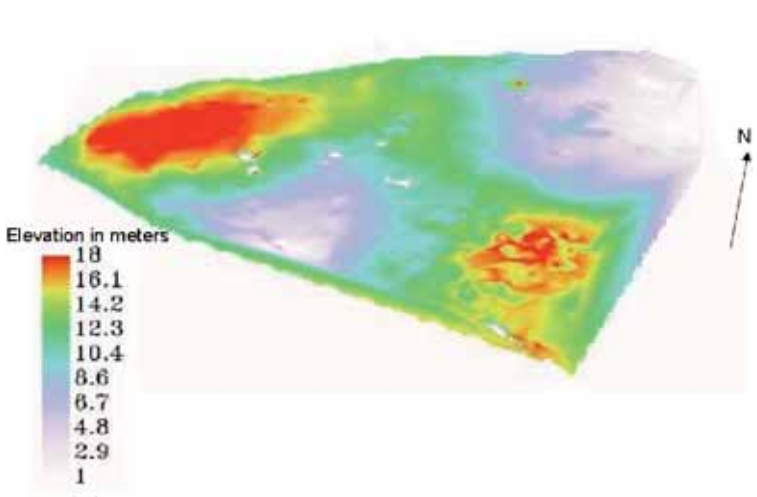



**Fig. 9.1: DEM of Anupuram Township**

#### (ii) DAE Committee on R&D on Tsunami Data Sharing

Following the December 2004 tsunami event, a strong need was felt to strengthen abilities related to tsunami simulation, prediction and early warning system. In order to carry out Research & Development (R&D) efforts in a coordinated manner a DAE committee was constituted, including SRI, to simulate tsunami event and to identify the related impact to all coastal DAE installations. Data such as base map of the study area, high resolution DEM, high resolution bathymetry data for Kalpakkam near shore (pre and post tsunami period), locations for the prediction of inundation reach for Kalpakkam coastal area and locations for the prediction of Run-up for Kalpakkam coastal area were generated at SRI, Kalpakkam and shared with the DAE-Tsunami committee for planned round-robin exercise.

#### (iii) Spatial Decision Support System for Flood Inundation

A GIS based spatial Decision Support System (DSS) has been developed to find out the flood patterns inundation caused by tsunami/cyclones for Kalpakkam NPP site. This spatial DSS has been developed to simulate the flood patterns for every one-meter of seawater rise. An area of 50 km radius from Kalpakkam NPP site has been selected for the study. Using ArcObjects, this interactive computer-based system has been developed. This system can provide simulations to analyze and display scenarios caused by sea level rise. The system allows user to obtain the tabular summary about the inundated area for every 1 m inundation by selecting queries (Fig. 9.2).

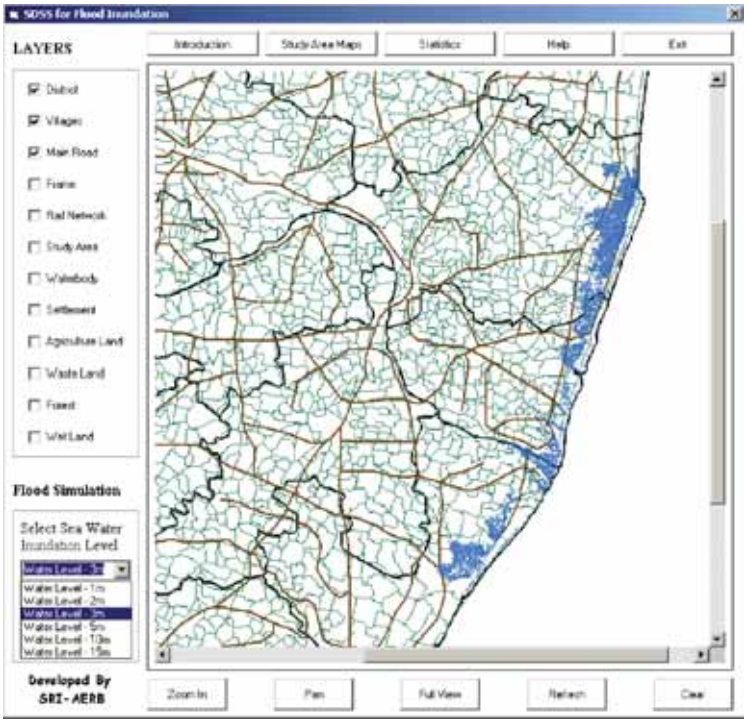



**Fig. 9.2: The Impact of 3 m Seawater Inundation Over the Land Use/Land Cover**

### 9.3.2 Hydrogeological Investigations at Kalpakkam

#### (i) Groundwater Geochemistry

To understand the geochemical aspects of groundwater, the groundwater samples were collected and analyzed to generate the ionic concentrations of Na+, K+, Ca2+, Mg2+, Cl-, CO32- and HCO32-. These were fed as input to the geochemical software, PHREEQC to understand the saturation index of the possible minerals. The dominance of anions in the study area are: Cl > HCO3 > CO3 and the dominance of cations are: Na > Mg > K > Ca. The preliminary studies indicate that the saturation indices of carbonate minerals Calcite, Aragonite and Dolomite are predominant in the study area.

#### (ii) Groundwater Hydrology Studies

The periodical monitoring of water table fluctuations, groundwater sample collection and analysis for ionic concentration were carried out. The annual water table fluctuation showed gradual rise in water table due to the recharge during the months of July to November and gradual decline during December to June, confirming the unconfined aquifer conditions at Kalpakkam.

#### (iii) Groundwater Modeling

A groundwater flow model was developed using VISUAL MODFLOW Pro graphic user interface for Kalpakkam, considering the sandy and weathered formations as a single homogenous unit layer. The aquifer parameters like storativity and hydraulic conductivity obtained from the field investigations were suitably assigned in the model. The April 2006 water table was taken as the initial head condition in the model development.

The model was calibrated by varying the hydraulic properties and boundary conditions within the site-specific conditions to attain a good match between the calculated and real field head values. Water table heads at 12 out of 14 bore-wells fall within 95 % confidence level. A good correlation between the simulated and field measured values was obtained with a correlation coefficient of 0.942.

The model after calibration was employed for prediction for 150 days in transient condition during October 2006 to February 2007 (i.e., for 300 days from the initial state). The water table elevation head for February 2007 generated by the model is shown in the Fig. 9.3. A good correlation was obtained between the model and actual field measurement.

