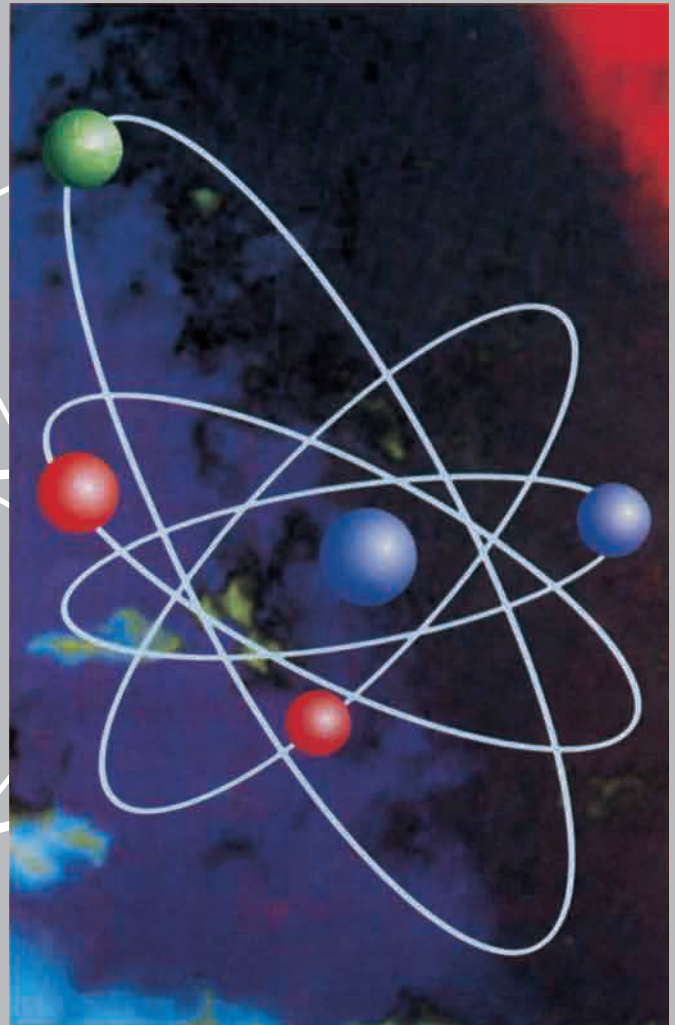




**ATOMIC ENERGY
REGULATORY BOARD**

Annual Report 2008-2009



25 Years of
Safety Regulation
1983 - 2008

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 periodically, seminars, workshops and discussion meetings.

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

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



GOVERNMENT OF INDIA
ATOMIC ENERGY REGULATORY BOARD

ANNUAL REPORT

2008-2009



25 Years of
Safety Regulation
1983 - 2008



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 of the emergency preparedness plans for nuclear and radiation facilities.
- Safety reviews for transport of large radioactive sources, irradiated fuel and fissile material.
- Review of 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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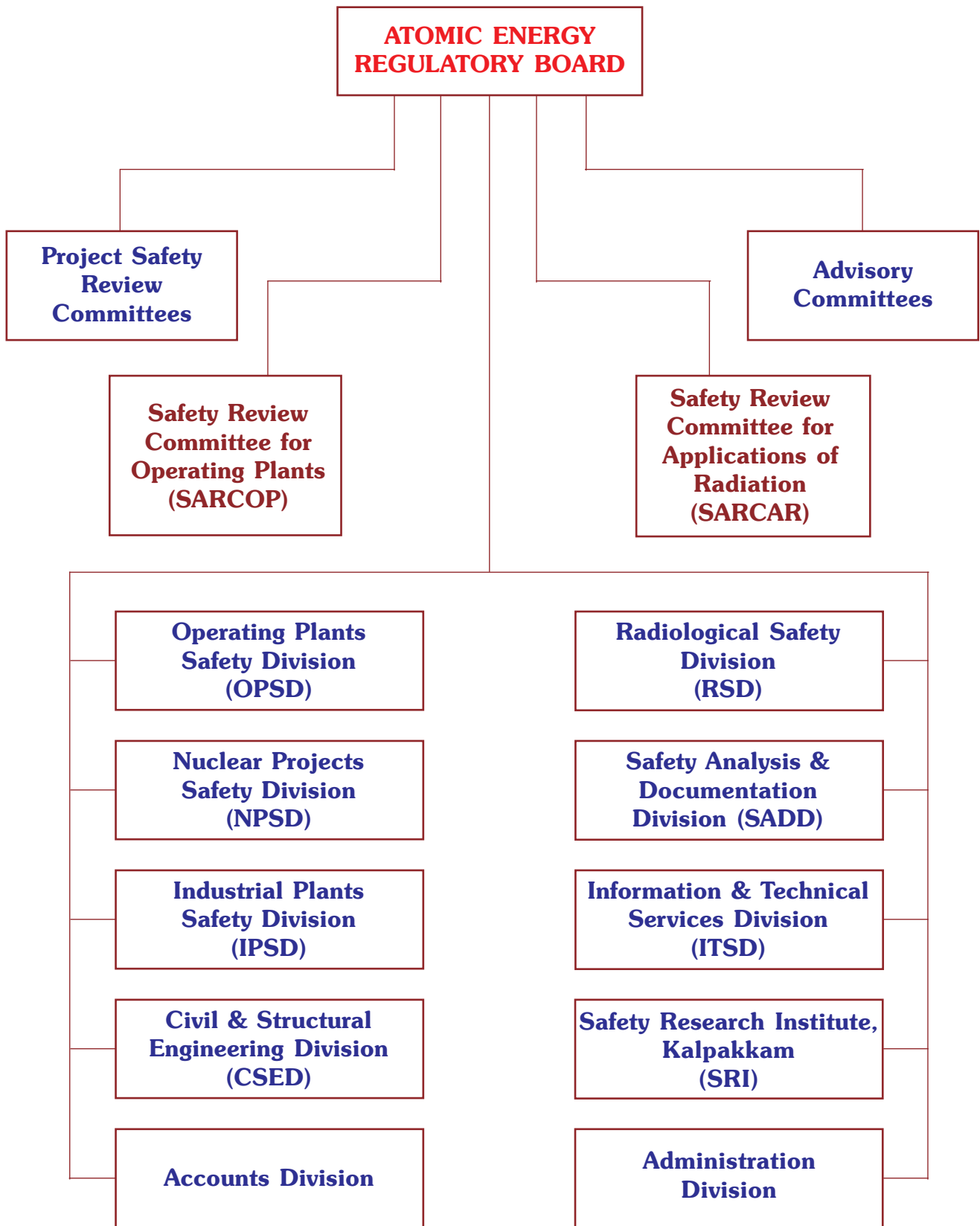
CHAPTER 1

GENERAL

1.1 COMPOSITION OF THE BOARD

1.	Shri S.K. Sharma, AERB	...	Chairman
2.	Shri S.K. Chande, AERB	...	Member (Ex Officio)
3.	Dr. K.V. Raghavan INAE Distinguished Professor Indian Institute of Chemical Technology Hyderabad	...	Member
4.	Prof. J.B. Joshi Professor and Director University Institute of Chemical Technology University of Mumbai, Mumbai	...	Member
5.	Dr. K.A. Dinshaw Former Director Tata Memorial Centre, Mumbai	...	Member
6.	Dr. Om Pal Singh, AERB	...	Secretary

1.2 ORGANISATION CHART OF AERB





1.3 SUMMARY

Presently, there are 17 nuclear power units in operation, 3 units under construction and 3 units under commissioning in the country. The operating front end fuel cycle facilities comprise of: 7 Heavy Water Plants, 4 Rare Earths Plants, 5 Uranium Mines, 2 Uranium Mills and the Nuclear Fuel Complex (NFC), Hyderabad. All the nuclear power plants and the fuel cycle facilities operated safely during the year.

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: In May 2008 at Kalpakkam, in September 2008 at Mumbai and in January 2009 at NFC, Hyderabad. During the meetings at Kalpakkam and Hyderabad, the members visited PFBR construction site and the NFC fuel fabrication facilities respectively.

AERB Board Meeting in Progress at Nuclear Fuel Complex, Hyderabad

(L to R: Dr. K.A. Dinshaw, Dr. Om Pal Singh, Shri S.K. Sharma, Shri S.K. Chande, Dr. K.V. Raghavan)

Silver Jubilee Year Celebration

The one year period starting November 15, 2007 was the Silver Jubilee Year of AERB as it was established on November 15, 1983. The celebrations during this report period included technical talks by Board Members, a special talk by Dr. M. A. Mashelkar, CSIR Bhatnagar Fellow and Former Director General, CSIR, awareness programmes and workshops on safety in radiation facilities and publication of monographs on “Seismic Safety of Nuclear Power Plants” and “Siting of Nuclear Power Plants” prepared by AERB Staff. The monographs on “Probabilistic Safety Assessment” and “Construction Safety” were released earlier in 2007. The Silver Jubilee Day was celebrated on November 15, 2008 by organizing a function, which was attended by Dr. Anil Kakodkar, Chairman, AEC, Dr. A. K. De and Shri S. D. Soman, former Chairmen, AERB, and several other senior officials. A book titled “AERB: 25 years of Safety Regulation” that presents the history and development of AERB over the last 25 years and the “AERB Code of Ethics” were released on this occasion. As a culmination of the Silver Jubilee Year Celebrations that coincided with the start of the birth centenary year of Dr. H.J. Bhabha, an IAEA International Conference on Topical Issues in Nuclear Installation Safety: Ensuring Safety for Sustainable Nuclear Development, was organized in November 2008 at Mumbai.

Safety Review of Nuclear Projects

Permission was accorded for draining of light water from moderator system of Kaiga Generating Station Unit-4 and Rajasthan Atomic Power Project Unit-5 after satisfactory review of light water commissioning test results. Clearance was issued for receipt and storage of fresh fuel assemblies in new fuel storage building at Kudankulam NPP site. Clearance was also given for erection of the Safety Vessel of Prototype Fast Breeder Reactor whereafter it was successfully erected in the reactor vault. A total of 16 regulatory inspections were carried out on nuclear power projects. Two nuclear power units, Kakrapar Atomic Power Project Units 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 granting clearance for start of excavation as the first stage of construction consent is also in progress for this project. Safety review of Demonstration Fast Reactor Fuel Processing Plant, Interim Fuel Storage Building and Fast Reactor Fuel Cycle Facility to be constructed at Kalpakkam was continued.



Safety Review of Operating NPPs and Research Reactors

All nuclear power plants and research reactors operated safely. NAPS-1 was authorized to operate upto 80 % full power after completion of En-masse Coolant Channel Replacement. FBTR was issued clearance for 15th irradiation campaign to facilitate test irradiation of one PFBR fuel assembly and structural material samples, and for irradiation of one fuel subassembly of FBTR beyond 155 GWd/t. Enmasse Coolant Channel Replacement is in progress in NAPS-2 and KAPS-1 for which safety review at various stages is continuing. En-masse feeder replacement in RAPS-2 was completed and safety review for re-starting clearance of the unit is in progress. A total of 22 regulatory inspections were conducted for operating plants.

Safety Review of Front-End Fuel Cycle Facilities

The authorizations issued in nuclear fuel cycle facilities include: commissioning of the Turamdih Mill at the designed capacity of 3000 tons per day of ore processing, operation clearance for the Boric Acid Enrichment Plant at HWP-Manuguru, Siting and Construction of Tri-Butyl Phosphate plant at HWP, Baroda and operation of 'Boron Enrichment Exchange Distillation facility at HWP, Talcher.

Industrial Safety

There were two fatal accidents during the report period, one at Kudankulam Nuclear Power Project and the other at Zirconium Complex, Pazhayakayal construction site. These accidents were investigated and the required remedial measures were taken. Regulatory inspections for industrial & fire safety aspects were strengthened at projects. Job Hazard Analysis (JHA), preparation of safe working procedures and use of field check list on JHA were made mandatory for all hazardous works at sites. A total of 27 regulatory inspections were carried out in nuclear facilities other than NPPs.

For industrial safety purpose, 40 monthly inspections were carried out at construction sites of nuclear power projects and 16 quarterly inspections at fuel cycle construction sites.

Safety Surveillance of Radiation Facilities

One medical cyclotron and 5 industrial gamma radiation processing plants were issued license for operation. With this, there are now 8 medical cyclotrons and 15 industrial gamma radiation processing plants in operation in India. Over 2400 licenses were issued for procurement of radiation sources and over 450 authorizations were issued for export and disposal of sources. A total of 1200 certificates of registration were issued to diagnostic X-ray installations. A total of 110 regulatory inspections were conducted in various radiation facilities and 6 unusual occurrences related to loss or misplacement of radiation sources were investigated.

Campaign for disposal of disused sources in various radiotherapy units was undertaken and 42 of the total 55 such sources were safely disposed. Work on disposal of the balance 13 disused sources is on hand.

Safety Documents and Safety Studies

This year 3 new regulatory documents were published and 3 documents were translated in Hindi and published. Two documents are under revision and 13 new safety documents are under development. Safety studies were conducted at AERB, Mumbai



and Safety Research Institute, Kalpakkam in the areas of Event Analysis of PHWRs and VVER-1000, Probabilistic Safety Assessment, Reactor Physics, Radiological Safety and Environmental Safety.

International Cooperation

Under AERB-USNRC nuclear safety co-operation, a technical discussion meeting was held in November 2008 where progress on joint exercise of benchmarking computer codes for safety analysis was reviewed. Under Indo-French nuclear safety co-operation, a seminar on Nuclear Reactor Safety was organized during May 2008. AERB staff also participated in several activities of IAEA such as Incident Reporting System, International Nuclear Event Scale based reporting system, Commission on Safety Standards, International Nuclear Safety Group and work related with development of Safety Standards.

Conferences/Workshops and Training Programs

An IAEA International Conference on Topical Issues in Safety of Nuclear Installations was organized in Mumbai during Nov. 17-21, 2008. Orientation training programme on regulatory processes was conducted for newly inducted personnel of AERB. Workshops on radiation safety of consignments containing radioactive material, safe transport of radioactive material by air and sea, X-ray baggage inspection system at airports and the DAE Safety and Occupational Health Professionals Meet-2008 were also conducted.



Dr. Anil Kakodkar, Chairman, AEC addressing at the IAEA International Conference on Nov. 17, 2008 at NPCIL Auditorium in Mumbai.

(L to R): Shri S.K. Sharma, Chairman, AERB, Dr. A.C. Lacoste (Conference President), France, Dr. Taniguchi, Deputy General, Nuclear Safety & Security, IAEA, Dr. El - Shanawany and Dr. Om Pal Singh, AERB

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'. Work on posting of AERB Safety Documents on the Website was initiated.

CHAPTER 2

SAFETY SURVEILLANCE OF NUCLEAR FACILITIES

2.1 NUCLEAR POWER PROJECTS

2.1.1 Project Safety Review

KGS-3 was operated upto 90%FP as per the AERB Authorization. KGS-4 and RAPP-5 are under commissioning. Construction activities of RAPP-6 have been completed and commissioning activities have been started.

KK-NPP-1&2, each of 1000 MWe capacity VVER reactors and 500 MWe capacity Prototype Fast Breeder Reactor (PFBR) are under construction. Major civil construction activities have been completed for KK-NPP-1&2 and equipment erection is in progress. Preparations for commissioning of KK-NPP-1 are in progress. NPCIL has submitted an application alongwith Site Evaluation Report and Design Basis Information Report seeking siting consent for locating 4 additional VVER type reactors (KK-NPP-3 to 6) near KK-NPP-1&2. Review of this application will be taken up shortly. In case of PFBR, construction activities are in progress and Safety Vessel (SV) was erected in the reactor vault after clearance by AERB.

Two units of PHWRs (KAPP-3&4), each of 700 MWe capacity, are proposed to be located at Kakrapar near the operating 220 MWe PHWRs, KAPS-1&2. Review for Siting consent is nearing completion. Safety review for site-excavation consent is also in progress.

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) continued during the year.

AERB has been following a well-established multi-tier review process for safety review of nuclear 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 Groups (SGs)/Working Groups (WGs)/Task Forces (TFs), carry 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, educational 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 of AERB.

The safety review process is supplemented by periodic regulatory inspections as per the established practice for verifying compliance with the requirements recommended by the safety committees and those specified in various codes, guides and standards of AERB.

Table 2.1 lists the number of meetings held by various safety committees during the year. 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: Meetings of Projects Safety Review Committees

Project Safety Committee	Number of Meetings
ACPSR-LWR	3
ACPSR-PHWR	1
ACPSR-FBR	1
PDSC-KGS-3&4 and RAPP-5&6	5
PDSC-KAPP-3&4	6
SEC-700	2
PDSC-PFBR	11
PDSC-DFRP	4
KK-CG	2
CESC	8

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

(i) KGS-3&4 & 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 mainly in plant layout and control & instrumentation systems. Safety review process for these projects continued mainly on topics related to commissioning activities, commissioning results, operating experience feedback from similar type of reactors, significant event reports, safety related modifications, resolution of balance design issues and salient observations made during regulatory inspections.

(ia) KGS- 3&4

KGS-3 operated upto 90% FP during the year. Commissioning activities of KGS-4 are in progress. Most of the Light Water Commissioning tests including those for Primary Shutdown System (PSS), Reactor Regulating System (RRS), Automatic Liquid Poison Addition System (ALPAS) and Liquid Poison Injection System (LPIS), Emergency Core Cooling System (ECCS) Integrated test, Small Leak Handling System (SLHS) Integrated test have

been completed. PHT system has been kept filled and preserved with chemically treated water. Moderator system is also under wet preservation. AERB has accorded permission on April 6, 2009 for draining of light water from the moderator system based on review of the application and associated submissions. Some of the important observations/recommendations made during safety review of these Units are given below.

- For each DG set of KGS-3&4, passive system based on ejector has been installed in place of an exhaust fan provided in earlier design to maintain sub-atmospheric pressure inside the crank case. Similar modifications have also been implemented in all DG sets of RAPP-5&6.
- Hydrogen ingress had occurred in stator water cooling circuit due to failure in generator of KGS-3. The fault was rectified.
- In KGS-4, deflection of calandria with light water filled was measured and was found to be less than the acceptable limit of 0.5 mm.
- Verification and validation of the Computer Based Systems of KGS-3&4 was completed.

(ib) RAPP-5&6

In RAPP-5, subsequent to satisfactory completion of light water commissioning, Primary Heat Transport (PHT) and moderator systems were drained and dried. PHT system is kept under dry preservation. Moderator system was flushed using 20 tons of fresh heavy water. An application seeking clearance for initial fuel loading in the reactor core has been received and it is under safety review. The construction activities of RAPP have almost been completed and commissioning activities have been started. Some of the salient observations/recommendations made during safety review of these Units are as follows.

- One DG set of RAPP- 5 had an unwarranted start, while under maintenance. During this incident, DG operated in unloaded condition without proper jacket cooling water flow and resulted in damage of one piston and liner of one engine cylinder. Possible cause for unwarranted startup was attributed to voltage fluctuation in one of the CPU power supply modules of Emergency Transfer (EMTR) logic and incorrect status of switches on control panel and DG auxiliary system, while the DG set was under maintenance. The incident was reviewed in detail. Corrective measures were implemented to avoid recurrence of such an incident. These measures are also being implemented, as necessary, in DG sets and associated control logics of other PHWR units.
- During air hold test of moderator system in RAPP-5, calandria isolation (box-up) valves were found passing

due to scratch marks on sealing area of valve plug due to foreign material on their seats. After corrective actions, the air-hold test was repeated and the results were found satisfactory. To avoid recurrence of such problem in the Unit, the system flushing procedure has been modified for ensuring exclusion of foreign materials.