**Environmental Chemistry Laboratory at SRI**

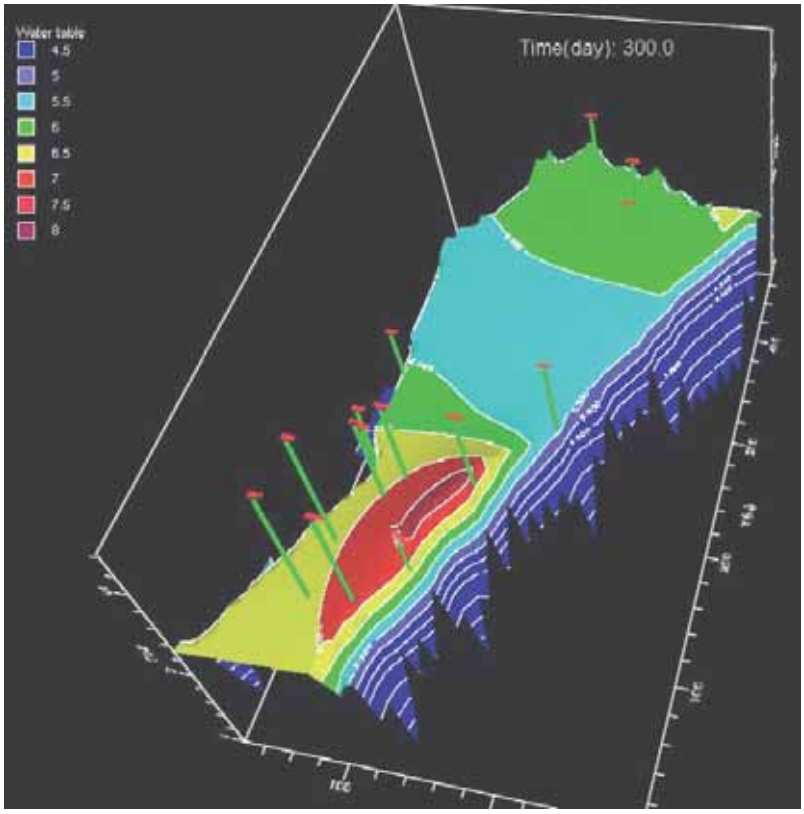



**Fig. 9.3: Model Run for Prediction for 150 days**

### 9.3.3 Colloidal Transport of Radio Nuclides in Groundwater

These studies are taken up to understand the role of colloids on the transport of radio nuclides such as cesium and strontium by carrying out detailed characterization of colloidal particles for its size, size distribution, morphology, elemental composition, and zeta potential and to understand the geochemical processes occurring during sorption. Periodic collection of water samples collected from bore wells identified for this purpose and their characterization with respect to physicochemical parameters as well as colloid concentration were carried out. Two groundwater types, viz., fresh water type and brackish type based on the salinity levels in the groundwater samples were identified.

The colloid concentration was varying between 0.05 mg/l and 6 mg/l. Colloid concentration was more in wells with low ionic strength. The number of colloidal particles was varying between 3 ? 109 particles/l to 3 ? 1011 particles/l. The average colloid size was varying between 200 nm and 350 nm for various samples. The zeta potential of the colloidal particles was varying in a range of -34.0 mV to -34.4 mV.

The groundwater samples were analyzed for total and dissolved concentration of cesium and strontium. The difference in concentration of strontium and cesium in the unfiltered and filtered samples indicates the importance of colloids in the sorption of strontium and cesium. It is found that there is a little or no sorption of cesium in filtered and unfiltered samples and for strontium, it is significant. Further studies are in progress.

### 9.3.4 Environmental Impact of Power Plant Chlo rination on Marine Microalgae

Studies were carried out to evaluate the effects of chlorine on diatoms and microalgae isolated from the study area at MAPS jetty towards assessment of influence of chlorine on marine Phytoplankton. The main observation from the above study is that the increase in chlorine concentration showed a decrease in cell division rate, chlorophyll content, primary production and metabolic activity. Studies also indicated that cells exposed to chlorine showed satisfactory recovery.

Confocal Laser Scanning Microscopy (CLSM) based technique for quantitative assessment of impact of chlorine on Chlorella vulgaris showed that chlorine causes inhibition in chlorophyll fluorescence and intracellular esterase activity.

### 9.3.5 Photocatalytic Degradation Studies

Studies have been taken up for the degradation of organic pollutants such as Ethylene Diamminete Traacetic Acid (EDTA), and Hydrazine in water using semiconductor

photocatalysis using a photoreactor. Semiconductor nanoparticles such as titanium dioxide and gallium oxide were synthesized for this purpose and characterized using techniques like XRD, FTIR, TG-DTA, and Raman Spectroscopy. Studies indicated the beneficial effect of complete degradation of EDTA (1000 ppm) and Hydrazine (100 ppm) taking place in less than 2 hours with 2 mg of catalyst. The degradation products were innocuous in nature.

## 9.4 FIRE SAFETY AND THERMAL HYDRAU LIC STUDIES

### 9.4.1 Fire Modeling Studies

Work has been initiated in fire modeling studies with the use of CFD code 'Fire Dynamics Simulator' (FDS). In order to get an in-depth understanding of the code and its salient modeling features, it is being applied to analyze some of the fire related experiments for which results are available. To start with, enclosure pool fire scenarios have been taken up for well ventilated as well as boxed up conditions. Parameters such as fire duration, fuel mass loss rate, compartment oxygen depletion rate, ventilation flow rate, compartment pressure and temperature transients are being assessed.

### 9.4.2 Thermal Hydraulic Studies

Containment thermal hydraulic studies have been taken up using the computer code, Fluent. This involves simulating injection of steam water in the Reactor Containment atmosphere and resulting condensation of steam on the walls, simulating water spray and fog formation in the containment.

A 3-D finite volume code is being developed to simulate thermal-hydraulics of a vertical core. Initially the code is to be applied to a vertical annulus. Subsequently it would be modified to include models for heat transfer from fuel bundles during accident conditions. Thus it will also have models for nucleate boiling and film boiling heat transfer and critical heat flux.

# CHAPTER 10

## PUBLIC INFORMATION

### 10.1 PRESS RELEASES

AERB periodically issues press releases in English and Hindi to keep the public informed about important regulatory and other related activities. Press releases were issued on the following topics during the year. The details of these are also available on AERB website 'aerb.gov.in'.

- A 5-member delegation of the French Nuclear and Radiation Regulatory Organization, namely, Nuclear Safety Authority (ASN) led by Mr. Olivier Gupta, Head of the Direction of Nuclear Power Plants of ASN visited the AERB during May 8-10, 2007. This visit was under the Agreement on Exchange of Information and Co-operation in the Regulation of Nuclear Safety and Radiation Protection. As part of the programme, a seminar on 'Pressurized Water Reactors' was organized in which a large number of senior officials from AERB, BARC, IGCAR and NPCIL participated. The salient presentations in the seminar led to a better appreciation of regulatory practices and safety review approaches followed by the two regulatory bodies, safety objectives and approaches for new reactors and design assessment of reactors with evolutionary new features.

- This has reference to the news item regarding "seizure" of 700 grams of uranium by Lucknow police that appeared in certain sections of the Press on June 1, 2007. AERB deputed two experts to Lucknow to ascertain the nature of the seized material. Preliminary examination of the material indicated that the material seized by the police is not uranium. The material will be tested in BARC, Mumbai to identify its chemical composition.

- The Hon. Prime Minister of India dedicated TAPS-3&4 nuclear power plants at Tarapur to the Nation on 31st August 2007. The press release on this occasion contained the information on the construction aspects of TAPS-3&4 units and extensive safety reviews conducted by AERB.

- A 6-member delegation of the United States Nuclear Regulatory Commission (USNRC) led by Mr. James Edward Lyons, Director, Division of site and Environmental Reviews, Office of New Reactors, USNRC visited AERB during February 25-28, 2008 under the on-going nuclear safety co-operation programme between the two regulatory bodies. The topics during the meeting included Advanced Light Water Reactor Designs, Digital Systems Reliability and Software, Experience on Construction and Operation of new reactors in India. The ongoing collaborative work related to joint exercises of bench marking computer codes through analysis of standard problems in Thermal Hydraulics was also discussed.

- AERB presents industrial safety awards to the DAE units every year whose performance in industrial safety area is of a high order. The industrial safety awards presentation function was held on March 7, 2008. Shri S.K. Saxena, Director General, Directorate General Factory Advice Service & Labour Institutes (DGFASLI), Mumbai presented the safety awards for the year 2007 to KK-NPP in construction group, KGS-1&2 and IREL in production units group, and VECC in research units group. Shri S.K. Sharma, Chairman, AERB released 'Industrial Safety Statistics-2007 of DAE units' on this occasion. The industrial safety performance of DAE units is significantly better as compared to other similar industries in the country.

- A workshop on 'Information Exchange on Nuclear Safety between Atomic Energy Regulatory Board (AERB) and Rostekhnadzor, the Regulatory Body of Russian Federation' was held during March 25-27, 2008 at Mumbai. A three-member delegation from the Russian Federation, led by Mr. Vladislav Manakov, Deputy Department Head of the Rostekhnadzor participated in the workshop. Technical presentations were made by the Russian delegation and the Indian team on the topics of regulatory and licensing process, construction experience, severe accident analysis, control and instrumentation, pre-stressing system for primary containment and reactor pressure vessel.

### 10.2 AERB NEWS LETTER

AERB News Letter covers AERB press releases, important national and international news, safety reviews of plants / projects and authorizations issued to nuclear and radiation facilities, activities related to training, workshops, colloquia, seminars, symposiums, etc., The News Letter also carries expert views regarding safety of nuclear and radiation facilities. AERB News Letters Vol. 20 No.1-2 was published in Hindi and English for the year 2007.

### 10.3 ANNUAL REPORT

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

## 10.4 INTERACTION WITH MEDIA

Queries raised by press are replied over phone as well as during press meets by the senior officers of AERB.

## 10.5 RIGHT TO INFORMATION ACT-2005

Required measures were taken on the implementation of 'Right to Information Act (RTI)' in AERB and the required information has been put on AERB website. Nineteen queries received from various applicants under RTI Act were replied during the year.

"Experience Sharing Seminar on RTI" was organized during January 2008 by DAE and AERB's experience on RTI was presented at the Seminar.

## 10.6 AERB WEBSITE

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

# CHAPTER 11

## INTERNATIONAL COOPERATION

### 11.1 AERB-USNRC NUCLEAR SAFETY COOPERATION PROGRAM

The nuclear safety co-operation between AERB and USNRC was resumed in February 2003. A total of 8 meetings took place between the two regulatory bodies during the years 2003 to 2007. The meetings are being held alternatively in India and USA every year. The objective of these meetings continues to be furthering the dialogue on nuclear safety between India and US.

The 9th discussion meeting under the program was held at AERB during February 25-28, 2008. The USNRC delegation consisted of six members and was led by Mr. James Edward Lyons, Director, Division of Site and Environmental Reviews, Office of New Reactors. Topics discussed during this meeting included Advanced Light Water Reactor Designs and Digital Systems Reliability and Software. The Indian side also made presentations on experience with construction and operation of new reactors in India. The ongoing collaborative work related to joint exercises of bench marking computer codes through analysis of standard problems in Thermal Hydraulics was also discussed. The NRC delegation later visited the Powai works of M/s Larsen & Toubro where several large sized components for Indian nuclear power plants are under manufacture. On 3rd & 4th March, the USNRC delegation visited the PFBR construction site and some of the facilities of IGCAR at Kalpakkam.

**9th Discussion Meeting between AERB and USNRC in Progress at AERB**

*(Shri S.K. Sharma, Chairman, AERB on the right and Shri S.K. Chande, Vice-Chairman, AERB on the left are seen at head of the table. Mr. J. E. Lyon, USNRC delegation leader is sitting on the side of Shri S.K. Chande)*

The meeting participants reiterated their high degree of satisfaction with the continuing improvement in understanding of issues relating to safety of nuclear power

***US-NRC Delegates with PFBR officials at Construction Site***

plants in both countries as a result of our ongoing cooperation. It was agreed that the following topics are considered to be ongoing areas of cooperation:

- New Reactor Designs (LWRs) (e.g., technical basis for certification for a design; models/reviews/ technology-independent safety criteria, experimental work for developing enabling technologies for advanced reactor designs and reliability evaluation of passive safety systems);
- Probabilistic Risk Assessment (PRA) Methods & Application (including seismic evaluations)/Severe Accident Analysis & Management (for both operating reactors and new designs);
- Digital Systems (hardware/software) Reliability and Qualification (including control room designs and operator support systems), and;
- Construction and Operating Experience Feedback in India and the U.S.

Three standard problem exercises were identified during the last meeting.

- A thermal-hydraulic standard problem exercise utilizing data from the PANDA test facility to assess selected thermal-hydraulic computer codes for analysis of passive containment cooling systems;
- A thermal-hydraulic and severe accident standard problem exercise aimed at reanalysis of the Three Mile Island Unit 2 accident, and;
- A standard problem exercise on performance of the prestressed concrete containment vessel under severe accident conditions will be carried out in two parts.

Out of these three, significant progress has been made

on the first two by both sides. This meeting has provided opportunities to both sides to compare the work done so far and decide the course of action for the future.

The work on the third standard problem exercise on containment structure ultimate load strength is expected to start by November 2008 by which time NRC expects to provide the required data.

It was decided to hold the next NRC-AERB Nuclear Safety Projects Meeting in U.S. in the spring of 2009. However, certain follow up discussions on the standard problem exercises may be held, when the NRC staff comes to India in November 2008, in connection with the IAEA International Conference.

The following topics, among others, are proposed for discussion at the next NRC-AERB Nuclear Safety Projects Meeting:

- Advanced Light Water Reactors
- Digital Systems Reliability and Software
- Progress in the three Standard Problems Exercises.

Other topics to be included for discussion at that meeting would be identified through mutual discussion in the intervening period.

## 11.2 NUCLEAR SAFETY CO-OPERATION WITH FRENCH REGULATORY BODY

Under the Indo-French Nuclear Safety Co-operation, an AERB delegation visited France in December 2000 when discussions were held on topics like transportation of radioactive materials, fire safety, seismic safety and licensing procedures for nuclear power plants. In November 2001 a discussion meeting between DSIN, the French Nuclear Safety Authority and AERB was organised in Mumbai. A French delegation headed by Mr. Andre Claude Lacoste, Director General, DGSNR visited AERB on October 25, 2005. Discussions were held on topics like Flooding Events, Safety and Leak Tests of Pre-stressed Concrete Containments and Safety and Transport of Radioactive Materials. The agreement between the AERB and the Nuclear Safety and Radiation Protection Directorate of France for the Exchange of Information and co-operation in the Regulation of Nuclear Safety and Radiation Protection was renewed for a period of 5 years in continuation of the earlier Agreement signed in July 1999. A seminar on Pressurized Water Reactors, under this agreement was held in Mumbai during May 8-9, 2007. From Indian side, presentations were made on Design Safety Review of Kudankulam Nuclear Power Plant (KK-NPP), An approach for Design Safety Review of New Designs: AHWR a case study and Pressurized Water Reactor: Indian Prespective. French side made presentations on PWR safety objectives and safety approach, Evolutionary Pressurized Water Reactor

**Delegation of the French Regulatory Body, ASN with Senior Officials of AERB in the Technical Meeting held at AERB**

(EPR), Design Basis and Design Licensing Process, Severe Accidents Management and Instrumentation and Control. There was extensive discussion on all the presentations and better insight were gained on new features and systems of EPR and KK-NPP.

While discussing future program of AERB-ASN nuclear safety cooperation, it was decided to have extensive discussions on more specific topics of PWR technology safety assessment. The topics were to be finalized by mutual discussion between AERB and ASN. The next meeting is planned during May 2008.

## 11.3 AERB ROSTEKHNADZOR NUCLEAR SAFTETY WORKSHOP

A workshop on Information Exchange on Nuclear Safety between AERB and Rostekhnadzor, the Nuclear Regulatory Body of Russian Federation, was held during March 25-27, 2008 at Mumbai. This was the second workshop organised under the Agreement for co-operation in the field of nuclear safety, between the two regulatory bodies. A three member delegation from the Russian Federation, led by Mr. Vladislav Manakov, Deputy Department Head of the Rostekhnadzor participated in this workshop.