- Seismic walk-through of the RAPP-5 was carried out by Task Force bringing out the need for certain corrective actions for enhancing safety.
- Based on observations made by RI team, aspects such as adequate gap between high enthalpy lines and cable trays, provision of adequate supports of the high enthalpy lines as well as for cable trays in the area where they run close to each other, etc. were reviewed by project personnel and thirteen locations were identified for corrective actions.

(ii) KK-NPP-1&2

Civil construction activities and installation of piping, equipment, ducts, cables, etc. remained in progress for both the Units. Works related to off-shore structure and caissons are nearing completion. Threading and grouting of horizontal and vertical pre-stressing cables of primary containment building have been completed. Pre-stressing of the cables of primary containment of Unit-1 has been taken up after satisfactory completion of safety review and mock-ups. For unit -1, most of the major Equipment and associated piping have been erected.

ACPSR-LWR held 3 meetings and reviewed topics related to licensing of operations personnel for startup and initial phase of operation, pressurized thermal shock-fracture assessment for reactor pressure vessel, severe accident analyses, application for receipt and storage of fuel assemblies, design related observations made during RIs, status of training simulator, etc. After satisfactory review, Clearance for receipt and storage of fresh fuel assemblies in new fuel storage building and opening of packaging set and storage of fresh fuel in racks at KK-NPP site was issued.

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

- Based on safety review findings the document on "Licensing of Operations Personnel for Startup and Initial Phase of Operation of KK NPP" has been revised. An additional paper on "Engineered Safety Features and Safety Analysis" has been included for written examination. The draft documents on "Plant and Site Emergency Preparedness Procedures (Volume-I)" and "Off-Site Emergency Preparedness Procedures (Volume-II)" have also been reviewed
- During RI, It was noted that certain design changes have been made vis-à-vis the design given in Preliminary Safety Analysis Report (PSAR), which was earlier

reviewed by AERB. Some design changes were noticed in second stage ECCS hydro-accumulators, shutdown cooling system, etc. A detailed list of all such changes along with justification and supporting analysis to demonstrate meeting of respective design intent was asked for review. Modified design will be reviewed in detail.

- CPS-AR drive mechanism would be qualified by test for seismic and environmental conditions.
- Many observations have been made/clarifications sought during review of severe accident analyses. The document would be revised and reviewed again.
- It was observed that the pitch between two adjacent storage locations in racks for vertical storage of fuel assemblies has been reduced. This reduction of pitch has been done to achieve compact storage by using sleeves of borated steel in racks. The design change was reviewed from consideration of minimum required sub-criticality margin and was found acceptable.
- It is recommended that calibration/sensitivity checks of neutronic instruments should be checked at site, as part of commissioning.
- Training simulator should represent the plant in as built condition.

(iii) PFBR

Civil construction activities and fabrication of various major equipment/components including those at site-shop remained in progress. Heavy duty crane for handling and erection of safety vessel (SV) and other heavy/over dimensional components was commissioned. The clearance was given for erection of SV in reactor. The required mock up tests for SV erection were completed and the SV was lowered in the reactor vault.

Design safety review was carried out for variety of topics such as, sodium heat transport circuit, effect of argon bubbles on core reactivity, results of hydraulic experiments carried out on MV cooling models, blockage of primary cover gas lines connected with sodium circuits, sodium vapour deposition and its impact, instrumentation and control, effect of wind on fluid flow and heat transfer from natural convection air heat exchangers of safety grade decay heat removal system, radiation monitoring system, qualification test requirements for high temperature fission counters, design adequacy for various load combination for reactor assembly components, integrity of fuel sub-assembly impacting on the grid plate along with gripper, event analyses, plant services systems, electrical power supply systems and plant operation. The review of application seeking regulatory consent for erection of major equipment has been completed upto second stage of three tier review process and is now submitted to the AERB Board for their consideration for approval.



Safety Vessel of PFBR being lifted from Trolley for Erection in Reactor Vault

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

- During review of 'Power Raising Procedure during Regular Startup', it was brought out that the reactivity can increase due to cooling down of primary sodium. In view of this the reactor start up and power raising procedures are being reviewed further.
- On recommendation from AERB, various options for measurement of drop time of DSR, such as Kalman Filter technique, Eddy Current Position Sensor and Acoustic technique were studied and the development work on these techniques is in progress. The Kalman Filter technique holds promise as no hardware changes would be required in the design of rods or drive mechanisms. This technique would be proven first in FBTR.
- After detailed review of the 'Temporary Sodium Transfer System', permission was granted for receipt and storage of a large quantity of nuclear grade sodium in the tanks. Consignments of sodium are being received progressively and transferred to the tanks with due safety precautions as per the AERB approved procedures.
- For post Core Disruptive Accident (CDA) condition, provision for neutron-monitoring in addition to monitoring of core gamma were recommended and towards this purpose one of the detector channels will be qualified for the Post CDA environment.
- During dimensional measurement and alignment of Core Catcher (CC) with MV, deviation from the design intended gap between the CC and MV was observed. Analysis showed this is not of any safety concern.
- Safety Grade Decay Heat Removal (SGDHR) is a passive system and aspects such as its reliability, performance, etc. are under discussion. The designer has been advised to keep a provision for option of

providing forced circulation in SGDHR intermediate circuit.

- Emergency transfer logic circuit needs to be modified to meet the requirements related to single failure criteria, fail safe operation, provision for DG load testing, periodic testing of logic, etc.
- The environmental conditions that the containment isolation dampers would encounter in case of CDA are to be worked out and the dampers are to be qualified for the identified environmental conditions.

(iv) KAPP-3&4

Site Evaluation Committee (SEC-700) has completed review of application seeking consent for siting and associated submission of KAPP-3&4. Further review for siting consent is nearing completion. The safety review for excavation consent is also under progress.

Topics such as 3-Zone philosophy for radiological protection, post closure safety assessment of Near Surface Disposal Facility (NSDF), Reliability Analysis of ECCS & Containment Isolation System, radiation shielding efficacy of End-Shields, plant layout and radiological impact assessment under accident conditions were reviewed in detail.

Important observations/recommendations made during the review by SEC and PDSC- KAPP - 3&4 are given below.

- SEC-700 reviewed site evaluation report and in particular checked the compliance with IAEA NS-R-3 on "Site Evaluation Requirements" and brought out a few issues such as, a detailed Quality Assurance Manual during siting stage needs to be prepared as part of site evaluation process and the details regarding the site safety impact assessment considering augmentation of existing NSDF for KAPS-1&2 to cater to KAPP-3&4 solid wastes needs to be done. Also, implications of the location of NSDF vis-à-vis exclusion zone boundary need to be assessed and reported.



Meeting of PDSC-KAPP-3&4 (700 MWe PHWR) in Progress

- As the ECCS recirculation line, pumps and valves are proposed to be located outside containment, the designers have been asked to address the aspect of containment bypass, dose assessment due to radioactive ECCS lines outside containment and possible effects due to ECCS recirculation equipment failures and maintenance aspects for the proposed layout.
- It was noted that the secondary containment is not considered while evaluating containment isolation system reliability. The designers have been asked to model the primary and secondary containments and associated isolation logics in reliability analysis.
- It was noted that blockage events in reactor coolant channel are not analysed as a PIE. There is a possibility of non-detection of channel flow blockage in the reactor above 85% FP with ~3% boiling permitted in the outlet of coolant channels, as outlet temperatures of coolant channels remain unchanged because of boiling above 85 % FP. The issue of partial/full flow blockages and related analysis would be reviewed further.
- It was noted that some of the systems, Induced Draft Cooling Towers (IDCTs), fall within the missile zone of KAPS-2 turbine. Inventory for emergency cooling water make-up for 7 days heat sink requirements has been provided in the basins of two IDCTs. In case of occurrence of turbine missile event resulting in damage to an IDCT, the cooling water inventory requirement will reduce to nearly 50% against the cooling water inventory of 7 days for decay heat removal. The designers were asked to perform detailed analysis for the postulated event and submit the results for review.
- Designers were asked to address the problem of waste disposal aspects of highly radioactive spent Self Powered Neutron Detectors.
- Site Safety Assessment (SSA) was performed by NPCIL for the Near Surface Disposal Facility (NSDF) (geo-hydrological and soil analysis studies) of KAPS-1&2 considering requirement for additional two Units (2X700 MWe) of KAPP-3&4. NPCIL was asked to address the potential contamination of grass/vegetations and surveillance of bore-wells all around the NSDF.
- The proposal for adopting three radiation zoning concept in KAPP-3&4 (instead of 4-zone concept followed in the present PHWRs) is under review.
- NPCIL has been asked to submit detailed information on the all new/FOAK Systems/Concepts that are to be implemented in the design of KAPP-3&4.

(v) DFRP

IGCAR is setting up DFRP to process spent fuels of FBTR and PFBR. This is a forerunner of the reprocessing facility FRFCF, to close the fuel cycle of PFBR. 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 was completed at the time of construction of Kalpakkam Reprocessing Plant (KARP). Civil construction of HEF is in progress.

PDSC held four meetings and discussed certain design related RI observations along with site responses; Action Taken Report (ATR) on recommendations made by PDSC in their earlier meetings No. 1 to 20; report of WG on "Off gas and ventilation system"; Status report of WG on "Waste management system", criticality evaluations, operational feedback from Lead Mini Cell (LMC), fire safety, sharing of systems with KARP, etc.

Some of the salient observations/recommendations made during the safety review of RI observation, action taken report on PDSC recommendations and WG reports, are given below:

- Adequacy of the concrete shielding is to be ensured before hot commissioning of the plant.
- In the present design, possibility for back flow of the active off gas exists as all the off gas lines join to a plenum in the header and the header is connected to the stack. It is recommended to analyze the design and ensure that back flow will not take place.
- In depth review of the interlock logic of the ventilation system revealed certain inadequacies. The design of the filters cells is under review.
- As per the designers fire inside hot cells is to be considered as BDBA, this was not accepted by the reviewers.

(vi) IFSB

AERB had granted clearance for construction for IFSB in August, 2006. The construction of the facility is in progress.

(vii) FRFCF

FRFCF is planned to reprocess the spent fuel of PFBR. AERB had issued siting consent for FRFCF in Sept. 2006. The detailed design of the facility is in progress.

2.1.2 Authorizations/Clearances/ Permissions Issued

- Permission for light water draining from moderator system of RAPP-5 and KGS-4.
- Authorization for addition of 20 tons of heavy water to moderator system of RAPP-5.
- Clearance for receipt and storage of fresh fuel assemblies in packaging sets in new fuel storage building at KK NPP Site.
- Extension of validity period for Clearance for installation of SV and construction of upper lateral upto 31.5m elevation from April 30, 2008 to September 30, 2008.

- Permission for opening of packaging sets and storage of KK-NPP fuel assemblies in racks at KK-NPP Site.

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. In addition, one Special RI for FHS related aspects of KGS-3&4 was also conducted during September 8-9, 2008.

Table 2.2: Regulatory Inspections of Nuclear Projects

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

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

(i) KGS-3&4

- In KGS-3, unexpected delay was experienced during operation of DCHS-PCS while generating control signal for feed and bleed valves in case of pressure transients like load rejection test. Also, it was noted from Control room log book that fuelling machine supply pump did not come on 'Auto' when primary pressurizing pumps were stopped during hot shut down condition of PHT system. The deficiencies related to pressure maintenance of PHT systems were asked to be corrected.
- In Supplementary Control Room (SCR) of KGS-4, 'system trouble' audio visual alarm for both the fire alarm panels was found registered. The Site referred the issue to the designer.
- For KGS-4, it was noted that Construction Completion Certificate (CCC) of calandria system was accepted in spite of the pending works like welding of man-hole cover of calandria and calandria vault box-up job. The lapse was pointed out and site was asked to complete the pending works.
- In pump room of KGS-4, control cables of all 3 channels were found running to gether It was recommended to ensure channel segregation in line with IEEE 384.
- For KGS-4, it was observed that calibration of Multiple Input Alarm System (MIAS) and a few SSS Time Delay Relay calibrations were due. Also, in setback panel two

Time Delay Relays were set at 40 sec on the dial instead of 10 sec. It was recommended to verify the required calibration validity for all the safety related instruments before proceeding for next commissioning phase.

- For KGS-4, some of the detectors and Linear Heat Sensing (LHS) cables were indicating trouble alarm in Fire Alarm System panel. One fire alarm loop related to TG area was yet to be commissioned. Site was asked to rectify the fire detectors and LHS cable problems and commission the pending fire alarm loop at the earliest.
- It was recommended to carry out surveillance test related to "FM in Rehearsal Test Facility for one upstream and one downstream sequence" as per frequency specified in Technical Specifications for operation and maintain records of surveillance tests.
- For Fuelling Machine rehearsal facility in KGS-4, it was noted that semi-auto command was used for final positioning. Exchange/ Bundle transfer operation with FT in South side could not be carried out due to STS ball-screw problem. Site was asked to carry out full scale uninterrupted refuelling rehearsal operation at high pressure in auto mode for five channel refuelling operation before actual on-power refuelling. Integrated operation of FM and FT system and discharging bundles to SFSB should be carried out for both side and bundle should be inspected at SFIB/SFSB for qualifying the fuel transfer operation.

(ii) RAPP-5&6

- Mix-up of power and control cables in FM Vault (South) and channels for SSS ion chambers and start up of counters of RAPP-5 was noticed, the segregation of the cables as per criteria was recommended.
- Only a small number of scheduled internal audits were carried out in year 2008, site was asked to carry out internal audits of all departmental sections and contractors in accordance with approved QA Manual.
- For RAPP-5, safety related cables and fuel supply lines feeding to DGs are laid in a tier arrangement on a concrete structure in the open area. The structure is running very close to the unfinished quarry hill (left as it is during site excavation) which has loosely bonded rocks. Damage to the above structure can interrupt fuel supply/power supply of fuel transfer system of DG set. It was recommended that site should take needed corrective actions.
- The layout of DG-3 of RAPP-6 (located in Unit-5 area) and its auxiliaries was found highly congested with no proper access to monitor the auxiliary system parameters. It was recommended to improve access route taking into consideration personnel safety while taking system performance data during DG operation.
- In RAPP-6, proper segregation of SS tubes of boiler pressure control and boiler level control by following

principle of channel segregation was recommended.

- The site was asked to provide the basis of change in the high level alarm setting for seismic alarm from 0.04 g to 0.08 g.

(iii) KK NPP-1&2

- For civil structures around PHRS, eighteen out of twenty six RCC rib walls have been converted to structural steel truss members. The site was asked to check and confirm that the structural steel members are providing the same order of stiffness as that of the reinforced concrete members.
- Certain design changes in the systems important to safety such as ECCS and PHRS were observed. Site was asked to bring out all the design changes with reference to earlier PSAR and provide justification.
- Implications of eccentricity between RPV- 2 centerline and its cavity axis to be examined and reported.
- Damage to nozzle flanges for the two PHRS HXs of Unit-2 was observed. Site would carry out repair of damaged nozzles in consultation with designers.
- On noticing a sub-contractor carrying out radiography jobs without having AERB clearance certificate for one of the cameras, site was asked to ensure necessary documents with the contractors / sub-contractors, as per the AERB requirements for gamma cameras.

(iv) PFBR

- In line with recommendation of the AERB constituted Task Force to check design adequacy of Inner Vessel (IV) under seismic event, RI revealed that no details/design provision has been worked out for the same. It was recommended to take an early action in this regard.
- For preservation of Safety Vessel (SV), temporary cover put on SV was observed to be not sealed properly. Large gaps were found around the circumference and at locations where instrumentation junction box is placed. It was recommended to take steps to inspect, clean and preserve SV as per procedure.



Visit of Board Members to PFBR Site, Kalpakkam

- Construction deficiencies like bulging/dipping beams and columns, honey-combing etc. were observed in

Nuclear Island Connected Buildings. It was recommended to submit a detailed Note giving root cause for these occurrence and action planned to rectify these deficiencies and measures taken to prevent such occurrences in future.

(v) DFRP

- Hook up joints, which indicated defects during NDT are not repaired or replaced. Instead, another sleeve is put on the pipe and fillet welded. Justification of the adequacy of these measures has been asked for review.
- There is no fencing between KARP and DFRP area. The fence provided earlier has been removed for ease in working as certain contractor jobs are being taken up in KARP area. Considering certain security and other aspects fencing has been recommended between KARP and DFRP area.
- It was observed that excavation work for a transformer building is under progress just adjacent to the DG building of DFRP. The Site has been cautioned not to endanger the DG building structure.
- It was recommended to conduct of internal audits as per approved schedules.
- It was seen that there is no procedure for preservation of equipment/materials other than austenitic SS components. It was recommended to identify and prepare a list of all the equipment/materials (apart from austenitic, SS) which require preservation and accordingly preservation procedures should be made and implemented.

(vi) IFSB

- Side slopes of the excavated pit for the main building was observed to be very steep as compared to the approved slopes in excavation drawing. Site was cautioned and asked to take measures for ensuring the side slopes stability.
- It was recommended to expedite the preparation of QA documents on commissioning and operation for review by AERB.
- It was recommended to revise the QA manual for construction by addressing all requirements as per AERB Code on QA.

2.2 NUCLEAR POWER PLANTS AND RESEARCH REACTORS

2.2.1 Safety Status of Operating Plants

All the NPPs and Research Reactors operated safely. The Operating Plants Safety Division (OPSD) of AERB tracks and monitors the safety performance of operating NPPs and Research Reactors. The Safety Review Committee for Operating Plants (SARCOP), the apex committee for safety review of operating plants, held 15 meetings during the calendar year 2008. The Unit Safety Committees (USC) established under SARCOP met a number of times to review

safety related issues of individual plants in detail. The number of meetings conducted by various safety committees during the year 2008 is given in Table 2.3.

Table 2.3: Meetings of Safety Committees

Name of the Safety Committee	No. of Meetings
SARCOP	15
TAPS-1&2 Safety Committee	7
TAPS-3&4 Safety Committee	7
RAPS-MAPS Safety Committee	5
NAPS-KAPS Safety Committee	19
KGS-1&2 and RAPS-3&4 Safety Committee	9
IGCAR Safety Committee	8
CESCOP	2

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 one batch of Co-60 in "Augmentation of Cobalt Handling Facility (ACHF)", RAPPCCOF, Kota (June 12, 2008).
2. Permission for operation of NAPS-1 upto 80% FP after completion of En-Masse Coolant Channel Replacement (EMCCR) works.
3. Renewal of authorisation for operation of NAPS upto April 2009.

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

1. Incident of spurious opening of instrumented relief valve in primary heat transport system followed by light water injection through emergency core cooling system in NAPS-1 on October 4, 2008.
2. Light water leak from the end-shield cooling system of MAPS-1 on April 20, 2008.

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

(i) TAPS-1&2 and TAPS-3&4

TAPS-1&2 and TAPS-3&4 operated safely during the year without any significant safety related events.

(ii) RAPS-1&2 and RAPS-3&4

RAPS- 1 and RAPS- 2 continue to be under shutdown. RAPS- 3 and RAPS- 4 operated safely during the year.

• Defuelling of RAPS-1 Core

RAPS-1 continues to remain shutdown since October 2004. RAPS had retained some of the fuel bundles with low irradiation in the core of RAPS-1 with the intention

to reuse them in RAPS-2. Subsequently, RAPS decided not to reuse these bundles and transferred them to spent fuel storage bay. RAPS-1 core is now defuelled fully and PHT system is operating with diluted heavy water.

- **En-masse Feeder Replacement of RAPS- 2**

RAPS-2 continues to remain shutdown since July 2007 for EMFR in PHT system. The replacement of feeders with material having better resistance to flow assisted erosion / corrosion was completed in August 2008. During this outage inspections of major equipments were undertaken for their health assessment. The various systems of the plant are operational. The fuel loading of plant has also been approved after reviewing the necessary documents.