***Shri S.K.Sharma, Chairman, AERB greets Mr. Vladislav Mankov, Deputy Department Head, ROSTECHNADZOR, Russian Federation during the Workshop on Information Exchange on Nuclear Safety held at AERB***

Technical presentations were made by the members of Russian delegation and the Indian team on the topics of regulatory and licensing process, aspects related to construction experience, severe accident analysis, and on the experience on safety review of control and instrumentation, pre-stressing system for primary containment and reactor pressure vessel of the Kudankulam VVER type reactors. Two units of 1000 MWe each of this type are under construction at Kudankulam in Tamil Nadu in co-operation with the Russian Federation.

## 11.4 OTHER INTERNATIONAL CO-OPERATIVE ACTIVITIES

AERB also participates in several activities of the IAEA. These include the IRS, INES based reporting of events, Commission on Safety Standards, International Nuclear Safety Group (INSAG) and the work related to development of Safety Standards, Co-ordinated Research Programmes, Conduct of Training Workshops and Technical Meetings, etc. AERB also participates in the IAEA annual meetings of senior Regulators of countries Operating CANDU Type Nuclear Reactors. In 2005, the meeting of this group was held in Mumbai during November 14-18, 2005 where representatives from Argentina, Canada, China, Korea, Pakistan, Romania and the IAEA participated and visited the Tarapur Atomic Power Station, Unit-4. In 2006, India has also joined the WWER Forum in which operating and other experiences of countries operating/constructing WWER type Pressurized Water Reactors (PWRs)are discussed annually. AERB participated in the meetings of the Forum held in June 27-29, 2006 at Yerewan in Armenia and July 3-5, 2007 at Dubna, near Moscow in Russia.

## 11.5 IAEA COORDINATED RESEARCH PROJECT

AERB is one of the participants of IAEA Coordinated Research Project (CRP) 'Evaluation of Uncertainty in Best Estimate Accident Analysis'. This is the first year of this CRP. The following activities have been carried out during the year. As per the work schedule prepared in first Research Co-ordination Meeting, post test analyses with uncertainty evaluation of two tests (task group 1 activity) are to be carried out with the objective to extend these conclusions of uncertainty analysis to the NPP applications. The first test is station black out in PSB VVER integral thermal hydraulic test facility at EREC, Russia and the second test is hot leg break LOCA (SB-HL-02) in LSTF/ ROSA IV, Japan. A brief description of PSB VVER ITF, LSTF/ROSA IV ITF and for the transients to be analysed have been prepared. RELAP5 sample input for both the tests has been provided by IAEA. Input assessment and development for steady state level qualification have been done for both tests. Acceptance criteria for geometrical parameters, boundary conditions and initial conditions for steady state level qualification have been evolved based on literature. Errors are generated by comparing the values of these criteria from input and experimental values. Certain modifications in input deck based on test specification are incorporated in the input and qualified steady state level qualifications have been achieved. The first year progress report has been sent to IAEA. Work on transient part for both the tests is in progress now.

# CHAPTER 12

# HUMAN RESOURCE DEVELOPMENT

## 12.1 MANPOWER AUGMENTATION

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

- Two students sponsored in AGFS for M. Tech in 2005 joined AERB in August 2007.
- Five officers, one each from training schools of BARC, NFC and IGCAR and two from NPCIL, joined AERB in August 2007.
- Three officers joined from Radiological Physics Advisory Division (RPAD) Training Scheme of BARC.
- Five officers joined AERB through inter-unit transfer; two from BARC, one from IGCAR, one from DCSEM and one from DAE.
- Nine staff members joined through direct recruitment.
- Two students each in IIT Madras and Bombay were sponsored for M.Tech in August 2007.

As on 31-03-2008, the total staff strength in AERB is 199 comprising 157 scientific and technical and 42 supportive staff.

## 12.2 TRAINING

### 12.2.1 AERB In-house Orientation Programme

AERB In-house Training Programme was conducted during September 2007 to November 2007 for the scientists/engineers recruited directly and other technical staff. Fifty-seven lectures were organized on regulatory and safety related activities of AERB. The course proved very useful in apprising the staff about the activities of AERB.

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

Two engineers, selected under AGFS, underwent training in Orientation Course for DGFS Fellows (OCDF) of Human Resource Development Division, BARC.

### 12.2.3 Nuclear Training Centers of NPCIL

1. Two engineers underwent four months 'On Job Training' (OJT) at MAPS, Kalpakkam and TAPP-3&4, Tarapur respectively.
2. Three engineers cleared Licensing examination for CE (Level-III) at TAPP-3&4.
3. Four engineers from NPCIL training school in OCES-2007 are undergoing training in PWR stream at Kundankulam site.
4. One officer was deputed to TAPS-1&2 to participate in NDT works of Recirculation Loop-B normalization.
5. Two officers have been deputed to RAPP-5&6 for getting familiarized with the commissioning activities of RAPS-5.
6. Two officers have been deputed to TAPP-3&4 for getting License of control engineers.
7. One officer was deputed to RAPP-5&6 for OJT.
8. Three engineers were deputed to TAPS-1&2 for attending to TAPS Training Programme.

## 12.3 REFRESHER COURSES

Refresher Courses were organized on 'Fast Breeder Reactor Technology'. Lectures covering the topics on 'PFBR Core Engineering Design', 'Design of Reactor Assembly Components', 'Sodium Circuits' and 'Shutdown Systems & Decay Heat Removal Systems' were delivered, in which a large number of AERB personnel attended.

## 12.4 DEPUTATION ABROAD

- One officer completed one-year deputation in the University of Pisa, Italy where he worked on 'Uncertainty Analysis of Thermal Hydraulic Safety Studies'.
- Two officers deputed to USNRC, Washington, USA for one year to complete their assignment related to 'Nuclear Reactor Regulation, Probabilistic Risk Assessment Licensing and Nuclear Regulatory Research in Probability Risk Assessment.
- One officer deputed to Tokyo, Japan under the fellowship of Japan Society for Promotion of Science to work on 'Simulation of Radionuclides Migration through Bentonite-Sand Backfill in a Geometrical Centrifuge'.
- One officer has been deputed to University of Texas to work on 'Physics Modelling of Generic Fast Breeder Reactor Core Analysis'.

## 12.5 AERB COLLOQUIA

Following colloquia were organized.

- 'Fifty Years of Radiation Protection' by Shri G. Venkataman, Former Head, Radiation Protection Services Division, BARC. The talk focused on the

development of radiation protection measures in medical, industrial and research applications of radiation during the last fifty years. The talk recollected the early experiences of diagnostic radiology and the subsequent developments in this area. The talk addressed some of the radiation incidents, as well as valuable lessons learnt from them.