- **Authorisation for Operation of RAPS-2**

In August 2005, AERB had given the authorisation for operation of RAPS-2 upto May 31, 2007. RAPS had submitted the report on Periodic Safety Review (PSR) for the Unit based on AERB Safety Guide on "Renewal of Authorisation for Operation of NPPs" (AERB/SG/O-12) in December 2006 and requested for renewal of authorisation from June 2007 to May 2017. The detailed review of PSR had indicated that other than deterioration of the PHT system feeders, there was no major significant issue. However, additional submissions were required from RAPS to address the issues of ageing management, equipment qualification, revision of safety report and ISI manual, etc. to complete the review process. RAPS made these submissions which are under review in AERB. During the outage of the Unit, inspections related to ageing management, retrofits related to seismic re-evaluation and other safety related requirements have been completed. The reports for these inspections have been reviewed and accepted by concerned Expert Groups / Safety Committee of AERB. The application for re-start of the Unit and authorisation for operation are under review in AERB.

- (iii) **MAPS-1&2**

Both the Units operated safely during the year.

- **Leak from End Shield of MAPS-1**

On April 20, 2008, when MAPS-1 was under cold shutdown, light water leak was observed from the end-shield cooling system. There was a noticeable drop in the water level in end-shield expansion tank and presence of water was detected in the calandria vault drain lines. The estimated leak rate, which was about 15 l/hr, reduced to about 8 l/hr after stopping the end shield cooling pumps. Various attempts were made to identify the source of leak by external leak search, monitoring of leak rate after isolation of end shield pumps one by one, raising the temperature of end shield and PHT system. During these investigations, the leakage rate reduced to less than 1 l/hr. Based on the observations, MAPS opined that it was difficult to identify the leak location with such low leak rate and requested permission for restart and operate the Unit with continued monitoring. The application was reviewed in AERB in the light of the investigations carried out for identification of

leak, implications of the existing light water leak on pressure tube leak detection capability, the contingency plans for handling events of leak from end shield cooling system and the findings of the studies on the effect of any leaking water dripping on a hot coolant channel. Based on these reviews, permission was given for restart of the Unit with the conditions for close monitoring of the leakages and reporting of any rising trend in leak rate to AERB. Further it was stipulated that in case the end shield expansion tank make-up requirement approaches to once per shift (i.e., about 10-12 litres/h), the Unit should be brought to shutdown state and investigations should be undertaken to locate the source of leak. The Unit was subsequently restarted on May 23, 2008. Station is regularly monitoring the leakage from end shield in the Unit. Presently the leak rate is about 450 ml/h and the end shield expansion tank make-up is about 90 kg in 7 to 8 days.

- (iv) **NAPS-1&2**

NAPS-1 was restarted after EMCCR on February 25, 2008. NAPS had subsequently sought permission for raising the reactor power to 80 % FP. The application was reviewed considering the performance of the plant systems during operation up to 50 % FP. Based on the review, AERB permitted operation of the Unit up to 80 % FP, in the first week of June 2008.

- **Renewal of Authorisation for Operation of NAPS**

The authorisation for operation of NAPS was valid till June 30, 2008. AERB provisionally extended the authorization for operation of NAPS-1 till end October 2008 to facilitate the review of the Application for Renewal of Authorisation (ARA). The review indicated that the overall safety status of NAPS is satisfactory and the authorisation for operation of NAPS could be renewed. However an event of spurious actuation of Instrumented Relief Valve of PHT System took place in NAPS-1 on October 4, 2008 (Ref. Section 2.2.10 on Significant Events). Review of this event brought out certain issues which needed to be addressed. Pending satisfactory resolution of these issues, the authorisation for operation of NAPS was extended upto the end of April 2009.

- **EMCCR in NAPS-2 and KAPS-1**

As brought out in previous annual report, NAPS-2 continues to be under shutdown for EMCCR since December 18, 2007. KAPS-1 was also shutdown on July 1, 2008 for EMCCR campaign. During this outage, the old Zircaloy-2 pressure tubes with two loose garter springs are being 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 life span 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 are also being replaced. Also a number of upgradation jobs are being carried out, which will help in enhancing the safety and

availability of the units. The activities related to EMCCR, feeder replacement, systems upgradation and results of inspection of plant systems are being closely reviewed and monitored by a special review group of AERB.

(v) KAPS-1&2

KAPS-1 continues to be under shutdown for EMCCR campaign as mentioned above. KAPS-2 operated safely during the year.

(vi) KGS-1&2 and KGS-3

KGS-1,2&3 operated safely during the year. Design safety review of KGS-3 has been completed and all the commissioning activities completed except for the load rejection tests at 100 % FP operation. Permission to start KGS-3 was granted in September 2008.

(vii) RAPPCOF

RAPPCOF had undertaken a project for augmentation of Cobalt Handling Facility to facilitate processing of increased quantities of Co-60 and to fabricate sealed sources in their final form. AERB reviewed the aspects related to design, construction and commissioning of the facility and granted permission for processing of one batch of Co-60 on trial basis. RAPPCOF has submitted the report on this trial operation and requested permission for regular operation of the facility. This application is under review of AERB.

(ix) Indira Gandhi Center for Atomic Research

• **Fast Breeder Test Reactor (FBTR)**

FBTR operated at 16.6 MWt after completion of 14th irradiation campaign. FBTR submitted proposal for 15th irradiation campaign. The campaign was taken up for the following purposes.

- * Irradiation of PFBR test assembly upto the target burn-up of 100 GWd/t at the design LHR of 450 W/cm.
- * Irradiation of structural materials samples (D9 & SS)
- * Irradiation of one high burn-up MK-1 SA beyond the present level of 155 GWd/t, to establish its endurance limit.
- * To obtain the operational experience with coolant temperature close to the design values, which is achieved by blanking some of the tubes in each SG module.
- * To study the feasibility of production of Sr89.

While considering the proposal, the results of the post irradiation examination of the FBTR fuel SA discharged from FBTR after reaching a burn-up of 155 GWd/t and the results of analytical assessments carried out to check the feasibility of further extending the burn up of fuel subassembly beyond 155 Gwd/t were reviewed. The implications of the extended burnup on the fuel handling forces on the Mark-1 Sub-Assembly were also reviewed. Considering all the safety aspects, AERB agreed to the

proposal for 15th irradiation campaign of FBTR.

• **KAMINI**

An incident of high reactor tank water activity occurred in KAMINI on June 30, 2008. The water sample collected one hour after shutdown of the reactor indicated activity of 51 Bq/ cm³ against the Technical Specification limit of 50 Bq/cm³. Spectral analysis of the reactor tank water sample indicated the possibility of breach of fuel clad. IGCAR requested a special clearance for limited operation of the reactor for some urgent neutron radiography application, with the limit on water activity level not exceeding Technical Specifications limit. The permission of limited operation was granted and performance of systems during the radiography campaign was found satisfactory.

An Expert Committee constituted by IGCAR suggested an experiment for sniffing the water from outlet of each sub-assembly to check whether the problem of activity increase is of generic nature or otherwise. It was also proposed to increase the limit on reactor water activity to 200 Bq/cm³ for facilitating the investigations. After detailed review, permission was granted for KAMINI operation for a limited period for conducting the proposed tests. The test results indicated that the higher activity was due to uranium contamination on fuel clad surface of two subassemblies. After review of the test results, AERB permitted the operation of the reactor with increased monitoring and supervision.

• **FBTR Fuel Reprocessing**

AERB had earlier given authorisation for taking up campaigns for reprocessing of FBTR fuel pins in the CORAL facility. IGCAR has completed these campaigns successfully and sought authorisation for taking up further reprocessing campaign of the remaining FBTR spent fuel assemblies with 155 GWd/t burn-up in CORAL facility. After review of the safety aspects and the performance during the previous reprocessing campaigns, AERB authorized IGCAR to take up reprocessing of these fuel pins.

2.2.2 Regulatory Inspections

Regulatory Inspection (RI) of operating Nuclear Power Plants 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/ SARCOP directives,
- confirm compliance with the maintenance, in service inspection and quality assurance programmes,
- confirm proper maintenance of records/ documentation, and
- check that 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'. The RIs were carried out once in six months for NPPs and once in a year for research facilities.

During the calendar year 2008, a total of 22 RIs were undertaken in the operating NPPs and research facilities, of which 20 were pre-planned inspections as per the RI programme. A special Inspection of NAPS-1 was conducted to investigate the details pertaining to ECCS light water injection incident at NAPS-1. Another special inspection of NAPS-2 was conducted for checking progress of EMCCR activities.

The observations during the inspections are summarized into 5 different categories depending upon their significance, as given below.

Category: I	Deviations from Technical Specifications and other regulatory requirements/ stipulations.
Category: II	Deficiencies and degradations in Systems/ Structures/Components of Safety and Safety Related systems.
Category: III	Shortcomings identified in the design of Safety, Safety related and Safety support systems, based on operating experience including generic deficiencies.
Category: IV	Procedural inadequacies.
Category: V	Observations on housekeeping and departure from good practices.

There were no RI findings of Category I in any facility. Number of findings in categories II, III, IV and V were 33, 55, 370 and 51 respectively in the total of 23 RIs.

Some of the important observations made during the RIs in 2008 are as follows:

- 1) At TAPS-3, large numbers of cable and pipe penetrations were repaired as they were observed to be leaking. Station has taken corrective measures which are reviewed in AERB.
- 2) Significant deviations in SPND readings from core physics simulation values using TRIVENI code were observed in both TAPS-3&4. Performance of SPNDs are reviewed and further follow up is in progress.
- 3) Transfer of SPNDs to and from WIP, BARC Tarapur for post irradiation examinations was carried out by TAPS-3&4 authorities without prior permission of the competent authority. Station informed that this step

was necessitated to obtain details for final disposal and a proposal will be submitted to AERB for review and approval for regular transfer/disposal of SPNDs to waste management facility. Station was instructed that the transfer of special radioactive waste/material even for any examinations should be done with the prior approval of the competent authority.

- 4) One particular control rod drive mechanism was getting stuck at TAPS-3. During the biannual shutdown, PM checks of all reactivity devices were carried out and the reason for sticky movement was observed to be the deterioration in lubricating grease. Station has changed the lubricating grease and the driver performance is being monitored by AERB.
- 5) At KAPS and NAPS, Control Room Computer System (CRCS) is having two servers. The stand by server is not a hot standby type and manual actions are required to bring it into service. Station was asked to expedite the necessary modification for keeping the second server in hot standby condition.
- 6) Special RI of NAPS-1 was carried out to investigate the details pertaining to ECCS light water injection incident at NAPS-1 on 4th Oct 2008. This incident has revealed some generic issues such as PHT storage tank design requirement, primary containment pressurization due to nitrogen venting and failure of fuel machining pump to develop desired pressure. Station was asked to rectify the weaknesses observed in the system/equipment design and operations prior to the start of the Unit. Necessary submissions including proposed modifications are submitted for review. After the detailed discussion on the incident and review, AERB permitted the operation of the unit.
- 7) During a civil engineering inspection, cracks were observed in pump room floor slab inside Reactor Building (RB) of KAPS. The reasons for cracking and methodology for repair were discussed and sealing of cracks by appropriate flexible sealing material and subsequent monitoring was recommended.

2.2.3 Licensing of Operating Staff

The number of operating personnel, who were licensed from various nuclear power plants during the calendar year 2008, is tabulated in Table 2.4. In addition, for the operation of FBTR, three persons were licensed for the position of Senior Shift Engineer, one person was licensed for the position of Senior Fuel Handling Engineer, two persons were licensed for the position of engineer In-charge and six persons were licensed for the position of Control Room Assistant / Field Supervisor. One person was licensed for the position of Shift In-charge, KAMINI.

Table 2.4: Licensing of Operating Personnel

Plants	No. of Persons cleared for the Positions					Licensing Committee Meetings
	SCE	ASCE	ASCE (F)	CE	CE(F)	
TAPS-1&2	4	4	-	4	-	2
TAPS-3&4	10	6	2	8	7	2
RAPS-1&2	3	2	2	8	4	2
RAPS-3&4	1	4	2	8	3	2
RAPS-5&6	9	7	2	19	2	2
MAPS	1	2	1	4	3	2
NAPS	4	2	6	1	0	2
KAPS	9	5	2	9	1	2
KGS-1&2	1	6	2	5	0	2
KGS-3&4	3	1	0	1	0	2
Total	45	39	19	67	20	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)

2.2.4 Significant Events

It is obligatory for operating nuclear power plants to report promptly to the regulatory body, events that occur in the plant which have or may have impact on operational safety. The events are divided into two categories, termed as, (a) Events and (b) Significant Events, depending on importance to operational safety experience feedback and the safety significance of the event.

The Significant Event Reports (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 1 to 3 are called Incidents with an event at level 1 called as anomaly. Events at level 0 or below the scale are called deviations. The INES scale is depicted at the end of the report.

The numbers of SERs for the last five years and their ratings on INES are given in Table 2.5. The classification of SERs for the year 2008 on INES scale is given in Table 2.6. A total of 24 SERs were reported in the year 2008 from various NPPs in India. Two events were rated at level 1 on the INES and the rest were rated as level zero. The system wise classification of SERs in NPPs is given in figure 2.1.

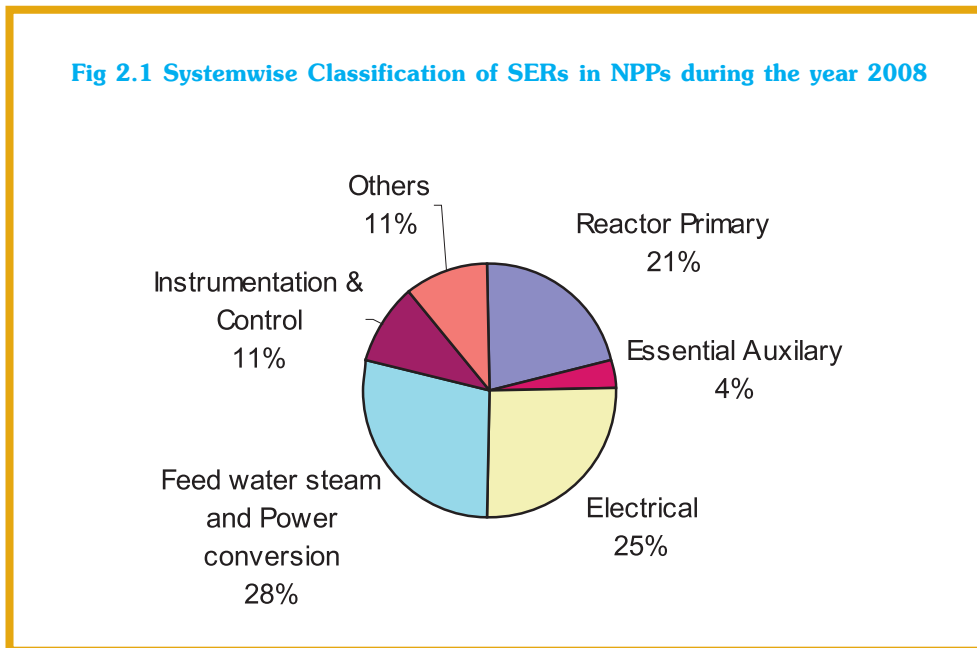
Table 2.5 Classification of SERs in NPPs as rated on INES

INES Levels	2004	2005	2006	2007	2008
0	39	26	34	28	22
1	4	2	5	8	2
2	1	0	0	0	0
3	0	0	0	0	0
>3	0	0	0	0	0
Total	44	28	39	36	24

Table 2.6 Classification of SERs in NPPs (2008)

Plant Name	International Nuclear Event Scale Level					Total
	0	1	2	3	>3	
TAPS-1&2	1	0	0	0	0	1
TAPS-3&4	6	0	0	0	0	6
RAPS-1&2	0	1	0	0	0	1
RAPS-3&4	1	0	0	0	0	1
MAPS-1&2	7	0	0	0	0	7
NAPS-1&2	2	1	0	0	0	3
KAPS-1&2	2	0	0	0	0	2
KGS-1&2	3	0	0	0	0	3
KGS-3	0	0	0	0	0	0

Fig 2.1 Systemwise Classification of SERs in NPPs during the year 2008



In an event at RAPS-2, a temporary radiation worker received a cumulative radiation exposure of 17.04 mSv in the year against the allowed annual radiation exposure limit of 15 mSv. The annual radiation exposure limit for regular plant workers is 30 mSv where as it is 15 mSv for temporary workers. The exposure took place as the work was carried out without a request for radiation field survey and with a preconceived notion of lower radiation field in the area. The event was rated at level 1 on the INES.

At NAPS-1, one Instrumented Relief Valve (IRV) of the PHT system opened spuriously due to the failure of

its actuator diaphragm. This resulted in hot PHT coolant entry to Bleed Condenser (BCD) and automatic reactor trip on 'PHT system pressure very low'. Standby Primary Pressurizing Pump (PPP) started automatically. On observing rise in BCD pressure, operator manually stopped both PPPs and all the four running primary circulating pumps in contravention of the operating procedures. Fuelling machine supply pump started automatically but could not increase PHT system pressure. Emergency Core Cooling System (ECCS) injected heavy water as PHT system pressure dropped below the injection set point. Reactor Containment got boxed up as per design and subsequent to ECCS heavy

water injection, nitrogen from ECCS accumulators got vented in to containment which resulted in increase in containment pressure. PHT pressure dropped further as the FM supply pump could not restore the PHT pressure immediately. Increase in containment pressure and the reduction in PHT pressure resulted in light water ECCS injection along with actuation of Secondary Shutdown System, automatic liquid poison addition and cool down of PHT system at a fast rate as per the plant design. During the event, delay in BCD isolation resulted in PHT water entry to PHT storage tank and lifting of the storage tank relief valves. The relief valves discharged PHT water into a relief tank. Due to the event plant emergency was declared at 0300 hrs as per emergency plan and emergency was lifted at 0710 hrs after normalizing the plant status. This event brought to light some design and operational deficiencies and hence was rated at level 1 on INES.

2.3 FUEL CYCLE FACILITIES AND R&D UNITS

Review and monitoring of safety status of fuel cycle facilities and other nuclear facilities are carried out by IPSP of AERB. A three-tier review process is followed for granting consent for major stages for hazardous facilities of nuclear fuel cycle. For less hazardous facilities, a two-tier review process is followed with first review being conducted by Unit Safety Committee (USC) of the operating facility or Design Safety Review Committee (DSRC) for projects. The nuclear fuel cycle facilities and R&D Units covered are as below.

- Nuclear Fuel Complex (NFC), Hyderabad and Zirconium Complex of NFC, Pazhayakayal
- Heavy Water Plants (HWP) at Baroda, Talcher, Thal, Hazira, Manuguru, Tuticorin and Kota
- Uranium Corporation of India Ltd. (UCIL), comprising mines at Jaduguda, Bhatin, Narwapahar, Turamdih, Banduhurang, Bagjata, Mohuldih, Tummalapalle and Gogi, and mills at Jaduguda and Turamdih.
- Indian Rare Earths Limited (IREL) plants at Udyogamandal, Manavalakurichi, Chatrapur and Chavara and Indian Rare Earths Research Centre-Kollam,
- Electronics Corporation of India Ltd. (ECIL), Hyderabad.
- Atomic Minerals Directorate for Exploration and Research (AMD), Hyderabad.
- Beach Sand Mineral Facilities at various locations.
- Raja Ramanna Centre for Advanced Technology (RRCAT), Indore.
- Variable Energy Cyclotron Centre (VECC), Kolkata.

Highlights on safety status, safety 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 Safety Review

(i) Nuclear Fuel Complex

All the plants of NFC, Hyderabad operated safely during the year. After ensuring satisfactory compliance to the safety requirements, following proposals were approved/agreed by NFC Safety Committee (NFC-SC) and SARCOP.

- The application for renewal of license for operation of NFC for a period of five years with effect from September 26, 2008
- The revision of technical specifications for operation of NFC.
- The processing of 1 MT slightly enriched UO₂ (0.9% & 1.1% U₂₃₅) campaign basis.
- The commissioning of dry and wet sections of the Uranium Oxide Plant after revamping of the plant.
- The operation of scrap chlorinator in the rehabilitated zirconium sponge plant.

The applications for commissioning of Zirconium Complex, Pazhayakayal and construction of New Oxide Chlorination Facility at NFC, Hyderabad are under review.

Significant event reports of high air activity at New Uranium Oxide and Fabrication Plant (NUOFP) were reviewed and measures were recommended to prevent recurrence of such incidents in future.



Visit of Board Members to NFC, Hyderabad

(ii) Heavy Water Plants

The Heavy Water Plants at Thal, Baroda, Hazira, Kota, Manuguru and solvent facilities at Talcher operated safely. HWP-Tuticorin is under total shutdown due to non-availability of synthesis gas from M/s SPIC.

The following important proposals/ safety issues were discussed in the Heavy Water Plants Safety Committee (HWP-SC), Design Safety Review Committees for Diversified Projects (DSRC-DP) and Uranium Extraction Project (DSRC-UPEP), 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/renewal of Licence were granted/given.

- The renewal of Licence for operation of HWP-Hazira for 5 years with effect from July 15,2008.
- The renewal of Licence for operation of HWP-Thal upto December 2009. Renewal of License beyond December 2009 would be based on satisfactory resolution of identified issues.
- The renewal of Licence for operation of HWP-Manuguru upto June 2010. Renewal of Licence beyond June 2010 would be based on satisfactory resolution of identified issues.
- Authorisation for operation of Boric Acid Enrichment Plant at HWP-Manuguru. .
- The Siting and Construction Clearance for the proposed Tri Butyl Phosphate (TBP) Facility at HWP-Baroda.
- Operational clearance of Boron Enrichment Exchange Distillation Facility at HWP, Talcher.
- The revised technical specifications of ammonia based HWPs, namely, Thal, Hazira, Tuticorin and Baroda were reviewed and the HWP-SC recommended the approval.
- The proposals for cold commissioning of the Heavy Water Clean-Up Facility at HWP, Kota, commissioning of the Technology Demonstration Plant at RCF, Chembur, construction of Dry Fly Ash Collection System at HWP, Manuguru and revamping and modernization of Instrumentation System at HWP-Kota are under review.

The significant events of leakage of synthesis gas from the top gas pipeline of potassium amide recovery tower (in final enrichment unit) at HWP, Thal, failure of mobile crane accident at HWP, Kota during the installation job of Turbo-Generator set and leakage of hydrogen sulphide from a pinhole developed at downstream of a level control valve at HWP-Kota were reviewed in detail and measures were recommended to prevent recurrence of such incidents in future.

(iii) Uranium Corporation of India Ltd.

Jaduguda, Bhatin, Narwapahar, Turamdih, Banduhurang mines and Jaduguda mill were under normal operations. Turamdih mill cold commissioning run with inactive material was completed. Development of mines at Bagjata, Mohuldih, Tummalapalle and exploratory mining at Gogi are in progress.

After ensuring satisfactory compliance to the safety requirements and review by USC and ACPSR-FCF, Authorisation was granted for Commissioning of the Turamdih Mill.

The proposals for production of uranium peroxide as final product (instead of magnesium di-uranate) at Jaduguda mill, enhancement of production capacity of

Jaduguda mill and the proposal of water management, sludge removal and effluent treatment in Mine Water Treatment Plant (MWTP) of the Bagjata Mine are under review.

The significant events of flash leakage of sulphuric acid at Turamdih mill, leakage through breach in discharge pipeline of Jaduguda mill and outflow of liquid from decant water pond and the check dam at the downstream of Turamdih tailings pond (consequent to heavy rainfall in the area), were reviewed by safety committees and measures to minimize the possibility of such incidents in future were recommended.

(iv) Indian Rare Earths Limited (IREL)

The IRE plants at the Chavara, Manavalakurichi, Chatrapur and Udyogamandal operated safely.

Beach Sand Minerals Safety Committee and SARCOP reviewed the industrial & fire safety and radiological safety status of the following proposals of the IREL plants for clearance and took appropriate decisions.

- Review of Thorium Retrieval Uranium Recovery & Storage (THRUST), Phase-II operations at IRE, Udyogamandal and storage of thorium oxalate.
- Enhancement of rare earths production from thorium concentrate from existing 2.5 tons to 60 tons per month at IREL Udyogamandal.
- Storage of thorium oxalate at IGCAR and processing of the thorium concentrates transported from IGCAR at IREL Udyogamandal.
- Management of solid waste generated from thorium plant at IREL, Chatrapur (OSCOM).
- Structural stability of plants and silos at IREL, Udyogamandal, pilot plant for processing of monazite through sulphuric acid route at IREL, Udyogamandal, proposal for pumping of thorium oxalate slurry in silo no. 4 at IREL, Udyogamandal, temporary storage of thorium oxalate in sheds of IREL, OSCOM and technical specifications of IREL, Udyogamandal, and IREL, Manavalakurichi are under review.

The significant events of fall of RCC sunshade slabs and cement plastering from roof slab of Solvent Extraction Plant-I at IREL, Udyogamandal and a fire incident in SEP-I IREL, Udyogamandal were reviewed and measures to minimize the possibility of such incidents in future were recommended.

(v) Beach Sand Minerals Facilities

The notification on the requirement of licensing of beach sand minerals facilities by AERB was issued.

The License applications under the Atomic Energy (Radiation Protection) Rules, 2004, received from IREL Chavara and Manavalakurichi, M/s DCW Ltd., M/s Blast Abrasives Pvt. Ltd., M/s Cochin Minerals and Rutile Ltd., Alwaye, M/s V.V. Mineral, M/s Trimex Sands Pvt. Ltd., BMC

Pvt. Ltd., M/s Transworld Garnet India Pvt. Ltd., M/s Kerala Minerals & Metals and M/s Miracle Sand & Metals are under review.

(vi) Atomic Minerals Directorate for Exploration and Research

The authorization for exploratory mine development of Gogi underground uranium mine in Gulbarga district, Karnataka by AMD was granted last year. The exploratory mining activities including establishment of ventilation system are in progress and are periodically reviewed by AERB.

2.3.2 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 at front-end fuel cycle facilities and R & D units. The major recommendations made were as follows:

(i) Fuel Cycle Facilities

- At IREL-Manavalakurichi, proper engineering measures should be adopted to minimize the spillage of monazite-enriched fraction in the plant area.
- At IREL-Chavara, bottom trays should be provided over the entire length of the conveyors carrying the monazite-enriched fraction to minimize the spillage in the plant area.
- At IREL-Udyogamandal, adequate shielding should be provided to the door opening of the Rare Earth Chloride store to reduce the background radiation.
- At IREL, Chatrapur rerouting of water pipelines passing through the Main Control Room should be carried out.
- At UCIL it shall be ensured that radium body burden measurement is carried out for all UCIL mines and personal dosimeters are issued to all mine workers.
- At NFC, proper machine guard shall be provided to all moving parts of machines to avoid injury to workers.

(ii) Beach Sand Minerals Facilities

M/s V.V.Mineral, Tisaiyanvilai, M/s Beach Sand Minerals Company Pvt. Ltd., M/s 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:

- Radiation monitoring instrument should be calibrated periodically and records maintained.
- Mineralogical analysis for monazite content of the feed material and monazite-enriched tailings from illemenite purification plant should be done periodically.
- Pits for disposal of the monazite-enriched tailings should

be topped with silica rich sand, uniformly leveled and clearly identified by display boards.

- The monazite content in the tailings sent to the pit should be analyzed periodically and records maintained.
- Radiation caution board should be displayed in English and local language in the 'tailings collection tank' area to avoid unnecessary occupancy.

2.3.3 Licensing of Plant Personnel

- Licensing Committee for licensing of operating personnel for Heavy Water Plants met at HWP-Kota, Thal, Hazira, Baroda and Manuguru and authorised/re-authorised 58 operation personnel.
- Authorisation interviews were held at Zirconium Complex, Pazhayakayal for the positions of shift-in-charges of Oxide Production Facility/Sponge Production Facility/Utilities and 25 operational personnel were authorised.
- Authorisation interviews were held at Nuclear Fuel Complex, Hyderabad for the positions of Shift-in-charges of New Uranium Oxide Fabrication Plant-Oxide/Uranium Oxide Plant/Zirconium Oxide Plant and 26 operation personnel were authorised.

2.4 OTHER FACILITIES

2.4.1 Variable Energy Cyclotron Centre

The existing cyclotron (K-130) was under shutdown for up-gradation. In Super Conducting Cyclotron (K-500), commissioning of the RF system is under progress. In Radioactive Ion Beam (RIB) Facility, phase wise testing of stable beam operation is in progress. Piling work has started in Medical Cyclotron Facility. The proposal for post facto approval for siting and construction of Super Conducting Cyclotron at VECC, Kolkata and its commissioning clearance are under review. Measures were recommended for improving structural stability of the building.

The proposal for siting and construction clearance for the proposed new building for RIB project, VECC, Kolkata is under review.



Visit of VECC&RRCAT Safety Committee to VECC, Kolkata

During regulatory inspection, AERB recommended to VECC to ensure that the radiation monitoring instruments, the interlocks and access control for the Super Conducting Cyclotron are put in service prior to any test beam tuning operations.

2.4.2 Raja Ramanna Center for Advanced Technology

Indus-1 was operating and producing 450 MeV beam energy at 100 mA current. VRSC and SARCOP reviewed the proposal for commissioning of stage-4 of Indus-2 (i.e., injection of the beam into Indus-2 storage ring at 2.5 GeV energy at 50 mA current) and authorization was granted. The technical specifications for operation of Indus-

1 and Indus-2 at RRCAT, Indore were approved. The application for trial operation of 750 KeV DC accelerator is under review.

2.4.3 Electronics Corporation of India Limited

The industrial and fire safety related issues of ECIL namely, revamping of existing fire hydrant system, strengthening of industrial safety section, recruitment of fire officer and periodical medical examination of workers as per the Atomic Energy (Factories) Rules, 1996 and the proposals for uranium plating facility and construction of Electromagnetic Interference / Electromagnetic Compatibility facility at ECIL premises are under review.

CHAPTER 3

RADIATION FACILITIES

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 manufacturer of consumer products. Research installations include universities and other research institutes handling a variety of sealed and unsealed radiation sources and also X-ray facilities for research purposes.

Information on number of various radiation installations and radiation devices, which are regulated by AERB as on March 31, 2009, 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 <ul style="list-style-type: none"> • Teletherapy • Brachytherapy 	Telecobalt 283 Telecesium 1 Accelerators 131 Gamma Knife 4 Tomotherapy 1 High Dose Rate 137 Low Dose Rate 26 Manual (Intracavitary) 92 Manual (Interstitial) 34 Ophthalmic (90Sr) 20 Ophthalmic (125I) 4 Ophthalmic (106Ru) 2	239
3	Nuclear Medicine <ul style="list-style-type: none"> • Diagnostic & low dose therapy • High dose therapy 	Not applicable	155 122 33
4	RIA	Not applicable	400
5	Research	Not applicable	350
6	Industrial Radiography <ul style="list-style-type: none"> • Radiography Cameras • X-ray units • Accelerators 	1507 235 12	486
7	Gamma Irradiators		15
8	Nucleonic Gauges	7850	1485
9	Consumer Products <ul style="list-style-type: none"> • Gas Mantle • Lamp starters • Smoke Detectors • Electron Capture Detectors (ECD) 	Not applicable -	62 20 102 667

3.1 TYPE APPROVALS, NO OBJECTION CERTIFICATES AND APPROVAL OF RADIOLOGICAL SAFETY OFFICERS

3.1.1 Type Approvals

For the purpose of ensuring that the radiation doses received by workers and members of the public do not exceed the prescribed dose limits and further that such doses are kept As Low As Reasonably Achievable (ALARA), design safety is accorded primary importance and operational control measures are monitored. With this in view, all devices including radiation generating equipment and those incorporating radioactive sources are subjected to a type approval procedure. AERB permits only type-approved devices to be marketed in India. The criteria for type approval are stipulated in the Standards Specifications (SS) documents on a variety of devices, issued by AERB. These SS documents are periodically reviewed and revised, where necessary, in order to meet internationally accepted and current standards. Safety Review Committee for the Application of Radiation (SARCAR) examines the design safety features of each device and recommends issuance of type approval. SARCAR held five meetings during the year. Based on the recommendations of SARCAR, AERB issued No Objection Certificates (NOCs) and type approval certificates to the manufacturers/suppliers of devices incorporating radioactive material and radiation generating equipment. NOCs are issued to the vendors for importing one unit which can be tested for issuance of type approval. Number of NOC and Type Approval and consents issued during the year is given in Table 3.2.

Table 3.2: Type Approvals Granted

(Radiation Generating Equipment and Equipment Containing Radioactive Material)

A. NOC for procurement and handling

Sr. No.	Type of Equipment	Number of NOCs Issued
1.	Medical Diagnostic X-ray Units	39
2.	Computed Tomography (CT) Units	7
3.	Radiotherapy Simulators	9
4.	Medical linear accelerators	7
5.	Container scanning systems	2

B. Type Approvals

Sr. No.	Type of Equipment	Number of Models Type approved
1	Medical Diagnostic X-ray Units	30
2	Computed Tomography Units	18
3	Tele Cobalt Units	1
4	Medical Linear Accelerators	5
5	Radiotherapy Simulators	1

6	Leksell Gamma Knife Unit	1
7	Remote Controlled After-loading Brachytherapy Units	2
8	Industrial Gamma Radiography Exposure Devices (IGRED)	2
9	X-ray Baggage Inspection Systems	3
10	X-ray imaging System integrated with Remote Controlled Afterloading Brachytherapy Unit	1
11	X-ray Imaging System integrated with Medical Linear Accelerator	1

C. Other Consents

Sr. No.	Type of Application	Permission Granted
1	Site Approval for installation of Gamma Radiation Processing Plant	1
2	Site Approval for installation of Medical Cyclotron	1
3	Design and Construction Approval for Medical Cyclotron	3
4	Design and Construction Approval for Gamma Radiation Processing Plant	1
5	Licence for routine operation of Gamma Radiation Processing Plant	5
6	Licence for routine operation of Medical Cyclotron	1
7	Commissioning Approval for Medical Cyclotron	1
8	Certificate of Approval for radiation processing of food products	1
9	Approval of 125I Ocuprosta Sealed Seed Sources to Radiopharmaceutical Division, BARC, Mumbai	1
10	Approval of 192Ir radiography Special Form Sealed Source RC-2 to M/s. Board of Radiation and Isotope Technology (BRIT), Mumbai	1
11	Permission for import and supply of industrial radiography sources in India to M/s. Electronics and Engineering Co. (I) P. Limited, Mumbai	1

3.1.2 Approval of Radiological Safety Officers

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

Table 3.3: Approval Issued to RSOs

Sr. No.	RSO Level	Number Approved
1	RSO Level-III (Medical)	105
2	RSO Level-III (Industrial Radiography)	11
3	RSO Level-III (Gamma Irradiators)	09
4	RSO Level-II (Industrial Radiography)	111
5	RSO Level-II (Nuclear Medicine Diagnosis)	44
6	RSO Level-I (Nucleonic Gauge)	58
7	RSO Level-I (Research Applications)	30

3.2 AUTHORISATION FOR PROCUREMENT, EXPORT AND DISPOSAL OF SOURCES AND FOR SHIPMENT OF RADIOACTIVE MATERIALS

3.2.1 Licensing / Authorization

Licenses for operation were issued to one medical cyclotron and five high activity gamma radiation processing plants.

AERB issued 1200 Certificates of Registration to diagnostic X-ray installations upon confirming that the applicable regulatory requirements are duly satisfied. A total of 11 and 121 NOCs were issued for export and disposal of sources respectively. Details of Licences/NOCs issued during the year 2008, 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 2008	
		Local	Import
1	Radiotherapy		
	• Telecobalt	21	17
	• Telecaesium	-	-
	• Accelerators	-	24
	• Gamma Knife	-	4
	Brachytherapy		
	• HDR	1	133
	• LDR	-	-
	• Manual (Intracavity & Interstitial)	7	-
	• Ophthalmic Sr-90	-	-
• Ophthalmic I-125	3	-	
• Ophthalmic Ru-106	-	1	
2.	Nuclear Medicine		
	• RIA facilities	2	91
	• Diagnostic & Therapeutic	170	159
	• Research	62	254
3.	Industrial Gamma Radiography Exposure Devices	1014	39

4.	Gamma Irradiators (Category-IV)	7	0
	Gamma Irradiators (Category-I)	4	2
5.	Nucleonic Gauges	58	182
6.	Diagnostic X-ray CT and Cath lab units	1200 (Registered) 105	-
7.	Consumer Products		
	• Gas Mantle	45	-
	• Lamp starters	2	-
	• Electron Capture Devices	-	71
	• Smoke detectors	-	07
	• Explosive detectors	-	55

B. Number of Sources Disposed Off

At BRIT	At WMD, BARC & CWMF Kalpakkam	At original supplier of source abroad
202	14498 (ICSD), 194 & 261 kg (DU)	262

3.2.2 Shipments under Special Arrangements and Approval of Packages for Transport of Radioactive Material

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.

As per AERB regulations, Type-A packages, which are permitted for transport of 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. During the period 11 packages were registered as Type A and 3 packages were approved as Type B.

3.3 REGULATORY INSPECTIONS

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

Table 3.5: Regulatory Inspections

Sr. No.	Facilities	No. of Institutions	No. of Inspections
1.	Radiotherapy	249	10
2.	Nuclear Medicine	155	30
3.	Industrial Radiography	505	39
4.	Gamma Irradiators	15	15
5.	Nucleonic Gauges	1485	16

3.4 RADIOLOGICAL SAFETY ASSESSMENT AND SURVEILLANCE

3.4.1 Radiation Diagnostic and Therapy Facilities

On the basis of pre-commissioning safety evaluation, AERB issued authorizations for the commissioning of 38 Teletherapy units (10 Telecobalt units and 28 Medical LINAC) and 34 remote after-loading Brachytherapy units, and for the decommissioning of 11 Teletherapy unit during the year. Permissions were accorded for re-starting 26 Telecobalt units after source replacement and for starting 11 new radiotherapy centres. Thirty nuclear medicine facilities were inspected. AERB reviewed annual safety status reports received from the licensees and inspected 46 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.

3.4.2 High Intensity Gamma Irradiation Facilities

Inspections were carried out at the following 15 operating gamma irradiation facilities:

- ISOMED, Board of Radiation and Isotope Technology (BRIT), Mumbai.
- SARC, Shriram Institute for Industrial Research, Delhi.
- RASHMI, Kidwa Memorial Institute of Oncology, Bangalore.
- RAVI, Defence Laboratory, Jodhpur.
- RVNRL, Raubber Board, Kottayam.
- PANBIT, Sree Chitra Tirunal Institute for Medical Science & Technology, Trivendrum.
- Radiation Processing Plant, BRIT, Vashi.
- VIKIRAN, Organic Green Foods Limited, Kolkata.
- STERICO, A.V. Processors Pvt. Ltd., Mumbai.
- Universal ISO-MED, Universal Medicap Limited, Vadodara.
- Vardaan Agrotech Pvt. Ltd., Sonapat, Haryana.
- Microtrol Sterilisation Services Pvt. Ltd, Bangalore.
- Agrosurg Irradiators (India) Ltd., Vasai.
- Gamma Agro Medical Processing Pvt. Ltd., Hyderabad.
- KRUSHAK, BRIT-BARC Facility, Lasalgaon, NASIK.