- 'Effective Communication Techniques' by Shri R. Bharathan, BARC highlighting on how to listen while hearing and speak while talking. The talk covered various day-to-day incidents and situations related to communication gaps and how they can be improved in an effective way.
- 'Recent Developments in Radiobiological Research: Implications to Human Health Risk and Radioprotection' by Dr. K. P. Mishra, Ex- BARC. This talk highlighted the emerging new perspectives in radiobiology with implications to risk assessment and radioprotection standards for human health.
- 'Bomb Detection & Disposal' by Shri R. P. Raju, NPCIL. This talk highlighted the various techniques involved in the detection of bombs, various precautions by the public and disposal methods.
- 'Regulatory Activities Prior to Formation of AERB' by Shri S. D. Soman, Ex- Chairman, AERB. This talk highlighted the regulatory activities for nuclear and radiation facilities prior to the formation of AERB. This talk also addressed how the regulatory procedures have evolved in AERB over a time period for ensuring the safety of nuclear and radiation facilities.
- 'Compact Reprocessing facility for Advanced fuels in Lead shielded cell (CORAL) Operations: Stepping-Stone for Fast Reactor Fuel Reprocessing Technology' by Shri R. Natarajan, Group Director, Reprocessing Group, IGCAR, Kalpakkam. This talk addressed various aspects involved in the reprocessing of spent fuel, experience of reprocessing of FBTR fuel, CORAL facility for advanced fuels in Lead Shielded Mini Cell, design aspects of the Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP) and the Fast reactor fuel Reprocessing Plant (FRP).
- 'NAPS-1 Criticality and Phase-B Experiments after EMCCR Works' by Shri A. Ramakrishna, AERB. NAPS-1 achieved criticality on 6th January 2008 after EMCCR works and subsequently, completed all Phase-B low power experiments on 7th January 2008 successfully. Prior to this criticality, NAPS-1 encountered problems due to high - fields and startup monitoring instrumentation. This talk addressed the chronological sequence of problems and their resolutions during the approaches to criticalities and low power experiments and comparison with other NPPs, which passed the same stages after EMCCR.
- 'Online E-Training for Continuous Improvement at Rapid Pace' by Dr. Mihir K. Das, USA on March 11, 2008. In this talk, the speaker emphasized the positive developments in the field of E-learning.
- 'Radiation Therapy of Tumors by Heavy Ions and Associated Radiation Protection' by Dr. Klaus Henrichs, Germany on March 27, 2008. In this talk, the speaker highlighted on advantages of heavy ion therapy and associated radiation protection problems.

## 12.6 KNOWLEDGE MANAGEMENT

A 'Knowledge Portal' was in operation during the year at the internal website of AERB, as part of knowledge preservation and easy retrieval. Training/teaching material, proceedings of Conferences and Seminars, Papers presented/ published by AERB personnel and management information system were posted on the portal at regular intervals. National and international codes/guides/manuals are also being posted on the portal.

A well-equipped library is maintained in AERB. A total of 230 documents and 275 issues of various subscribed periodicals have been added to the library. Reference and Information Services have been provided to the users and visitors of the Library. Hard and soft copies of Nucleonics Week and NUCNET are circulated among senior AERB staff regularly.

# CHAPTER 13
# SAFETY PROMOTIONAL ACTIVITIES

## 13.1 SAFETY RESEARCH PROGRAMME

One of the objectives of the AERB is to promote safety research and related activities relevant to safety and regulatory work. For this, a Committee for Safety Research Programmes (CSRP) has been constituted to frame rules, regulations and guidelines and to evaluate, recommend and monitor the research projects. The Committee also recommends financial assistance to universities, research organizations and professional associations for holding symposia and conferences of interest to AERB after scrutinizing the applications. The CSRP met 4 times during the year and deliberated on 16 new project proposals and recommended Grant-in-Aid for 5 new projects as given in Table 13.1. It also approved the renewal of 7 ongoing projects as given in Table 13.2. In addition, financial support was provided to 32 seminars, symposia and conferences.

**Table 13.1: New Research Projects Approved**

| Sr. No. | Project Title | Principal Investigator | Institution |
|---|---|---|---|
| 1. | Enhancement of Durability of Concrete Structures using Microbes | Prof.Abhijit Mukherjee | Thapar Institute of Tech nology, Patiala, Punjab |
| 2. | Validation of Gel Dosimetry as 3-D Verification Tool for Highly Conformal Radiotherapy Techniques | Dr.S. Vivekanandhan | All India Institute of Medical Sciences, New Delhi. |
| 3. | Multi-Material Multi-Rod 3-D Temperature Distribution in a Fuel Bundle with Temperature/Time Dependent Thermo-physical Property with Dirichlet/Neumann /Robbins and their Contribution as Boundary Conditions | Dr. P. K. Satapathy | College of Engineering and Technology, Biju Patnaik University of Technology, Bhubaneswar, Orissa. |
| 4. | Development of Model to Calculate Radiative Heat Transfer in Fuel Channels of Pressurized Heavy Water Reactors (PHWR) | Dr. S. C. Mishra | IIT-Guwahati, Guwahati, Assam. |
| 5. | Thermal Hydraulics Studies on Stability and Critical Heat Flux of relevance to Advanced Heavy Water Reactor (AHWR). | Dr. Kannan Iyer | IIT-Bombay, Mumbai, Maharashtra. |

## 13.2 WORKSHOPS/SEMINARS

### 13.2.1 Discussion Meet on Fire Modeling

Fire in any industrial installation is a safety concern as it can result in damage to and loss of property and life. The consequences can be more severe in a nuclear installation due to the added risk of release of radioactivity. Keeping in view the importance of fire modeling, two day 'Discussion Meet on Fire Modeling' was jointly organized by AERB and SRI, Kalpakkam on 20th - 21st September 2007, Niyamak Bhavan in AERB. The discussion meet focused on the topics such as regulatory perception, requirements for Fire Hazard Analysis of nuclear power plant facilities, computer codes for fire modeling - present predictive capabilities, CFD modeling of fires - current trends, benchmark data for validation of fire models and Fire-Probabilistic Safety Assessment. Future works to be carried out in this field were also identified.

### 13.2.2 Theme Meeting on Analysis and Management of Severe Accidents in Indian Nuclear Power Plants

A theme meeting on 'Severe Accident Analysis and Management for Indian Nuclear Power Plants' was organized on 26th March 2007 at AERB. The focus was on topics such as severe accident analysis and management, water ingression behavior in corium molten pool, quenching of heat generated from debris bed, thermal-hydraulic and thermo-mechanical investigations, identification of severe accident management strategies, identification of back fit measures for managing severe accident mitigation and computer code development for in-vessel core disassembly and R&D in severe accident.

**Table 13.2: Research Projects Renewed**

| Sr. No. | Project Title | Principal Investigator | Institution |
|---|---|---|---|
| 1. | Evaluation of Radiation Doses from CT Scanners - A Survey | Dr. S. Livingstone | Christian Medical College Hospital, Vellore, Tamil Nadu. |
| 2. | Developing Tissue Equivalent TLD Materials for Personnel Monitoring | Dr. S.K. Omanwar | Amravati University, Amravati, Maharashtra. |
| 3. | Temperature Prediction of the Thermowell in the Core Temperature Monitoring System of FBTR | Dr. A. Mukhopadhyay | Jadavpur University, Kolkata, West Bengal. |
| 4. | Investigations on Instabilities and Non-Linear Dynamics of AHWR | Dr. Man Mohan Pandey | IIT-Guwahati, Guwahati, Assam. |
| 5. | Transfer Coefficient of Radiostronium (90Sr) in Food Crops | Dr. A. Raja Rajan | Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. |
| 6. | Development of a 3D Space-Time Kinetics Model for the Analysis of Light Water Reactors | Dr. J.B. Doshi | IIT-Bombay, Mumbai, Maharashtra. |
| 7. | Development of Novel Polymeric Nuclear Track Detectors | Dr. V.S. Nadkarni | Goa University, Goa. |

### 13.2.3 International Workshop on New Horizons in Nuclear Reactor Thermal Hydraulics

The international workshop on new horizons in nuclear reactor thermal hydraulics on January 7-8, 2008 was jointly organised by AERB and BARC. The main objective of the workshop was to discuss the recent developments and future challenges in nuclear reactor thermal hydraulics such as, (i) the advancement and dissemination of knowledge of thermal hydraulic phenomena as they pertain to the steady state design, transient performance and accident behavior of nuclear power plants, (ii) dissemination of the state-of-the-art thermal hydraulic information on current and future generation nuclear reactors, (iii) promote effective interchange of thermal hydraulic information among the many professional groups and organizations participating in the development and application of nuclear reactor technology. The following topics were covered in the workshop.