The quarterly safety status reports were received from all the operating gamma radiation-processing facilities. The occupational exposures in gamma irradiation facilities in the last five years did not exceed 2 mSv/y, which is well below the prescribed dose limit of 20 mSv/y. Five proposals for the loading/ replenishment of Cobalt-60 sources from such facilities were reviewed and clearances were issued. Sites for installation of two more such facilities have been approved by AERB.

3.4.3 Industrial Radiography

There are 505 industrial radiography institutions in India. The total number of industrial gamma radiography exposure devices deployed for radiography work is 1507. There are about 235 Industrial X-ray units and 12 industrial accelerator facilities. During the year, AERB carried out announced as well as unannounced inspections of 39 industrial radiography sites and installations. The monthly safety status reports received from radiography institutions were reviewed by AERB to ensure availability of safety infrastructure and to check inventory of radiography devices/sources. A Type Approval application for radiography exposure device model ROLI-3, manufactured by BRIT, was reviewed and approved.

3.4.4 Nucleonic Gauging

The application of nucleonic gauges for level monitoring, thickness measurement, density measurement, moisture detection and 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 16 institutions. Safety status reports from these installations were reviewed by AERB to ensure availability of safety infrastructure and to check 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.

3.4.5 Transport of Radioactive Materials

Sixteen permissions for transport of radioactive material were issued. 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.

3.4.6 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 121. The number of authorizations for transfer to domestic supplier and waste management agencies was 79.

Before the authorization for disposal of the material is issued, safety assessments of the disused sources are done by physical inspection, correspondence with the waste generator and the authorized waste management agency. A total of 91 such assessments were done during the year.

3.5 UNUSUAL OCCURRENCES

All unusual occurrences at radiation installations were investigated and appropriate enforcement actions commensurate with the nature of occurrence were implemented.

3.5.1 On 07-05-2008, an incident was reported involving some damage to the civil structure control room and conveyor system of Gamma Radiation Processing Plant (GRPP) of M/s. Vardaan Agrotech Pvt. Ltd. (VAPL), Sonapat, Haryana, owing to demolition actions based on court orders in land ownership dispute between M/s. VAPL and other agency. On being informed of this by the RSO of the facility, AERB intervened immediately through the local police authorities and managed to get the demolition work stopped. The Honourable High Court of Punjab & Haryana appointed the Deputy Commissioner, Sonapat as Receiver of VAPL facility. In view of lack of security measures, non availability of RSO and certified operators and land ownership dispute, AERB issued Directive dated 13-07-2008 to M/s. Vardaan Agrotech Pvt. Ltd, Sonapat for suspension of routine operation of their gamma radiation processing plant till further instruction. For the removal of 60Co source from VAPL, an Application was filed by AERB in the Honorable High Court of Punjab & Haryana. The Honorable Court permitted AERB for removal of 60Co radioactive sources from M/s VAPL vide court order dated 01-08-2008. Subsequently, AERB communicated to BRIT, Mumbai, as supplier of the 60Co source, to initiate actions for the removal of sources from M/s VAPL. On 19-01-09, experts from BRIT and AERB arrived at VAPL, Sonapat for the removal of 60Co source. The transport flask had been sent by BRIT from Mumbai to VAPL, Sonapat. The removal operations had to be abandoned as per a Delhi high court order. Advice from Dy. Commissioner, Sonapat was sought on further course of action to be taken. Response is awaited.

3.5.2 BRIT, Mumbai informed AERB on 07-05-2008 regarding loss of decayed 192Ir radiography source (activity = 0.025 mCi as on 07-05-08) with sub-assembly part of source holder of an industrial gamma radiography exposure device (IGRED) model Gammarid, Sr. No. 27, belonging to M/s. Perfect Metal Testing and Inspection Agency (PMTIA), Kolkata. The incident was reviewed in the AERB Standing Committee for Investigation of Unusual Occurrences in Radiation Facilities. The damaged source assembly part has been physically examined by officers from RSD, AERB. M/s. PMTIA submitted explanation to the show-cause notice issued by AERB about the incident. A Directive dated 01-10-2008 was issued by AERB to M/s. PMTIA, Kolkata for surrendering the exposure device.

3.5.3 An incident was reported to AERB on 20-07-2008 involving damage of source capsule containing 2 TBq (54 Ci) 60Co industrial radiography source belonging to M/s. SITAS NDT Engineering, Bangalore leading to contamination in the cranking unit and guide tube of exposure device model Techops-680. The incident was noted by radiation workers of M/s. SITAS, Bangalore while retrieving the source in the exposure device during routine radiography exposure. The incident was reviewed in the AERB Standing Committee for Investigation of Unusual Occurrences in Radiation Facilities (SCURF). SCURF

recommended constitution of sub-committee for further investigation of the incident. Accordingly, Committee for Investigation of Industrial Radiography Incidents (CIIRI) was constituted to review this incident. The incident is under investigation by CIIRI.

3.5.4 An incident was reported to AERB on 02-09-2008 involving damage of source capsule containing 2.14 TBq (58 Ci) 60Co industrial radiography source belonging to M/s. Visvesvaraya Industrial Engineering Works, Coimbatore, leading to contamination in the cranking unit and guide tube of exposure device model Ten-680. The incident was noted by radiation workers of M/s. Visvesvaraya Industrial Engineering Works, Coimbatore while retrieving the source in the exposure device during routine radiography exposure. The incident was reviewed in the AERB by SCURF. SCURF recommended constitution of sub-committee for further investigation of the incident. Accordingly, Committee for Investigation of Industrial Radiography Incidents (CIIRI) was constituted to review this incident. The incident is under investigation by CIIRI.

3.5.5 An Industrial Gamma Radiography Exposure Device (IGRED) model Spec-2T, Sr. No. 1268 containing 74 GBq (2 Ci) 192Ir source belonging to M/s. RUMP Inspection & Engineering Services (P) Ltd., New Delhi was reported to be stolen from the Hazarat Nizamuddin Railway station while radiographer was boarding in the passenger train with above exposure device. The incident was reported to AERB on 09-09-2008. Officers from RSD, AERB were deputed to carry out investigation and radiation survey at the incident site. The missing IGRED could not be located despite extensive surveys carried out with the help of local Police Authorities. AERB issued Directive dated 10-09-2008 to M/s. RUMP for suspension of routine operation of radiography exposure device(s) till further instruction. M/s RUMP complied with the above directive.

3.5.6 An incident of loss of source was reported on Jan 22, 2009 by M/s Wens Quality Assurance Pvt. Ltd. (WQAPL), Chennai. Immediately a team was sent from AERB to help locating the source. The source could be located and brought under control. An employee of the company had intentionally stolen the source and thrown it out. Subsequently AERB issued a show-cause notice to M/s WQAPL on 28-01-2009 stating the violations such as (i) use of defective device for radiography operation, (ii) loaning of exposure devices, (iii) unqualified persons and helpers involved in radiography operation and (iv) non-submission of periodic safety status reports. M/s WQAPL submitted the reply vide letter dated 29-01-2009 accepting all the violations but denied that unqualified persons or helpers were involved in radiography operation. Following regulatory action has been initiated against the company by AERB: (i) No regulatory consent/clearance shall be issued to M/s WQAPL, Chennai for a period of three months from the date of issuance of directive to M/s WQAPL by AERB. (ii) Exposure device model Gammamat TI Sr. No. 666 shall not be returned to M/s WQAPL for a period of three months

from the date of its return at BRIT. (iii) The certificate of Site-In-Charge and radiographer shall be withdrawn for a period of three months from the date of its receipt at RSD, AERB.

3.6 MISCELLANEOUS

3.6.1 Response to Seizure of Material Claimed to be Uranium

AERB responded promptly to the news reports of seizure of material claimed to be uranium, by contacting through DAE the relevant law and order authorities of the concerned states where the incident took place. Altogether, there were six reports of seizure of material claimed to be uranium. Further investigation and laboratory analysis of the samples of the material seized revealed that none of the material seized was uranium; but turned to be some natural soil/rocks. The same was communicated to IAEA's Illicit Trafficking Database (ITDB) also.

3.6.2 Radioactive Contamination in Steel Products

Radioactive contamination was reported in steel products exported to USA, UK, France, Germany, Spain and Turkey. It was noted that most of the shipment of contaminated steel products originated from steel product manufacturers and exporters located in Maharashtra. Further investigation carried out by AERB revealed that the contamination in the products originated from a single steel foundry cum exporter. AERB conducted inspection of 20

factories associated with recycling steel industry. Radioactive contaminated items were located in some of the factories and safe disposal of the same is under process. The manufacturing units and exporters of steel products have been advised to use radiation monitoring equipment for detection of radioactive contamination. AERB conducted awareness programme for all stakeholders including steel foundries, manufacturing units, exporters and concerned government officials in collaboration with Engineering Export Promotion Council (Western Region). AERB also published articles on radioactive contamination in steel in the news bulletin of the relevant industry bodies.

3.6.3 Appeal against AERB Decision

In one case of a nuclear medicine facility, AERB on being informed that the facility was located in a residential building (as against the information filed with AERB that the facility was located in a commercial building), revoked the license of the facility. The licensee appealed to the Atomic Energy Commission (AEC) against AERB's action and also moved the law court. This was the first instance of a licensee appealing to AEC against the decision of AERB. The AEC, after careful consideration of all aspects of the case, rejected the appeal. In parallel, the licensee applied to AERB for shifting the facility to a non-residential building which was authorized by AERB after inspection of the proposed premises. The court case was subsequently withdrawn by the licensee.

CHAPTER 4

INDUSTRIAL SAFETY

AERB carries out review and monitoring of industrial safety status in nuclear power plants/ projects, nuclear fuel cycle facilities and other associated facilities of DAE. New project proposals, significant events, industrial safety occurrences and fire incidents at different units are reviewed by the unit safety committees and SARCOP.

Regulatory inspections for industrial & fire safety aspects were strengthened at projects for effective monitoring and rectification of 'unsafe acts & unsafe conditions' to ensure adequate level of industrial safety at the construction sites.

Licenses are issued/renewed and regulatory inspections are carried out under the Factories Acts 1948 and the Atomic Energy (Factories) Rules, 1996. Thirty-three persons were given approval as competent persons under various sections of the Factories Act, 1948.

There were 2 fatalities during the year (April 2008-March 2009) due to industrial accidents at KK-NPP and Zirconium Complex, Pazhayakayal construction sites. These accidents were investigated to arrive at the root cause and remedial measures were suggested to the sites to prevent recurrence. A summary of these accidents and recommendation made by the AERB Fatal Accident Assessment Committee (FAAC) of the incidents are described below.

On December 23, 2008 at KK-NPP, one contract worker, while moving on a platform at 12 meter elevation of the Caisson structure fell down from an opening into the 2 feet deep water, resulting in head injury and fatality. On the spot assessment of the incident was done by an AERB officer and subsequently reviewed in the FAAC. Remedial measures such as covering of all engineered floor openings by gratings, covering of open sides of structure above 3.5 m in height, provision of protective caged ladder, use of personal protective equipment like helmets, life jackets, etc., were recommended by the committee to prevent recurrence of such incident.

On February 23, 2009 at Zirconium Complex, Pazhayakayal, Tamilnadu a contract worker while carrying out cleaning of inside of the concrete turbo mixer, got entangled inside the mixer, when unknowingly the operator started the concrete batching plant. The victim suffered multiple body injuries with hemorrhage resulting into fatality. On the spot assessment of the incident was done by an AERB officer and subsequently reviewed in the FAAC. Remedial measures such as adherence to standard operating procedures, establishment of interlocks to prevent operation of the turbo mixer if its cover is open, implementation of safety work permit for carrying out maintenance, isolation

of electrical power supply before maintenance etc. were recommended to prevent recurrence of such incident.

In order to enhance industrial safety at construction sites, AERB decided to continue the conduct of "Special Monthly Inspections" at all project sites, with special focus on work at height. Monthly inspections were carried out at RAPP-5&6, KK-NPP, KGS-3 &4, DFRP at IGCAR, BHAVINI, Turamdih Mills, Zirconium Complex, Pazhayakayal, HEWAC facility at HWP-Kota, VSPP site at HWP-Talcher, Boron Enrichment Plant and Elemental Boron Plant at HWP-Manuguru. Implementation of minimum safety requirements, Job Hazard Analysis (JHA), preparation of safe working procedures and use of field check list based on JHA were made mandatory for all hazardous works at sites.

4.1 LICENSES/APPROVALS

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

- Licence for HWP-Hazira renewed for a period of five years.
- Licence for NAPS renewed for a period of five years.
- Licence for NFC, Hyderabad renewed for a period of five years.
- License for KAPS 1 & 2 renewed for a period of five years.
- Licence for KGS-3&4 was issued for a period of five years.

License for HWP-Thal renewed on December 2, 2008 for limited period upto December 31, 2009, as the formal authorisation of field operators and hydro/pneumatic test of ammonia converter are yet to be completed.

License for HWP-Manuguru was renewed on January 12, 2009 for limited period upto June 30, 2010, as strengthening measures pertaining to Ash Pond-I and issue of ISI manual are yet to be completed.

4.2 REGULATORY INSPECTIONS

During the year, 55 normal inspections, 40 monthly inspections at construction sites of nuclear power projects and 16 quarterly inspections of fuel cycle facilities construction sites were carried out. During these inspections, the inspectors ensured immediate rectification of the unsafe conditions and unsafe acts observed. NPCIL, HWB, and BHAVINI have initiated measures to encourage reporting of near miss incidents and dissemination of the lessons learned from an incident enhancing the safety culture of the units. The compliance to the findings of these inspections

and the AERB directives have improved the overall safety culture of the units, some of which are given below.

- In the operating plants where applicable, the cable entry / exit penetrating points of the control room wall have been sealed with fire retardant sealing material, reducing the possibility of damage to the safety related system of the plant due to any fire incidents.
- At ECIL, periodic medical examination of the persons working in the electroplating section, canteen and forklift has been initiated once in a year as per the relevant rules of the Atomic Energy (Factories) Rules, 1996.
- At NFC, Hyderabad, preparation of the document for ISI of the ammonia cracker tubes has been initiated.
- At IREL plants, the inventory of solvent in the mixer-settlers during extended shutdowns is being kept minimum, thereby reducing the fire load inside the plants.
- In HWPs, the periodic functional tests for the booster charge batteries as per the surveillance requirement of the revised Technical Specifications, is being strictly adhered to.
- At VECC, the oil leakages from tap changing units of transformers are rectified, reducing the risks of fire incidences.
- At the Nuclear Power Projects, the supervision of work has improved from line management and safety personnel and use of appropriate personal protective equipment with ISI certification is being strictly enforced. The covering of engineered floor openings has improved at all project sites.
- At all operating plants and project sites, certification of Scaffoldings by mechanical engineer for its fitness for use after erection is being followed. It is being impressed upon that the erection of scaffoldings should be done as per Indian Standard- Safety Code for Scaffold & Ladders (IS: 3696 (Part-1)).

4.3 PROMOTION OF INDUSTRIAL SAFETY

4.3.1 DAE Safety and Occupational Health Professionals Meet

The 25th DAE Safety & Occupational Health Professionals Meet was jointly organized by DAE Units at Kalpakkam site and the Atomic Energy Regulatory Board, Mumbai at Kalpakkam during December 18-20, 2008. The themes for this Silver Jubilee year's meet were "Safety Management & Safety Culture" for Industrial Safety and "Industrial Medicine" for Occupational Health.

There were plenary and parallel sessions and one poster session. The technical sessions on the first day had three invited lectures in each session from renowned experts. The lectures covered topics such as "Safety Management", "Safety Culture" & "Behavior based Safety Approach" and

"Emerging Approaches for Occupational Health Risk Management in Industrial Medicine", "Occupational Health Practices at the Workplace" and "Behavioral Aspects of Employees". Medical officers presented sixteen papers on "occupational health" in the parallel sessions. Presentations were made from DAE units on "Physical Hazards (Noise, Heat, Vibration, Illumination, etc) - Control at Workplace, Methods & Strategies". This year a session was organized for presentation by the Tradesman/operators etc.



Inaugural Session of 25th DAE Safety & Occupational Health Professionals Meet

(L to R) Shri Prabhat Kumar, PD, BHAVINI, Shri S.P. Sethi, Principal Advisor (Energy), Planning Commission, Government of India, Shri S.K. Chande, Vice-Chairman, AERB, Dr. S.K. Jain, CMD, BHAVINI & NPCIL, Shri S.K. Sharma, Chairman, AERB, Shri Abhijit Rajan, CMD, Gammon India Ltd., Dr. Baldev Raj, Director, IGCAR and Shri R. Bhattacharya, Head, IPSD, AERB.

AERB's Green Site Award for the year 2007 was won by The Indian Rare Earths Limited, Manavalakurichi plant and Kalpakkam Site (MAPS, IGCAR, BHAVINI & Other Units) and was presented on this occasion.

Dr. S.K. Jain, Chairman & Managing Director, BHAVINI & NPCIL released a booklet on Safety Management & Safety Culture. This professional meet is organized every year and is serving as a forum where the experts in industrial safety and occupational health exchange their experience.

4.3.2 Industrial Safety Statistics

The compilation of Industrial Safety Statistics-2008 of DAE units (other than BARC facilities and mines) which provides the data on accidents and analysis of number of injuries and man-days loss caused by various factors was published by AREB in March 2009.

There were 62 reportable injuries including 1 fatality (during the calendar year 2008) and 2 amputations and enucleations (on fingers), which contributed to 7866 man-days loss in the year 2008 compared to 33,234 man-days loss in the year 2007. The single fatality occurred at Kudankulam Nuclear Power Project on December 23, 2008. Fig. 4.1 gives the distribution of reportable injuries among DAE units and Fig. 4.2 gives the distribution of man-days lost in DAE units.

In the year 2008, 230 near miss accidents were reported from different units of DAE and the statistics analysis shows 16.8% of these were "Fall of objects", 14.1% were "Fall of person from height", and 13.2% were "Fall/slip of person on same level".

Four "Dangerous Occurrences" as per the rule 89 of the Atomic Energy (Factories) Rules, 1996 were reported in DAE units during 2008. Two of these industrial related incidents happened at Heavy Water Plants namely, failure of mobile crane at HWP-Kota during shifting of the turbine near steam turbo generator building & leakage of synthesis gas from the top gas outlet pipeline of potassium amide recovery tower (in final enrichment unit) at HWP-Thal and the other two incidents happened at IREL- Udyogamandal plant namely, fall of RCC sunshade slab of approximately 3 metres at Solvent Extraction Plant-I & fall of approximately

5 square metre cement plaster from the roof slab at the unused Rare Earth Chloride evaporation area of the same plant.

It was observed that industrial safety performance of DAE units is better than other similar industries in the country. Table 4.1 gives the comparison of incidence rates in some DAE units with other similar industries in the country. Unit-wise comparison of Injury Index and Frequency Rate (F.R) are given in Figs. 4.3 and 4.4 respectively and Year wise Comparison of Injury Index in DAE Units is shown in Fig. 4.5.

In Figs 4.6 to 4.8, 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.