- Modeling of Two-phase Flow in New Generation Reactor Systems.
- Natural Circulation in Innovative Reactors.
- Thermal Hydraulics of Supercritical Fluids Reactor Systems.
- Challenges of Thermal Hydraulics of FBRs.
- Containment Thermal Hydraulics.
- Severe Accidents.
- Best Estimate and Uncertainty Analysis.
- Thermal Hydraulic Challenges for HTRs and ADSS.
- Status of Thermal Hydraulic Research in India.
- Application of CFD codes.
- Nanofluids Applications.

### 13.2.4 Workshop on Ground Water Modeling using Visual MODFLOW & PHREEQC

Safety Research Institute, Kalpakkam organised a 3-day workshop on "Groundwater Modeling Using Visual Modflow PRO & PHREEQC" during 29-31 August 2007 to share its experience gained in groundwater modeling studies at Kalpakkam. The purpose of this workshop had been to provide basics of Groundwater and Geochemical Modeling aspects followed by hands-on-experience on the software: Visual Modflow Pro and PHREEQC for civil engineers, waste managers, geologists and researchers from BARC, IGCAR, BHAVINI, NPCIL, NFC, UCIL and AERB engaged in groundwater modeling studies.

The delegates were engaged with lectures on Groundwater as well as Geochemical Modeling during pre-lunch sessions. The post-lunch sessions were utilized for hands-on training in the above mentioned software. The faculty for the workshop was drawn from NGRI, Annamalai University and SRI-AERB. The 3-day workshop was attended by 20 delegates and it concluded with a valedictory function. Dr. L. Elango, Head, Department of Geology, Annamalai University, was the chief guest for the function and had distributed certificates to the participants.

### 13.2.5 Workshop on Internal Radiation Dosimetry

SRI in association with Indian Society of Radiation Physics (ISRP) organised a workshop on "Internal Radiation Dosimetry", WIRD-07 during June 20-22, 2007. About 50 participants from various DAE and NPCIL units attended the workshop. There were about 15 invited lectures delivered by experts drawn from BARC and IGCAR units. Further, hands on training on computer codes used in this area and practical exercises on whole body counter, shadow shield counter, alpha counter, bioassay procedures were given. Technical presentations were excellent and there were lively discussions by the participants during the sessions. During the feedback session, participants expressed a desire to hold such workshops at least once in 2 years covering also other topics relating to potential hazards in mining sector. Participants felt that each unit is following different procedure in assessing the internal contamination and also in estimating committed equivalent dose. This needs to be standardised. Proceedings of workshop CD and participation certificate were distributed to all the participants.

## 13.3 REVIEW OF IAEA DRAFT DOCUMENTS

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

- Severe Accident Programmes for NPPs (DS385)
- Regulations for the Safe Transport of Radioactive Material, TS-R-1 (DS345)
- Seismic Evaluation of Existing Nuclear Installations (DS 383)
- Geological Disposal of Radioactive Waste (DS334).
- Nuclear Security Culture.
- Safety Assessment for Facilities and Activities (DS348).
- Development and Applications of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants (DS394).
- Development, Implementation and Maintenance of a Design Basis Threat.
- Deterministic Safety Analysis for Nuclear Power Plants (DS 395)

## 13.4 REVIEW OF BUREAU OF INDIAN STANDARDS (BIS) DOCUMENTS

Head, IPSD has been appointed as Convener of Chemical Hazards Subcommittee, (CHD 8:2) and a member of the CHD 8 for revision of BIS documents related to chemicals and occupational health and entrusted to revise the IS 4209:1987 (Code of Safety in Chemical Laboratory). Revision of " Code of Safety in Chemical Laboratories" (IS 4209:1987) is in progress.

# CHAPTER 14

## OFFICIAL LANGUAGE IMPLEMENTATION

AERB continued its efforts to ensure effective implementation of Official Language Policy and enhance the use of Hindi. The progress in implementation of the policy is regularly reviewed in Executive Committee of AERB.

The Official Language Implementation Committee (OLIC) of AERB took steps to accelerate the use of Hindi for official purposes and progressive and effective implementation of the Official Language Policy. This year, an in-house inspection in the Divisions of AERB, was conducted to explore the areas where Hindi can be used effectively in routine matters.

During the year, 14 officers/staff members of AERB were trained for Pragya /Praveen examinations under the Hindi Teaching Scheme, Ministry of Home Affairs, Government of India. Hindi stenography training classes were started. In order to train employees to write letters, notes, etc. in Hindi, two Hindi workshops were organized jointly with DPS, DCSEM, HWB, Mumbai. Four employees of AERB attended these workshops. Necessary steps have been taken up to prepare scientific and technical literature in Hindi and make the same available for use by public as well as by other institutions.

Efforts were continued to translate/prepare technical documents in Hindi. This year, 4 documents namely "Role of the Regulatory Body with respect to Emergency Response and Preparedness at Nuclear and Radiation Facilities", "Quality Assurance in the Procurement of Items and Services for Nuclear Power Plants", "Liquid and Solid Radwaste Management in Pressurized Heavy Water Reactor based Nuclear Power Plants" and "Design Basis Events for Pressurized Heavy Water Rector" have been printed in Hindi. Four documents have been translated into Hindi and 29 documents have been taken up for printing in Hindi. With this 32 documents have been translated into HIndi.

As done every year, Hindi Day, Hindi Week and prize distribution functions were organized jointly by the Joint Official Language Co-ordination Committee of DAE units of Mumbai (AERB, DPS, DCSEM, and HWB). Elocution/Debate/Poetry recitation and Quiz Competitions were organized. AERB team participated in Quiz Programme and scored second position.

To create a conducive atmosphere to encourage use of Hindi by the officers and staff, 11 competitions in Hindi were organized. A prize distribution function was organized in September 2007. On this occasion, the greeting messages written in Hindi by Shri Shivraj Patil, Hon'ble Home Minister and Dr. Anil Kakodkar, Secretary, DAE and Chairman, Atomic Energy Commission on Hindi Day were read out. To encourage the staff to use Hindi in various official works, the ISM-2000 software was loaded in all the computers of AERB.

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


**AERB Hindi Day Function**
*(L to R: Shri S.P. Agarwal, Chairman, OLIC & Head, RSD, AERB, Shri S.K. Sharma, Chairman, AERB and Shri V.M. Thomas, AO-III, AERB)*

# CHAPTER 15
## MISCELLANEOUS

### 15.1 QUALITY MANAGEMENT SYSTEM (QMS) OF AERB

The ISO 9001:2000 certification was awarded to the Quality Management System (QMS) of AERB on 15th November 2006, the anniversary date of formation of AERB in 1983. The scope of the QMS includes the following 3 major processes of AERB.

- Consenting Process for Nuclear and Radiation Facilities.
- Regulatory Inspection of Nuclear and Radiation Facilities.
- Development of Safety Documents.

During the year, 2 internal audits of all Divisions of AERB, one on March 28-30, 2007 and another on July 3-5, 2007, were conducted. Actions to rectify the non-conformances were taken and subsequently the non-conformances were closed. Two management review meetings were held, (on May 22, 2007 and December 10, 2007) to review the results of internal audits, client feedback, aspect of continuing suitability as well as effectiveness of AERB-QMS and areas for improvement.

An in-house training program on "Internal Quality Audit cum Documentation" was conducted by BIS in September 2007. Eighteen staff members including three Directors/Heads of Divisions undertook the training. Presently there are 39 trained auditors and two lead auditors in AERB.

Two new Level-II documents, one on "Procedure for Consenting Process for New Projects" and other on "Procedure for Consenting Process for Operating Plants/ Facilities" were prepared. "Quality Manual of AERB" and "Procedure for Internal Audit" have also been modified for efficient implementation of quality policy.

First surveillance audit of AERB-QMS was carried out by BIS on January 7-8, 2008 and the continuation of the ISO certificate was recommended.