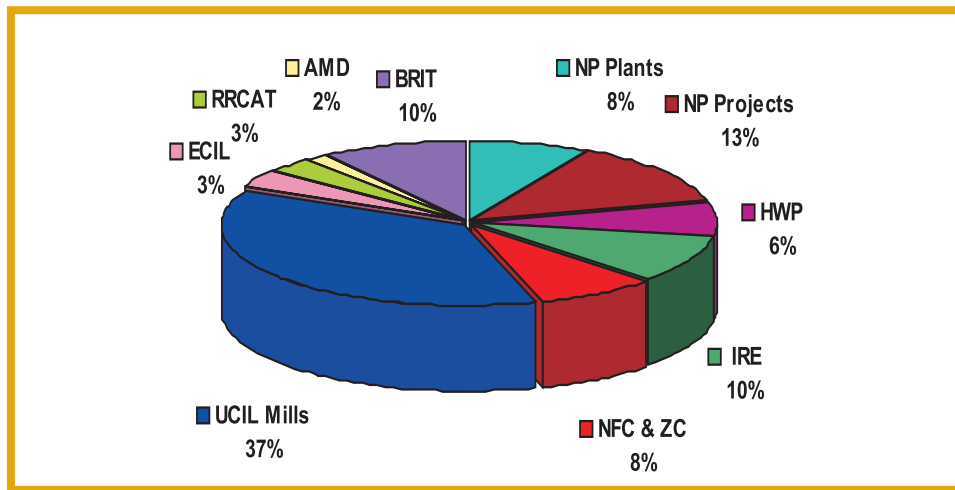


Fig 4.1: Distribution of Reportable Injuries in DAE Units (2008)

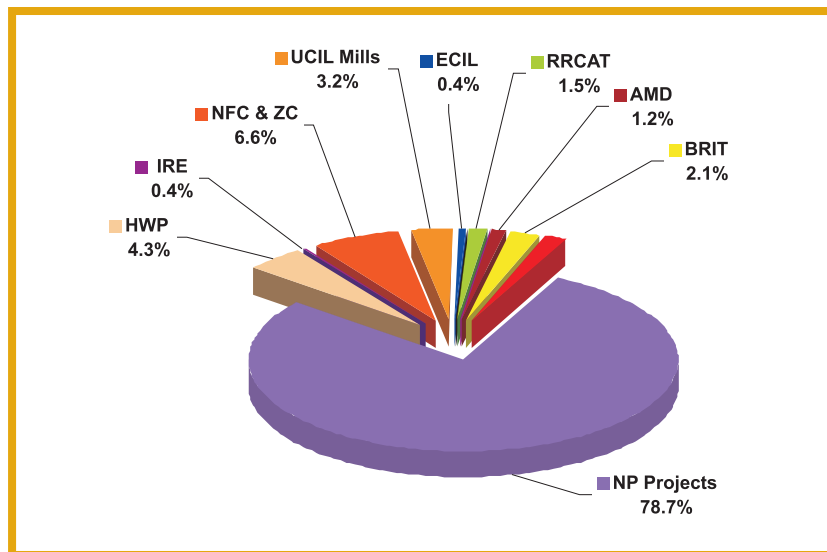


Fig.4.2: Distribution of Man-days Lost in DAE Units (2008)

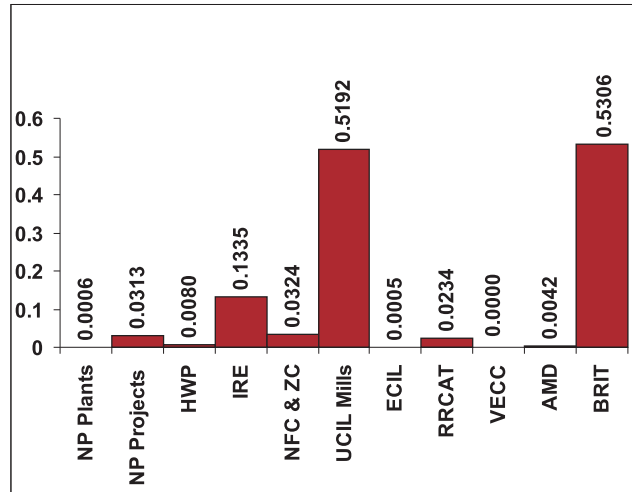


Fig. 4.3: Injury Index of DAE Units (2008)

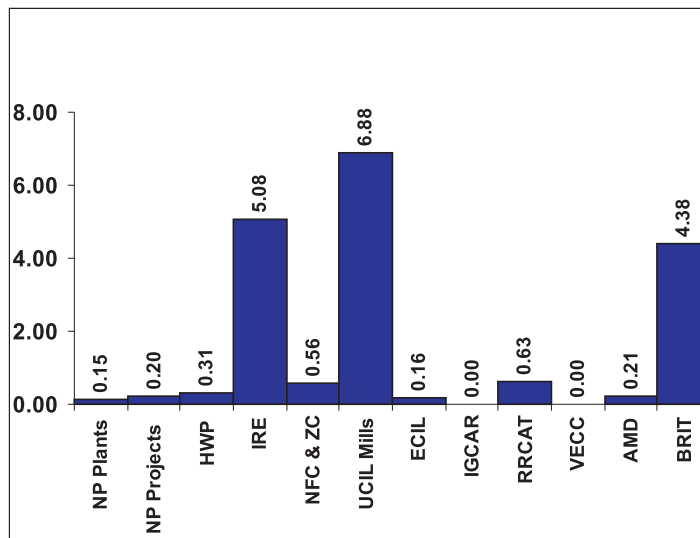


Fig. 4.4: Frequency Rates in DAE Units (2008)

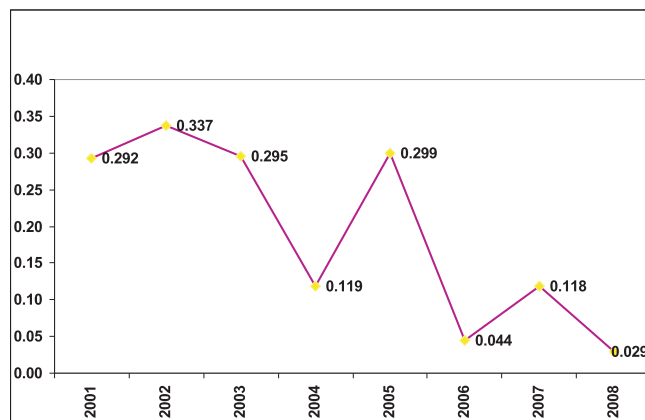


Fig. 4.5: Year wise Comparison of Injury Index in DAE Units (2008)

Table 4.1: Comparison of Incidence Rates in Some of the DAE Units (2008) with Equivalent Non-DAE Industries (2004)

Industry Type	Incidence Rate*	
	Fatal	Non-Fatal
Heavy Water Plants (2008)	0	0.73
Manufacture of Chemicals & Chemicals products (2004)	0.09	1.58
Nuclear Fuel Complex (2008)	0	1.11
Manufacture of Fabricated Metal Products except Machinery and Equipment (2004)	0.09	1.76
Nuclear Power Plants (2008)	0	0.36
Electricity, Gas, Steam and Hot Water Supply (2004)	0.29	5.98

*Incidence Rate : Number of lost time injuries per thousand persons employed

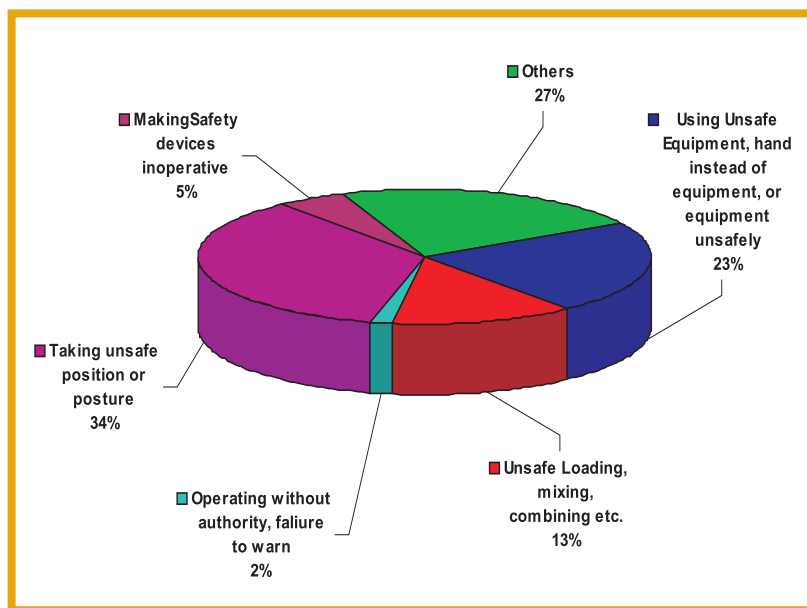


Fig. 4.6: Distribution of Injuries caused due to Unsafe Acts in DAE Units (2008)

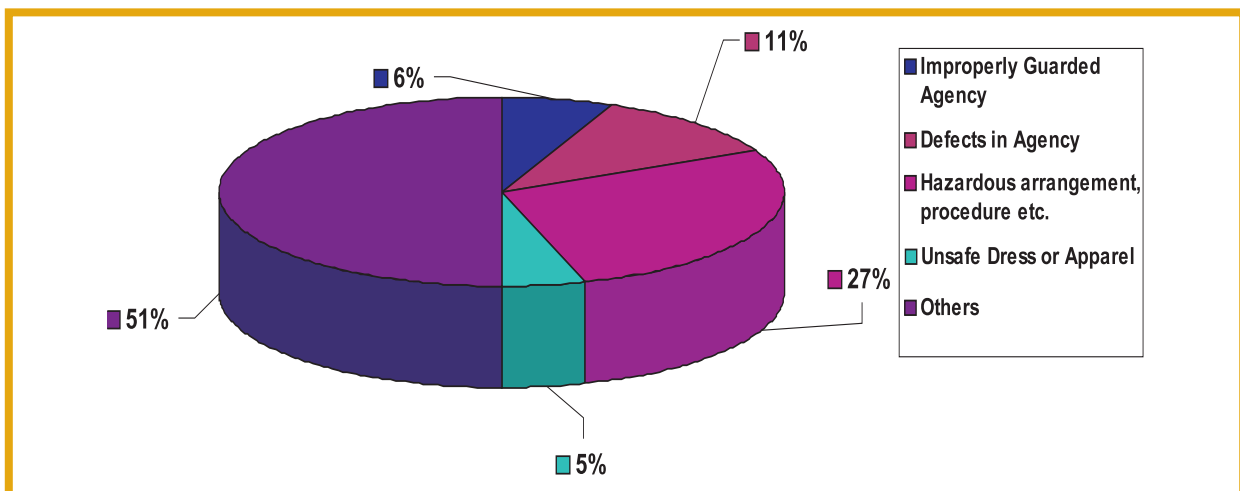


Fig 4.7: Distribution of Number of Injuries caused by various Unsafe Conditions in DAE Units (2008)

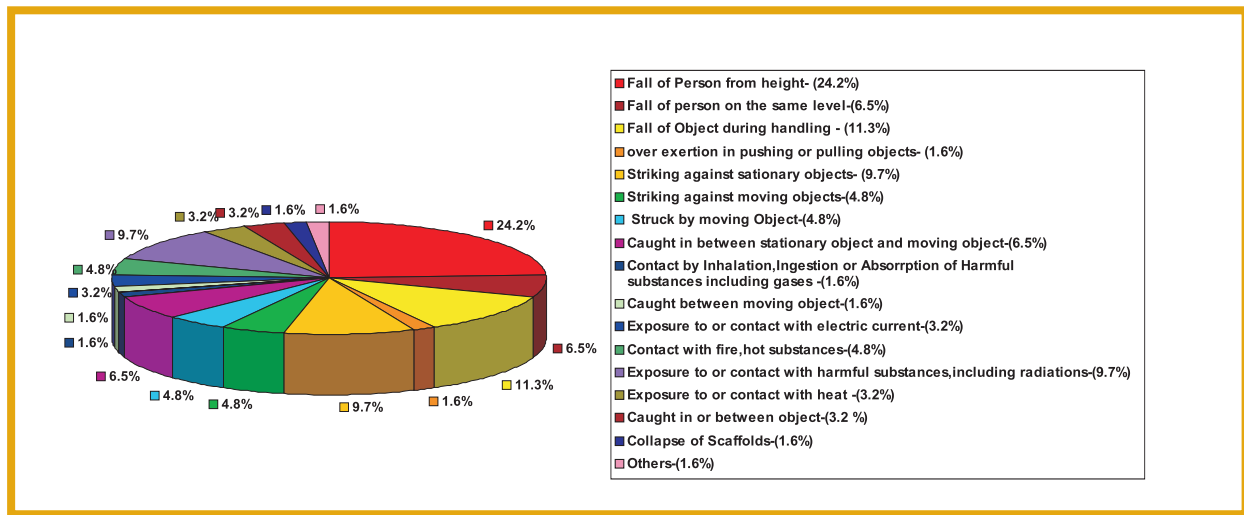


Fig 4.8: Distribution of Injuries with Respect to the Type of Accidents causing Injuries in DAE Units (2008)

4.3.3 Industrial Safety Awards

Atomic Energy Regulatory Board (AERB) presents Industrial Safety Awards every year to the Department of Atomic Energy (DAE) Units who achieve high levels of performance in Industrial Safety. The Industrial Safety Awards for the year 2008 were presented at a function held on March 6, 2009 at AERB Auditorium, Mumbai. Shri Apurba Saha, Executive Director & Asset Manager (Mumbai High), Oil and Natural Gas Corporation Limited presented the Awards. The Kaiga Generating Station 3&4, in Construction Group, Heavy Water Plant, Manuguru and Madras Atomic Power Station, in Production Units-I Group, Nuclear Fuel Complex, Hyderabad, in Production Units-II Group and Indira Gandhi Centre for Atomic Research, Kalpakkam, in Research Units Group were the winners.



Inauguration of AERB Industrial Safety Award Function
(L to R: Shri S. K. Chande, Vice-Chairman, AERB, Shri A. Saha, Executive Director, ONGC, Shri S. K. Sharma, Chairman, AERB and Shri R. Bhattacharya, Head, IPSD, AERB)

On this occasion, Shri S. K. Sharma, Chairman, AERB released a compilation entitled "Industrial Safety

Statistics - 2008 of DAE Units". This compilation provides analysis of industrial safety incidents and number of injuries and man-days loss caused by various factors.

4.3.4 Fire Safety Awards

The Fire Safety Awards are decided by taking into account the preventive efforts taken by the site, the fire incidents that had occurred during the period under consideration and the fire potential at the site. DAE units are categorized based on fire potential as Category-I (all operating NPP, HWP and NFC) & Category-II (IREL units, UCIL units, NPPs under construction, BHAVINI, RRCAT, VECC, BRIT, AMD, IGCAR and ECIL) and accordingly two awards are given in each category.

The annual Fire Safety Awards of AERB for the year 2007 were presented on April 29, 2008. In Category I joint winners were HWP, Manuguru and TAPS- 1&2 and in Category II, TAPS-3&4 was the winner. Shri D. K. Deshpande, Executive Director, HPCL, Mumbai presented the awards to the winning units.

A two-day seminar on 'Challenges and Innovation in Fire Safety' was organized on this occasion. The seminar had five technical sessions on varied themes like 'Fire Technologies and Fire Testing Facilities', 'Fire Analysis and Modeling', 'Fire Organization, Administration and Past Events', 'Fire Safety Challenges and Fire Analysis' and 'Operational Plants Fire Safety'. On this occasion, Chairman, AERB released a monograph on 'Fire Safety', that highlighted the various aspects of fire safety, description of some major fires that took place earlier, etc.

4.3.5 Fire Standard Revision

Fire protection in the nuclear facilities is accorded a very high priority and therefore, a standard for fire protection systems of nuclear facilities was developed and

released in 1996 by AERB. With rapid changes in technologies of fire prevention, detection and suppression and complexity of plant designs, the need for revision/ review of the standard was felt and the document has been revised. The revised draft document was discussed by the Advisory Committee on Industrial and Fire Safety (ACIFS). The revised document is in final stage of publication. Some of the significant changes made during the revision of the document are as follows,

- Reclassification of the fire brigade organization, recasting of fuel fabrication plants/spent fuel processing plants and revision of testing & surveillance frequency of the fire protection systems, based on the feedback from the operating plants.
- Updation of fire classification and portable fire extinguishers as per IS-2190-1992.
- Compliance of storage and usage of flammable liquids with the requirements of NFPA 30, the Factories Act, 1948, Petroleum Act, 1934 and Explosives Act, 1884.
- The fire protection of transformers as per the additional requirements of Indian Electricity Rules, 1956.
- Alternative suppression systems instead of the present 'halon suppression system' in use (as its use is being phased out).

4.3.6 Green Site Award

The Green Site Award for the year 2007 was given to winning units during the 25th DAE Safety and Occupational Health Professional Meet, which was held at Kalpakkam during December 18-20, 2008. The award is based on the highest value of Greenery of the site, which takes into account the existing greenery area, efforts made for making the site greener, terrain conditions of the site and effective site area. The DAE units are divided into two categories based on the total area of the plant including

housing colony site, namely, Category -A (<350 hectares) and Category-B (> 350 hectares). Based on these criteria, in Category-A, IREL- Manavalakurichi and in Category-B, Kalpakkam Site (MAPS, IGCAR, BHAVINI & Other Units) were the winners.

4.4 OCCUPATIONAL HEALTH

4.4.1 Advisory Committee on Occupational Health

The Advisory Committee on Occupational Health (ACOH) for employees of DAE Units reviews their occupational health records working in DAE, recommends measures to ensure their health, informs AERB of any observed case of occupational diseases and suggests ways to improve the occupational health activities. Four meetings of the committee were held during the year. The committee recommended the frequency of periodical medical examination for classified workers of all DAE units as once in a year and the conduct of audiometry examination for all workers exposed to noise level of above 85 dBA in the regular work areas. Committee reviewed and revised the yearly report formats on Occupational Health Services (C1) & Industrial Hygiene Surveillance (C2). Certifying Surgeons were appointed at HWP (Talcher), IREL-Manavalakurichi and IGCAR, Kalpakkam as per statute.

A workshop on "Trauma Management" was organized jointly by NFC, Hyderabad and ACOH, AERB at NFC, Hyderabad during September 26-27, 2008 for the benefit of Certifying Surgeons and Para Medical Staff working in the Occupational Health Centres/ First Aid Centres of various DAE units. Thirty-five para-medical staff, twenty-four certifying surgeons and ACOH members attended the workshop. Talks on Acute Trauma Management, Cardio Pulmonary Resuscitation (CPR) and practical demonstration on CPR were delivered by eminent speakers from recognized organizations like AMS, Hyderabad, Krishna Institute of Medical Sciences and St. John's Ambulance Association etc.