### 15.2 AERB EXPANSION PROJECT

The construction of Niyamak Bhavan-B (NB-B) adjacent to the existing Niyamak Bhavan-A was completed as part of 10th plan "AERB Expansion Project". Professor A.K. De, first Chairman of AERB, inaugurated the building on 23rd November 2007 at the function organized to mark the beginning of the Silver Jubilee year of AERB. Many dignitaries including Dr. Anil Kakodkar, Chairman, AEC and former Chairmen of AERB attended the inauguration function. The new building includes a well-equipped lecture hall, a well-appointed conference room, meeting rooms of various capacities and a spacious library.

**Professor A. K. De, First Chairman of AERB inaugurates Niyamak Bhavan-B, the new office building of AERB**

### 15.3 SILVER JUBILEE YEAR CELEBRATIONS OF AERB

AERB was established on 15th Nov 1983 with the mission to ensure that the use of ionizing radiation and nuclear energy in India does not cause unacceptable impact on the health of workers and members of the public and on the environment. On Nov. 15, 2007, the silver jubilee year of AERB started.

To mark the beginning of the silver jubilee year, a function was organized on Nov. 23, 2007. Dr. Anil Kakodkar, Chairman, AEC was the Chief Guest. All the former Chairmen (except Dr. A. Gopalkrishnan) and former Vice Chairmen of AERB were present as Guests of Honour and spoke on the occasion. Apart from the addresses by the luminaries, the "AERB Code of Ethics" and a "Monograph on Probabilistic Safety Assessment" prepared by AERB staff were released on this occasion.

A series of events is planned as part of silver jubilee year celebration. In the month of December 2007, a monograph on 'Construction Safety' prepared by AERB staff was released during the 24th DAE Safety, Occupational and Health Professional Meet' organized at Rawatbhata, Rajasthan site. In February 2008, AERB-USNRC safety co-operation meeting was organized in which international experience was shared on Light Water Reactor designs and digital systems reliability software. In March 2008, under AERB-Rostekhnadzor (Nuclear Regulatory Body of Russia) co-operation program, a workshop on Information Exchange on Nuclear Safety was organized, in which both the sides shared knowledge on topics of regulatory and licensing interest, severe accident analysis and pre-stressing system of primary containment. Seminars on 'Fire Safety', 'Emergency Preparedness' and a seminar for media are planned. The silver jubilee year celebration will culminate

with organizing the IAEA International Conference on Topical Issues in Nuclear Installation Safety, during Nov. 17-21, 2008. A book on historical aspects of AERB is also planned to be released on the Silver Jubilee Day.

## 15.4 AWARDS

The following senior officers of AERB were bestowed with Indian Nuclear Society (INS) Awards for the year 2006.

1. Shri S. K. Chande, Vice Chairman, AERB in the category of high technology in Nuclear Related Areas.
2. Shri A. U. Sonawane, SO/F, INS medal

The Awards were given by Prof. P. Rama Rao, Member, Atomic Energy Commission and Former Chairman, AERB at INS Annual Conference (INSAC) in Hyderabad held in Noember, 2007.


**Dr. Anil Kakodkar, Chairman AEC and Secretary DAE addressing the gathering during the function marking the beginning of AERB Silver Jubilee Year**

*Dignitaries on the dais (L to R) : Shri S. K. Sharma, Chairman AERB; Prof. S. P. Sukhatme, Prof. P. Rama Rao, Prof. A. K. De & Dr. S. D. Soman, Former Chairmen, AERB and Shri S. K. Chande, Vice Chairman, AERB*

# APPENDIX

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# ANNEXURE

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| ACI&FS | : | Advisory Committee on Industrial & Fire Safety |
| ACRS | : | Advisory Committee on Radiological Safety |
| ACNS | : | Advisory Committee on Nuclear Safety |
| ACOH | : | Advisory Committee on Occupational Health |
| ACPSR | : | Advisory Committee for Project Safety Review |
| ACPSR-FCF | : | Advisory Committee for Project Safety Review for Fuel Cycle Facilities |
| AERB | : | Atomic Energy Regulatory Board |
| AFW | : | Auxiliary Feed Water |
| AFWP | : | Auxiliary Feed Water Pumps |
| AGFS | : | AERB Graduate Fellowship Scheme |
| AGMS | : | Annular Gas Monitoring System |
| AGS | : | Annulus Gas System |
| ALARA | : | As Low As Reasonably Achievable |
| AMD | : | Atomic Minerals Division |
| ARA | : | Application for Renewal of Authorisation |
| ASN | : | Nuclear Safety Authority |
| AVR | : | Automatic Voltage Regulator |
| BARC | : | Bhabha Atomic Research Centre |
| BDBA | : | Beyond Design Basis Accident |
| BEXD | : | Boron Enrichment Exchange Distillation |
| BHAVINI | : | Bhartiya Nabhkiya Vidyut Nigam |
| BIS | : | Bureau of Indian Standards |
| BRIT | : | Board of Radiation and Isotope Technology |
| BSC | : | Biological Shield Cooling |
| CCC | : | Construction Completion Certificate |
| CCF | : | Common Cause Failure |
| C&I | : | Control & Instrumentation |
| CCWP | : | Condenser Cooling Water Pump |
| CDF | : | Core Damage Frequency |
| CE | : | Control Engineers |
| CESC | : | Civil Engineering Safety Committee |
| CESCOP | : | Civil Engineering Safety Committee for Operating Plants |
| CFD | : | Computational Fluid Dynamics |
| CLSM | : | Confocal Laser Scanning Microscopy |
| CORAL | | Compact Reprocessing of Advanced Fuels in Lead Cells |
| CRP | : | Coordinated Research Project |
| CSDV | : | Condenser Steam Dump Valves |
| CSRG | : | CANDU Senior Regulator Group |
| CSRP | : | Committee for Safety Research Programmes |
| CWMF | : | Central Waste Management Facility |
| CWPRS | : | Central Water Power Research Station |
| DAE | : | Department of Atomic Energy |
| DCR | : | Design Concession Reports |
| DCS | : | Distributed Control System |
| DEM | : | Digital Elevation Model |
| DFRP | : | Demonstration Fast Reactor Fuel Reprocessing Plant |
| DG | : | Diesel Generator |
| DGCA | : | Director General of Civil Aviation |
| DGFS | : | DAE Graduate Fellowship Scheme |
| DOE | : | Department of Energy |
| DRS | : | Directorate of Radiation Safety |
| DSR | : | Diverse Safety Rod |
| DSRC-DP | : | Design Safety Review Committee for Diversified Projects |
| DSRC-UEP | : | Design Safety Review Committee for Uranium Extraction Project |
| DU | : | Depleted Uranium |
| ECCS | : | Emergency Core Cooling System |
| ECIL | : | Electronics Corporation of India Ltd |
| EE | : | Equipment Erection |
| EELD | : | Extended Electrode Leak Detectors |
| EMCCR | : | En-Masse Coolant Channel Replacement |
| EMFR | : | En-Masse Feeder Replacement |
| EPR | : | Evolutionary Pressurised Water Reactor |
| ER | : | Event Report |
| ESL | : | Environmental Survey Laboratory |
| FAC | : | First Approach to Criticality |
| FBR | : | Fast Breeder Reactor |

| | | |
|---|---|---|
| FBTR | : | Fast Breeder Test Reactor |
| FDS | : | Fire Dynamics Simulator |
| FEL | : | Free Electron Linac |
| FFP | : | Fuel Fabrication Plant |
| FHA | : | Fire Hazard Analysis |
| FHI | : | Fire Hazard Index |
| FP | : | Full Power |
| FRLS | : | Fire Retardant Low Smoke |
| FRP | : | Fuel Reprocessing Plant |
| F.R. | : | Frequency Rate |
| FRFCF | : | Fast Reactor Fuel Cycle Facility |
| FWPH | : | Fire Water Pump House |
| GIP | : | General Implementation Procedure |
| GIS | : | Geographic Information System |
| GT | : | Generator Transformer |
| HEF | : | Head End Facility |
| HEWA | : | Heavy Water Clean Up Facility |
| HPU | : | Health Physics Unit |
| HTR | : | High Temperature Reactor |
| HWB | : | Heavy Water Board |
| HWP | : | Heavy Water Plant |
| HWP-SC | : | Heavy Water Plants Safety Committee |
| IAEA | : | International Atomic Energy Agency |
| IFSB | : | Interim Fuel sub-assembly Storage Building |
| IGCAR | : | Indira Gandhi Centre for Atomic Research |
| IGRED | : | Industrial Radiography Exposure Device |
| IGRPP | : | Industrial Gamma Radiation Processing Plant |
| IHX | : | Intermediate Heat Exchanger |
| ILRT | : | Integrated Leak Rate Test |
| IMO | : | International Maritime Organisation |
| INES | : | International Nuclear Event Scale |
| IREL | : | Indian Rare Earths Limited |
| IRS | : | Incident Reporting System |
| ISI | : | In-Service Inspection |
| ISO | : | International Organisation for Standardization |
| ITF | : | Integral Test Facility |
| IV &V | : | Independent Verification & Validation |
| IV & VC | : | Independent Verification and Validation Committee |
| JHA | : | Job Hazard Analysis |
| KAPP | : | Kakrapar Atomic Power Project |
| KAPS | : | Kakrapar Atomic Power Station |
| KARP | : | Kalpakkam Reprocessing Plant |
| KGS | : | Kaiga Generating Station |
| KK-NPP | : | Kudankulam Nuclear Power Project |
| LBB | : | Leak Before Break |
| LINAC | : | Linear Accelerator |
| LOCA | : | Loss of Coolant Accident |
| LTTM | : | Low Trajectory Turbine Missile |
| LWR | : | Light Water Reactor |
| MAPS | : | Madras Atomic Power Station |
| MCR | : | Main Control Room |
| MILD | : | Mutual Inductance Leak Detector |
| MoU | : | Memorandum of Understanding |
| MV | : | Main Vessel |
| NAPS | : | Narora Atomic Power Station |
| NDE | : | Non-Destructive Examination |
| NFC | : | Nuclear Fuel Complex |
| NOC | : | No-Objection Certificate |
| NDB | : | Neutron Detector Box |
| NPCIL | : | Nuclear Power Corporation of India Limited |
| NPP | : | Nuclear Power Plant |
| NTC | : | Nuclear Training Centre |
| OCDF | : | Orientation Course for DGFS Fellows |
| OECD | : | Organisation for Economic Cooperation & Development |
| OJT | : | On Job Training |
| OLIC | : | Official Language Implementation Committee |
| O&M | : | Operation & Maintenance |
| OPSD | : | Operating Plants Safety Division |
| OSCOM | : | Orissa Sand Complex |
| OSEE | : | Off-site Emergency Exercises |
| OSU | : | Oil Supply Unit |
| OTSG | : | Once Through Steam Generators |
| PC | : | Primary Containment |
| PCCS | : | Passive Containment Cooling System |
| PCP | : | Primary Coolant Pumps |
| 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 |
| PLC | : | Programmable Logic Controller |
| PORV | : | Pilot Operated Relief Valve |
| PPE | : | Personnel Protective Equipment |
| PPF | : | Process Plant Facility |
| PPP | : | Primary Pressurising Plant |
| PRA | : | Probabilistic Risk Assessment |
| PRV | : | Pressure Relief Valve |
| PSAR | : | Preliminary Safety Analysis Report |
| PSA | : | Probabilistic Safety Analysis |
| PSS | : | Primary Shutdown System |
| PWR | : | Pressurized Water Reactor |
| QA | : | Quality Assurance |
| QMS | : | Quality Management System |
| RADAS | : | Radiation Data Acquisition System |
| RAPP | : | Rajasthan Atomic Power Project |
| RAPS | : | Rajasthan Atomic Power Station |
| RB | : | Reactor Building |
| RCC | : | Reinforced Cement Concrete |
| RCP | : | Reactor Coolant Pump |
| R&D | : | Research and Development |
| RI | : | Regulatory Inspection |
| RIB | : | Radioactive Ion Beam |
| RL | : | Reference Level |
| RPAD | : | Radiological Physics Advisory Division |
| RPV | : | Reactor Pressure Vessel |
| RRCAT | : | Raja Ramanna Centre for Advanced Technology |
| RRS | : | Reactor Regulating System |
| RS | : | Remote Sensing |
| RSO | : | Radiological Safety Officer |
| RTI | : | Right to Information |
| RUP | : | Reprocessed Uranium Oxide Plant |
| RV | : | Reactor Vault |
| RWP | : | Radiological Work Permit |
| SARCAR | : | Safety Review Committee for Applications of Radiation |
| SARCOP | : | Safety Review Committee for Operating Plants |
| SBO | : | Station Black Out |
| SC | : | Safety Code |
| SCURF | : | Standing Committee for Investigation of Unusual Occurrences in Radiation Facilities |
| SCRAM | : | Safety Control Rod Accelerated Movement |
| SEC | : | Site Evaluation Committee |
| SEE | : | Site Emergency Exercise |
| SER | : | Site Evaluation Report |
| SER | : | Significant Event Report |
| SG | : | Safety Guide |
| SG | : | Steam Generator |
| SG | : | Specialists Group |
| SGDHRS | : | Safety Grade Decay Heat Removal System |
| SHP | : | Shift Health Physicist |
| SM | : | Safety Manual |
| SPE | : | Standard Problem Exercise |
| SPND | : | Self Powered Neutron Detector |
| SRI | : | Safety Research Institute |
| SS | : | Standards Specifications |
| SSC | : | Structures, Systems and Components |
| S.R | : | Severity Rate |
| SSS | : | Secondary Shut down System |
| SSSB | : | Spent Subassembly Storage Bay |
| SV | : | Safety Vessel |
| TAPS | : | Tarapur Atomic Power Station |
| TD | : | Technical Document |
| TF | : | Task Force |
| TG | : | Turbine Generator |
| TMI | : | Three Mile Island |
| Type B (U) | : | Type B (Unilateral) |
| USC | : | Unit Safety Committee |
| UCIL | : | Uranium Corporation of India Limited |
| USNRC | : | United States Nuclear Regulatory Commission |
| VDRM | : | Ventilation Duct Radiation Monitors |
| VECC | : | Variable Energy Cyclotron Centre |
| V & V | : | Verification and Validation |
| VSPP | : | Versatile Solvent Production Plant |
| VRSC | : | VECC and RRCAT Safety Committee |
| VVER | : | Water Water Energy Reactor |
| WG | : | Working Group |
| WTF | : | Waste Tank Farm |

## INTERNATIONAL NUCLEAR EVENT SCALE (INES)

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

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**Niyamak Bhavan-B, the new office building of AERB**

**Unveiling of the Plaque for the Inauguration of Niyamak Bhavan-B**

Dignitaries (L to R) : Shri S. K. Chande, Vice-Chairman, AERB, Shri G. R. Srinivasan, Former Vice-Chairman, AERB; Shri S. D. Soman, Prof. P. Rama Rao, Prof. S. P. Sukhatme, Prof. A. K. De, all Former Chairmen of AERB; Dr. Anil Kakodkar, Chairman, AEC & Secretary, DAE, Shri S. K. Sharma, Chairman, AERB and Shri S. V. Kumar, Former, Vice Chairman, AERB.