ADVISORY COMMITTEE ON OCCUPATIONAL HEALTH, AERB

Sitting: Dr. P. K. Sinha, Chief Medical Superintendent, Dr. Vanitha Steven, Certifying Surgeon, Tuticorin, Dr. P.T.V. Nair, Chairman, ACOH, Shri R. Bhattacharya, Head, IPSD, AERB

Standing: Dr. Bongirwar, Former Medical Officer Incharge, Trombay Disp., BARC, Shri K. Ram Prasad, SO/G, IPSD, AERB, Shri S.R.Bhave, Member Secretary, ACOH, Dr. J. Vijay Rao, Certifying Surgeon, NFC

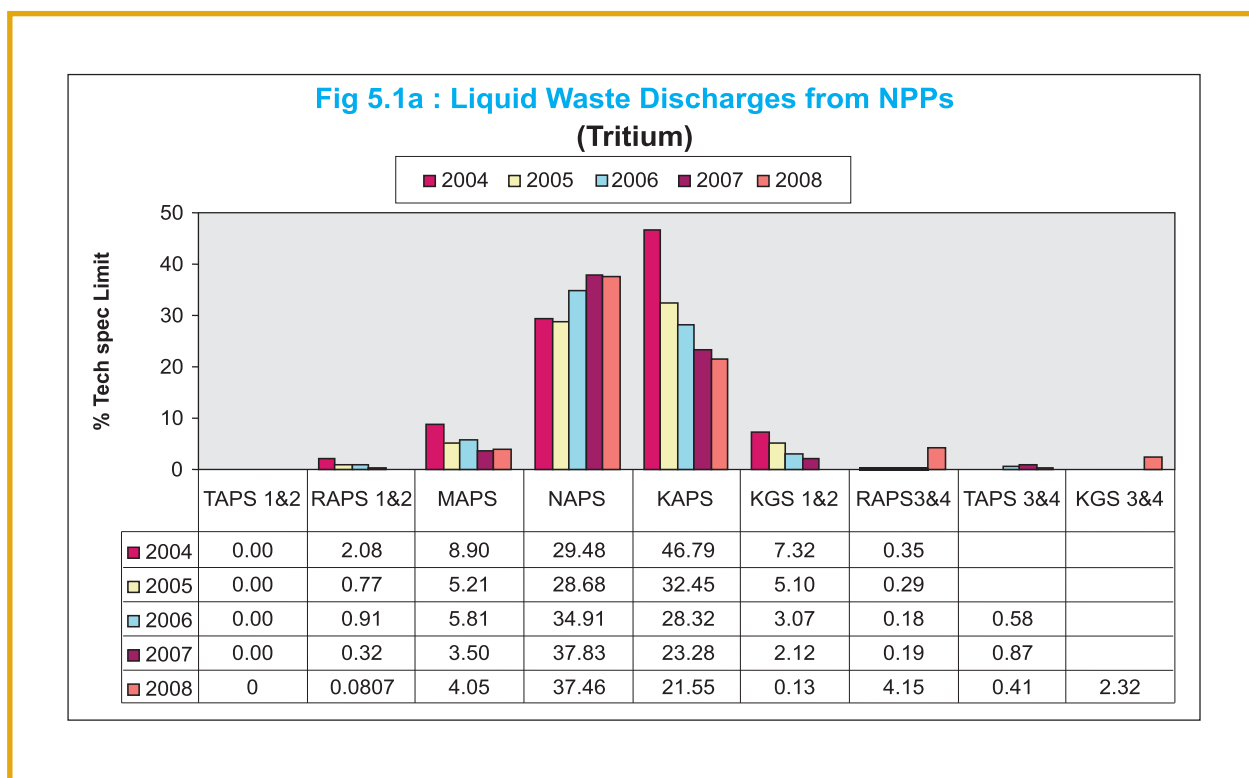
CHAPTER 5

ENVIRONMENTAL AND OCCUPATIONAL EXPOSURE SAFETY

5.1 ENVIRONMENTAL SAFETY

The Environmental Survey Laboratories (ESL) of the Health, Safety and Environment Group, BARC carry out environmental surveillance over an area of 30 km radius around the nuclear reactors at all the operating nuclear power plant sites. The liquid and gaseous waste discharged to the environment during the year 2008 from the operating Units was only a small fraction of the Technical Specification limits. Figs. 5.1a - 5.1e show the liquid and gaseous discharges from the plants for the years 2004, 2005,

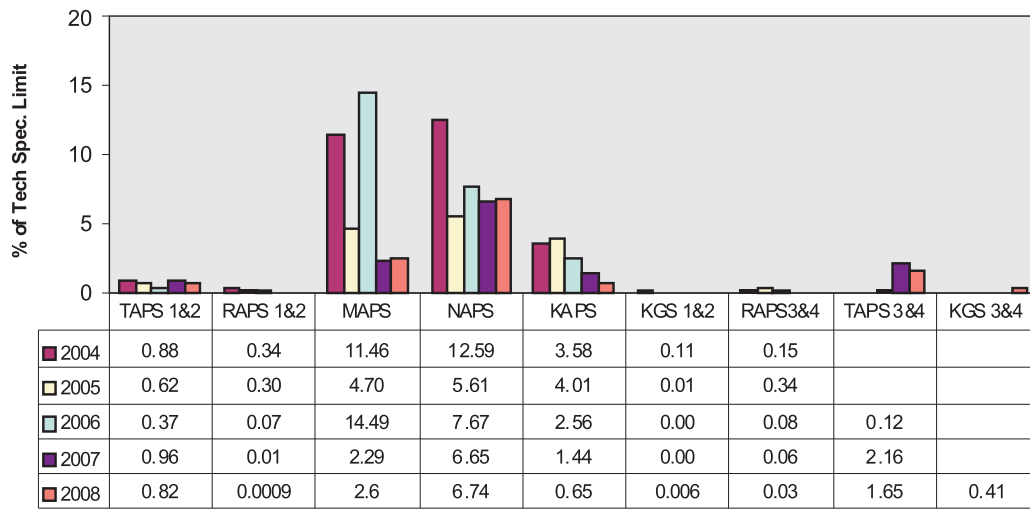
2006, 2007 and 2008 as percentage of permissible limits as per Technical Specifications. Figs. 5.2a and 5.2b show the committed effective dose to the members of the public due to the release of radioactive effluents from the plants. Radiation dose to members of the public near the operating plants is estimated based on measurements of radionuclide concentration in items of diet, i.e., vegetables, cereals, milk, meat, fish, etc., and through intake of air and water. It is seen that in all the sites the effective dose to public is far less than the annual limit of 1 mSv (1000 micro-Sievert) prescribed by AERB.



Note:

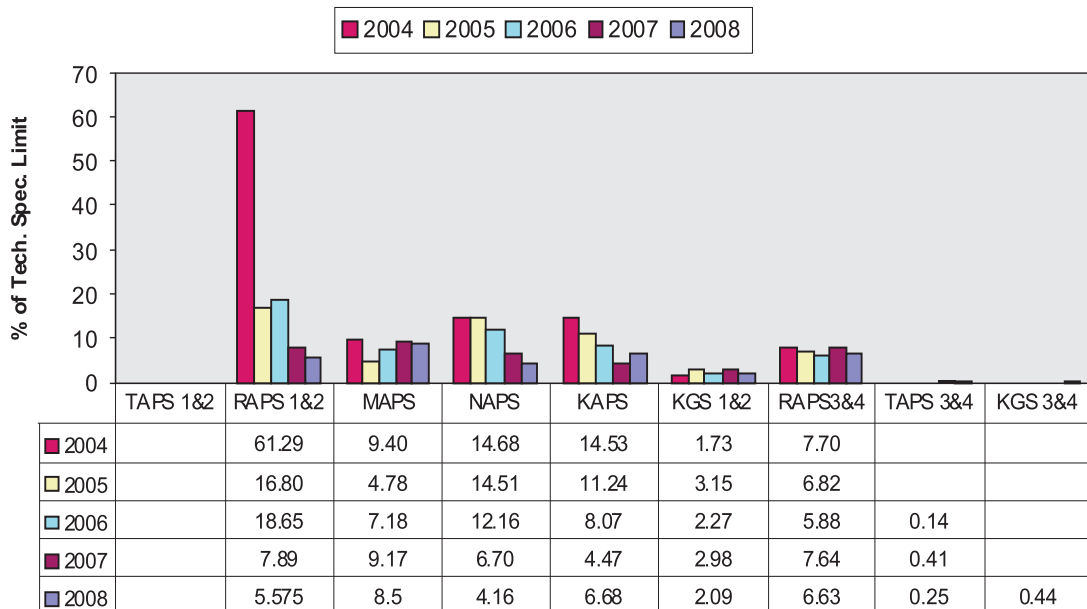
- 1) TAPS-1&2 are Boiling Water Reactors. Hence, there is no generation / discharge of Tritium.
- 2) The data of MAPS pertains to transfer of liquid waste to Centralised Waste Management Facility, Kalpakkam for processing & discharge to the environment.

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



Note: Percentage of Techs. Spec limit for KGS-3&4 is calculated for KGS-3 only.

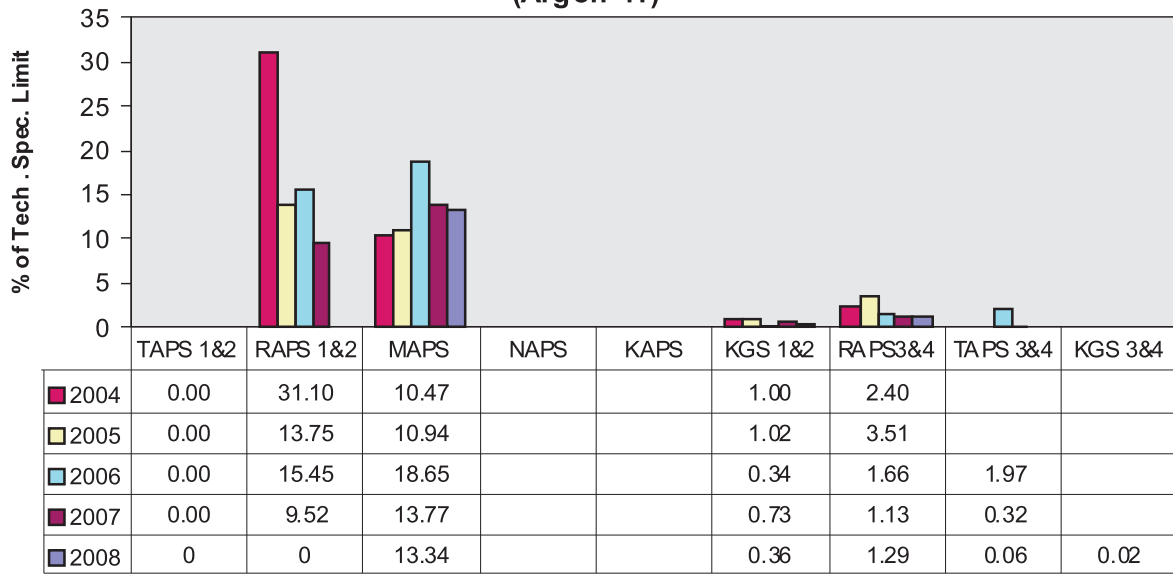
**Fig. 5.1c : Gaseous Waste Discharges From NPPs
(Tritium)**



Note:

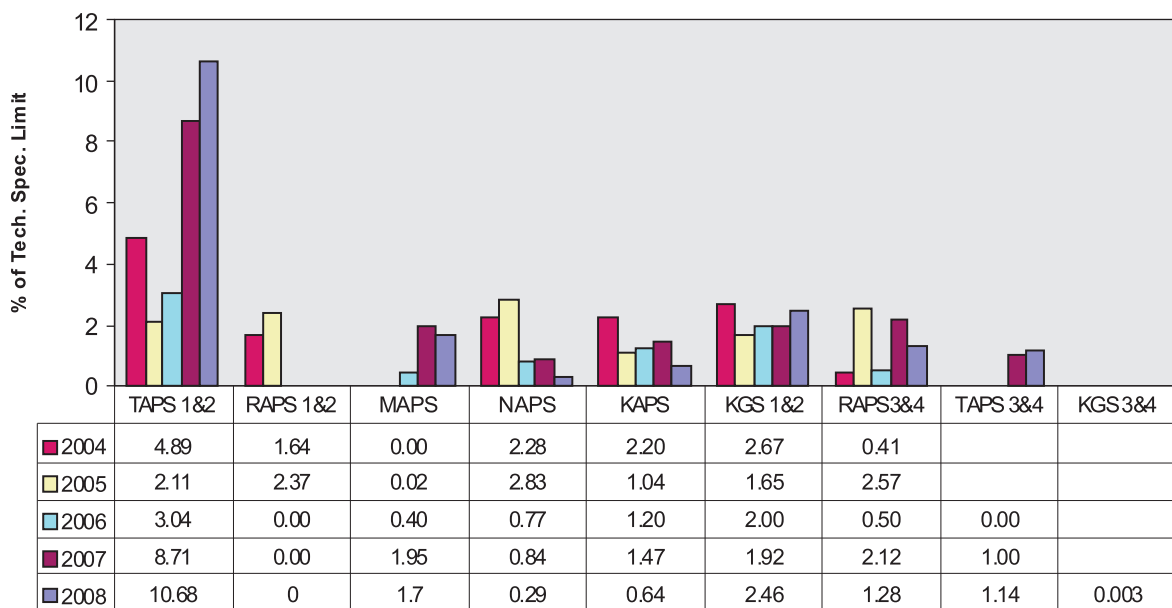
- 1) Tritium release from RAPS-1&2 was high in 2004 due to external heavy water leaks.
- 2) TAPS-1&2 are boiling water reactors. Hence there is no generation/dischARGE of Tritium.

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

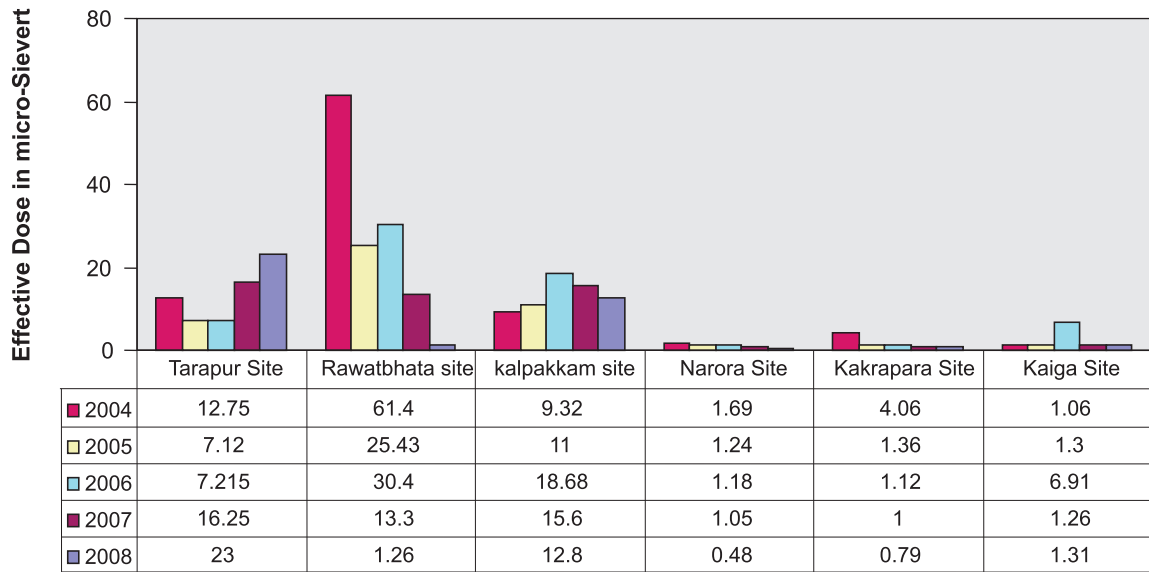


Note: Technical Specification limit for Ar-41 is included in the limit for FPNG at NAPS & KAPS. The separate limit for Ar -41 for NAPS was approved in October 2008 and is not considered in the above figures.

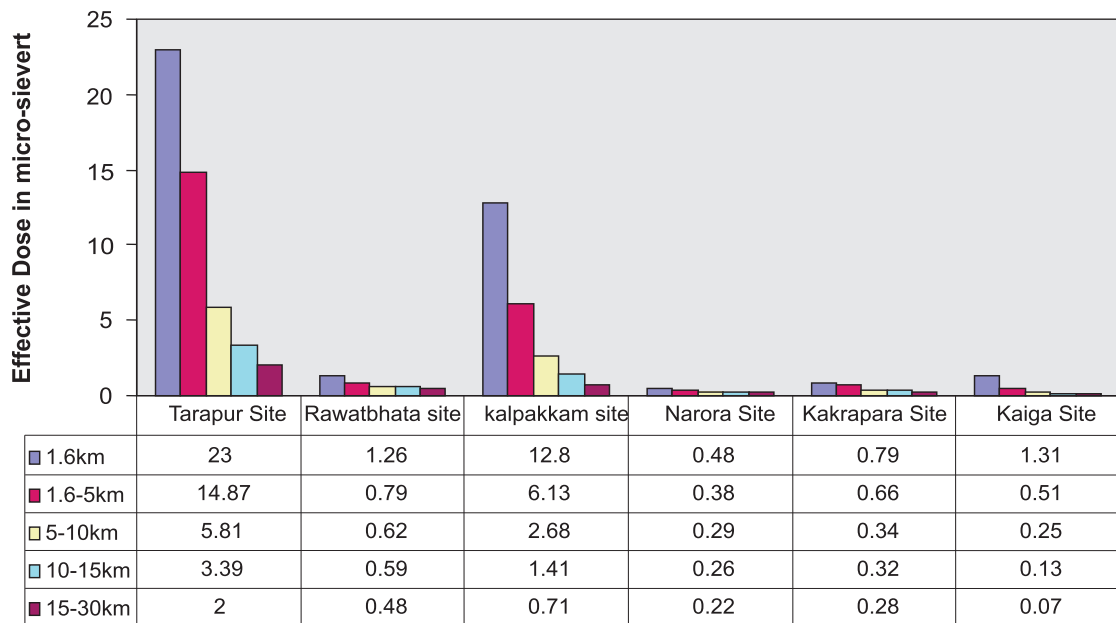
**Fig 5.1e Gaseous Waste Discharges from NPPs
(Fission Product Noble Gases)**



**Fig 5.2a: Effective dose to the Member of Public at 1.6 km Distance from NPPs
(AERB Prescribed Annual Limit is 1000 micro-Sievert)**



**Fig 5.2b : Effective Dose to the Member of Public at Different Distances from NPPs
(AERB Prescribed Annual Limit is 1000 micro-Sievert)**



5.2 OCCUPATIONAL EXPOSURES

No worker in Front End Fuel Cycle Facilities or NPPs or Medical, Industrial and Research Institutions received dose more than 30 mSv in 2008.

The information on number of workers who received dose between 20 and 30 mSv and above 30 mSv during the year 2008 in NPPs and in medical, industrial and research institutes is given in Tables 5.1 and 5.2 respectively.

The average individual effective dose to the workers of front end fuel cycle facilities namely, IREL, UCIL and NFC for the year 2008 was 3.34 mSv, 3.97 mSv and 0.962 mSv respectively.

Table 5.1: Radiation Doses Received by Workers in NPPs (2008)

NPP	Number of monitored persons	Average dose for monitored persons (mSv)	No. of exposed persons	Average dose for exposed persons (mSv)	Number of workers received dose in the range		
					<20 (mSv)	20-30 (mSv)	>30 (mSv)
TAPS-1&2	2371	3.66	2017	4.30	2017	0	0
RAPS-1&2	1872	2.61	1468	3.33	1468	0	0
MAPS-1&2	1177	1.66	1004	1.94	1004	0	0
NAPS-1&2	1997	2.83	1690	3.35	1690	0	0
KAPS-1&2	1490	1.85	1183	2.33	1183	0	0
RAPS-3&4	1686	1.05	1113	1.59	1113	0	0
KGS-1&2	1421	1.17	981	1.70	981	0	0
TAPS-3&4	1886	0.28	1126	0.48	1126	0	0
KGS-3&4	1455	0.13	438	0.44	438	0	0

Table 5.2: Radiation Doses Received by Workers in Medical, Industrial and Research Institutions (2008)

Type of Facility	Number of Monitored Persons	Average Dose for Monitored Persons (mSv)	No. of Exposed Persons	Average Dose for Exposed Persons (mSv)	Number of Workers Received Annual Individual Dose Excluding Zero Dose		
					<20 mSv	20-30 mSv	> 30 mSv
Diagnostic X-rays	24214	0.26	9700	0.66	9693	7	0
Radiation Therapy	5013	0.23	2085	0.57	2083	2	0
Nuclear Medicine	877	0.54	506	0.94	506	0	0
Industrial Radiography & Radiation Processing	4970	0.58	1741	1.65	1739	4	0
Research	2775	0.09	683	0.36	683	0	0

Table 5.3 gives collective dose for operation and maintenance of NPPs (excluding the dose for special campaigns like EMCCR, EMFR and upgradation activities) for last five years.

Table 5.3: Collective Dose (P-Sv) at NPPs

Year	2004	2005	2006	2007	2008
TAPS-1&2	5.38	5.45	5.15	4.35	4.92
RAPS-1&2	6.63	2.57	4.64	1.47	0.05
MAPS-1&2	2.83	1.46	3.71	1.62	1.95
NAPS-1&2	4.81	3.96	4.27	4.57	1.21
KAPS-1&2	2.34	3.27	2.53	1.12	0.68
KGS-1&2	2.48	2.05	1.76	1.83	1.66
RAPS-3&4	2.58	1.73	2.45	1.73	1.73
TAPS-3&4	-	-	0.38	0.79	0.53
KGS-3&4	-	-	-	-	0.19

CHAPTER 6

EMERGENCY PREPAREDNESS

Nuclear power plants 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. However in the event of a Beyond Design Basis Accident, it might become necessary to take certain mitigating measures in the public domain. Site-specific emergency preparedness plans are therefore drawn up at all stations for plant emergencies, site emergencies and off-site emergencies. To test these plans, periodic emergency exercises are carried out involving the station authorities, district administration, and the members

of public. Plant Emergency Exercises (PEE) are carried out once in a quarter by each NPP. Site Emergency Exercise (SEE) and Off-Site Emergency Exercise (OSEE) are carried out by each site once in a year and once in two years respectively. During the OSEE, AERB deputed its officers as observers.

The number of site and offsite emergency exercises carried out in 2008 is given in Table 6.1. The response of the plant personnel, officials and public involved in the exercise and general level of the awareness amongst the public were satisfactory.

Table 6.1: Site Emergency Exercises (SEE) and Off-site Emergency Exercises (OSEE)

NPP Sites	No. of SEE	No. of OSEE
Tarapur Site	1	-
Rawatbhata Site	1	-
Kalpakkam Site	1	-
NAPS Site	1	-
Kakrapar Site	1	1
Kaiga Site	1	-

The emergency preparedness exercises are also carried out in fuel cycle facilities. The SEE and OSEE were carried out at hydrogen sulphide based HWPs at Manuguru and Kota. SEEs, PEEs and fire drills were carried out at ammonia based HWPs at Baroda, Thal, Hazira and Tuticorin. SEE are carried out once in 6 months and fire

drills are carried out once in 2 months. OSEEs are carried out once in a year. AERB officials witnessed the SEE and OSEE and mock drills at 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

SAFETY DOCUMENTS

AERB develops safety documents, which include safety codes (SC), safety guides (SG), safety manuals (SM) and technical documents (TD) for nuclear and radiation facilities and related activities. The progress on various safety documents during the year is given below.

7.1 NEW SAFETY DOCUMENTS PUBLISHED

1. Safety guide on 'Extreme Values of Meteorological Parameters'(AERB/NF/SG/S-3)

This AERB safety guide provides guidance for estimating extreme values of meteorological parameters and outlines the methodology and procedures for carrying out analysis for the purpose for use in siting and engineering of nuclear facilities.

2. Safety code on 'Nuclear Power Plant Operation' [(AERB/NPP/SC/O (Rev. 1)]

This AERB Safety Code lays down the minimum requirements for safe operation of Nuclear Power Plants to ensure protection of the public, environment and the site personnel from any undue radiological consequences, prevention of any accident conditions and mitigation of the consequences of any accidents in the unlikely event of their occurrence. This code is revision of 1989 edition of Code of Practice on Safety in Nuclear Power Plant Operation (AERB/SC/O). This revision is issued to reflect developments that have taken place since then, specifically, new requirements arising from operational safety experience feedback, renewal of authorisations, plant life management and probabilistic safety assessments. New sections on nuclear security and, plant life management have also been added.

3. Safety code on 'Quality Assurance for Safety in Nuclear Power Plants' [AERB/NPP/SC/QA (Rev.1)].

This Safety Code provides basic requirements for establishing and implementing quality assurance programme for assuring safety. These basic requirements apply to the QA programme of the responsible organisation as well as any other organisation in each stage during the life of the nuclear power plant such as siting, design, construction, commissioning, operation and decommissioning. This code is a revision of the 1988 edition of Code of Practice on Quality Assurance for Safety in Nuclear Power Plant (AERB Code No. SC/QA). This revision is issued to reflect developments that have taken place since then. A new section titled 'Process Implementation' is added in the revised code to specify requirements for managing many processes in various stages of the plant. The explicit coverage on

documentation and records in the existing code has been deleted and merged as part of the requirements of generic processes, thus shifting the emphasis from 'documentation' to 'performance'. Several new clauses on resource management, configuration management, infrastructure and work environment, safety culture, management commitment, communication, managing organizational change and improvement of QA programme have been added.

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.

7.3 SAFETY DOCUMENTS TRANSLATED AND PUBLISHED IN HINDI

1. Safety guide on 'नाभिकीय परमाणु ऊर्जा संयंत्र प्रचालन के दौरान विकिरण संरक्षण (एईआरबी/एसजी/ओ-5; 1998)' [Radiation Protection During Operation of Nuclear Power Plants (AERB/SG/O-5; 1998)]
2. Technical Manual on 'आवासीय क्षेत्रों में रेडोन थोरॉन व उनके क्षयज उत्पादों की मापन विधियां (एईआरबी/टीएम/आरएम-1; 1992)' [Methods for The Measurement of Radon Thoron and their Progeny in Dwellings (AERB/TM/RM-1; 1992)]
3. Safety manual on 'चिकित्सीय निदानकारी एक्स-रे संस्थापनों के लिए निर्दिष्ट कार्ययोजना एटलस (एईआरबी/एसएम/एमईडी-1; 1988)' [Atlas of Reference Plans for Medical Diagnostic X-Ray Installations (AERB/SM/MED-1; 1988)].

7.4 SAFETY DOCUMENTS UNDER DEVELOPMENT

1. Safety guide on 'Seismic Qualification of Structures, Systems and Components of Pressurised Heavy Water Reactor' (AERB/NPP-PHWR/SG/D-23).
2. Safety guide on 'Computer Based Systems of Pressurized Heavy Water Reactors' (AERB/SG/D-25).
3. Safety guide on 'Commissioning of Pressurised Water Reactors' (AERB/NPP-PWR/SG/O-16).
4. Safety guide on 'Classification of Radioactive Waste' (AERB/NRF/SG/RW-1).
5. Safety guide on 'Predisposal Management of High Level Radioactive Waste' (AERB/SG/RW-3).
6. Safety guide on 'Decommissioning of Nuclear Fuel Cycle Facilities other than Reactors' (AERB/SG/RW-7).
7. Safety guide on 'Decommissioning of Nuclear Power

- Plants and Research Reactors' (AERB/SG/RW-8).
8. Safety guide on 'Design of Nuclear Power Plant Concrete Containment Structures' (AERB/NPP/SS/CSE-3).
 9. Safety guide on 'Consenting Process for Radiation Facilities (AERB/RF/SG/G-3).
 10. Safety guide on 'Uranium Fuel Fabrication Facilities' (AERB/FE-FCF/SG-3).
 11. Safety guide on 'Renewal of Licence for Operation of Nuclear Fuel Cycle Facilities other than Nuclear Power Plants & Research Reactors' (AERB/FE&BE-FCF/SG-7).
 12. Safety code on 'Nuclear Medicine Facilities' (AERB/RF-MED/SC-6/Rev.2).
 13. Safety code on 'Radiation Therapy Sources, Equipment and Installations' (AERB/RF-MED/SC-9).

CHAPTER 8

SAFETY STUDIES

8.1 SAFETY ANALYSIS

8.1.1 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 continued. The details of the exercise and progress in this area are given below.

(i) Simulation of Experiments Conducted at PANDA Facility

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. Prediction of system pressures and various mass flow rates are found to be in good agreement with the measured data. Calculations are rather poor on the phenomena of steam-air mixing and stratification in wetwell and drywell compartment of the test facility. The standard problem exercise has been completed and a combined USNRC-AERB executive summary and report on the analysis results has been prepared and released.

(ii) Uncertainty and Sensitivity Analysis of TMI-2

The TMI-2 accident occurred on March 28, 1979 and resulted in severe core and structural damage. The work on the analysis of the accident was continued. To check the sensitivity of results on the uncertainties in boundary conditions such as makeup flow, flow during the main coolant pump transient, models used in the computer code, nodalisation schemes adopted etc., uncertainty and

sensitivity analysis was carried out.

The uncertainty analysis methodology consists of selection and characterization of uncertain input parameters, generation of samples and the propagation of sampled inputs through an analysis. In this analysis 10 key input parameters were selected based on engineering judgment, code defaults and literature. The probability density function is assigned to each input parameter to represent uncertainties. These uncertainties are propagated through simulation approach using Latin Hypercube Sampling technique to generate a sample (sample size of 50 was used) and corresponding code calculations were performed. Also a separate code calculation was performed for the median inputs. Mean, median, 5th and 95th percentile values were estimated for key figure of merits. The standardized rank regression co-efficients and partial rank correlation co-efficients were estimated to see the sensitivity of the various parameters to the selected figures of merits. The coefficient of determination (R^2) was estimated to see the goodness of fit.

The sensitivity analysis results are described in the form of standardized rank regression coefficients (SRRCs) and partial rank correlation coefficients (PRCCs) in this study.

The key figure of merits selected in this study are primary pressure before and after re-flood, rate of pressurization from 144 to 153 minutes, final hydrogen, intact fuel fraction just before re-flood and RPV water level just before re-flood. The input parameters make-up flow rate during 100 to 200 minutes and PORV discharge coefficient (0.95 to 1.0) are found to be most important for the selected figure of merits.

8.1.2 International Collaborative Standard Problem on Comparison of HWR Thermal Hydraulics Code Predictions with Small Break Loss of Coolant Accident (SBLOCA) Experimental Data

The objective of the ICSP is to improve understanding of important phenomena expected to occur in SBLOCA transients, evaluate code capabilities in predicting these important phenomena, their practicality and efficiency by simulating an integrated experiment and suggest necessary code improvements or new experiments to reduce uncertainties.

The RD-14M experimental facility is modeled with thermal hydraulics code RELAP5. Modeling of primary and secondary circuit is completed. The inlet header, inlet feeder,

inlet end fitting, heated section, outlet end fitting, outlet feeder, outlet header, above header components, pumps, steam generator, jet condenser, secondary side heat exchangers and other components have been modeled. The input deck is said to be qualified for a particular transient when it is qualified for both 'steady state level' as well as 'transient level'. A note containing criteria of 'steady state level' qualification was distributed to the member countries participating in the ICSP. The steady state level qualification report for test B9006 was presented in the second meeting held during August, 2008 at Canada. The steady state level qualification for test B9802 and transient level qualification for test B9006 and B9802 is under progress and will be completed before the third meeting to be held in June 2009.

8.1.3 IAEA Coordinated Research Project on 'Uncertainty Evaluation in Best Estimate Accident Analysis'

Qualified transient analyses are done for (a) station black out in PSB VVER integral thermal hydraulic test facility at EREC, Russia (b) hot leg break LOCA (SB-HL-02) at LSTF/ROSA IV, Japan. For the qualified transient analysis, nodalisation is achieved with proper qualification process which includes 'steady state level' qualification and 'On transient level' qualification. For steady state level qualification the following parameters from the nodalisation are compared with test specifications and errors are generated: (a) geometrical parameters (b) boundary conditions (c) initial conditions obtained from system code output. These errors should be within acceptable limits. 'On transient level' qualification is to demonstrate the capability of the nodalisation and the code used for the analysis is to predict the relevant thermal-hydraulic phenomena expected in the transient. The following steps are performed for qualitative evaluation for on transient level qualification: (a) Comparison of resulting time sequence of significant events (b) Identification/verification of phenomena validation matrix developed by Committee on Safety of Nuclear Installations (CSNI). (c) Phenomenological Windows (d) Key Phenomena and Relevant Thermal-hydraulic Aspects (RTA) and (e) Visual comparison with experimental data. All the above steps are demonstrated for both the above mentioned tests and qualified transient analysis is carried out. This exercise is done as a part of IAEA Coordinated Research Project on 'Uncertainty evaluation in best estimate accident analysis' in which AERB is a participant. Post test analysis with uncertainty evaluation is being carried out with an objective to extend conclusions of uncertainty analysis to NPP applications.

8.1.4 IAEA Extra Budgetary Program on Protection of Nuclear Power Plants against Tsunamis and Post Earthquake Considerations in the External Zone

To enable member states to develop understanding about tsunami hazard assessment, International Atomic Energy Agency (IAEA), has initiated an extra budgetary project, EBP termed "Protection of nuclear power plants against tsunamis and post earthquake considerations in the external zone" (TiPEEZ). The objective of the proposed EBP is to share among member states available tools and knowledge in relation to emergency preparedness information management assistance required in case of nuclear disaster caused by earthquake or tsunami, and Tsunami hazard assessment as part of safety evaluation of the nuclear installation against external floods.

For achieving these goals, the EBP has been divided into two main activities. The first activity, Activity-1 is the disaster management system. This will be implemented in the participating member states based on the software (TiPEEZ) developed by JNES/NIED. Activity-2 is dissemination of methodologies for estimating tsunami hazard assessment, including the computer software as developed by a Japanese organization to the member states where there exists a potential for triggering of a tsunami. Training and benchmarking exercise of the supplied analysis program will also be carried out along with the benchmark tests of the selected problems. Atomic Energy Regulatory Board (AERB), India is participating in the second activity, i.e., tsunami hazard assessment.

As part of this work, AERB has installed the software provided by IAEA for tsunami hazard analysis. The benchmarking and validation of the software is in progress. A pre and post processing software has been developed in-house for data preparation and visualization of the output from tsunami hazard analysis.

8.1.5 IAEA Extra Budgetary Program on Seismic Safety of Existing NPPs

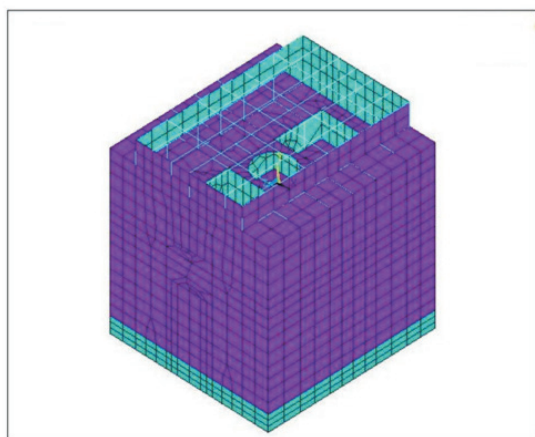
In July, 2007, a strong earthquake (moment magnitude of 6.6), the Nigataken-chuetsu-oki earthquake affected the TEPCO Kashiwazaki-Kariwa nuclear power station, the biggest nuclear power plant in the world, located at about 16km of its epicentre. There were no major damages in the safety related structures due to the earthquake. However, some minor damages were reported for the non-safety related components.

IAEA has floated an extra budgetary program on seismic safety of existing NPPs. The EBP mainly focus on the experience gained from this earthquake. The large amount of observations and data collected on site and the significant instrumentation which measured acceleration at different locations in soil and in structures will be used to understand what happened to soil and structures during the July 2007 earthquake. EBP also focuses on quantifying available margins, understanding the behaviour of structures, soil and equipment during earthquake and Identification of

main parameters influencing the response.

The EBP is divided into five working areas; WA1 - Reassessment of seismic hazard, WA2 - Re-evaluation of safety of existing NPPs, WA3 - Post earthquake plant operational response, WA4 - Databases on earthquake experience and WA5 - Lessons learnt from Kashiwazaki-Kariwa earthquake. AERB is participating in working areas WA2, WA3 and WA4.

One of the WA2 activities is benchmarking of the reactor building, unit 7. The benchmarking exercise calls for seismic response analysis of buildings, structures, systems and components in linear and non-linear domain. AERB has started modelling of Reactor Building. Finite element model of reactor building of Kashiwazaki-Kariwa nuclear power station is shown in figure.



Finite Element model of Reactor Building of Kashiwazaki-Kariwa nuclear power station

8.1.6 Transient Critical Heat Flux Measurement

Critical heat flux (CHF) is a parameter of paramount importance, which limits the heat transfer capability of nuclear reactors, heat exchangers, fossil-fueled boilers and many other heat transfer units. CHF has been extensively investigated during the last few decades, resulting in reasonable understanding of the phenomenon and several reliable prediction models. Exhaustive work has been reported on the CHF under steady state nuclear reactor operating conditions. However, transient CHF is of great importance for the analysis of the thermo-hydrodynamic characteristics of petrochemical and nuclear power plants. A project under Committee for Safety Research Project (CSRP) of AERB is awarded to IIT Bombay to carry out experimental study on CHF under transient conditions of power and mass flux. The main objectives of the project are: measurement of local heat transfer distribution with water under two phase conditions, measurement of transient CHF under low flow and low pressure conditions and development of correlations for CHF. An experimental setup is successfully commissioned and single-phase local heat transfer measurement has been carried out to benchmark

the wall temperature measurement technique using infrared thermal camera. Experiments for sub-cooled boiling are in progress.

8.1.7 Seismic Re-evaluation of FBTR

Seismic re-evaluation of Fast Breeder test Reactor (FBTR) at Kalpakkam was warranted as it was built adopting seismic standards prevailing during the period of its design/construction. This exercise is being carried out jointly by AERB and IGCAR. The exercise is undertaken in a manner consistent with current seismic re-evaluation criteria and internationally accepted practices. The re-evaluation programme covered the assessment of the seismic hazard by probabilistic approach, safety analysis of the NPP resulting in identification of the selected structures, systems and components (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.

Probabilistic seismic hazard analysis PSHA for determination of seismic hazard was adopted for the first time in seismic re-evaluation for an Indian facility. The activity was peer reviewed in detail and the documented work is expected to serve as a benchmark for future PSHA studies. PSHA requires earthquake sources in the region to be modelled as line, area or volume sources and hazard from each assessed appropriately. A typical aerial source model used in PSHA kalpakkam site is given in Fig 8.1, and the uniform hazard spectra generated is depicted in Fig 8.2. The safety analysis of the plant adopting an event tree approach considering various seismic initiated accident sequences brought out the various SSCs necessary for dealing with a seismic event. The capacity of these SSCs, systems and components were evaluated by either analysis, testing or experience based method. Civil engineering structures and mechanical systems were evaluated by analytical method. This activity involved detailed finite element modeling (Fig. 8.3), dynamic analysis and design check. Certain active electrical and instrumentation components were evaluated by seismic testing in a shake table. Other electrical and instrumentation components were evaluated by experience based method which involved a detailed plant walkdown.

Seismic re-evaluation of a plant can be considered complete only when the plant level seismic capacity has been evaluated. This can be carried out either by deterministic approach, which is termed as the seismic margin assessment (SMA) or by probabilistic approach termed as the seismic probabilistic safety assessment (SPSA). The event trees and fault trees developed in safety analysis were solved, by providing seismic capacities evaluated at component level as input. The result of SMA was the plant seismic capacity expressed in terms of peak ground acceleration. SPSA brings out the seismic core damage frequency of the plant.

8.1.8 Pretest Analysis for National Round Robin on Pushover Analysis

BARC had conceived a national round robin exercise, wherein a four storeyed RCC framed structure (Scale 1:1) was tested under incremental lateral loads until the failure of the structure. AERB participated in this round robin

and carried out the pre-test analysis of the structure. The physical structure of the four storied single bay RCC framed structure was transformed into a mathematical model for structural analysis using finite element method using ANSYS software. Moment curvature relations derived using a

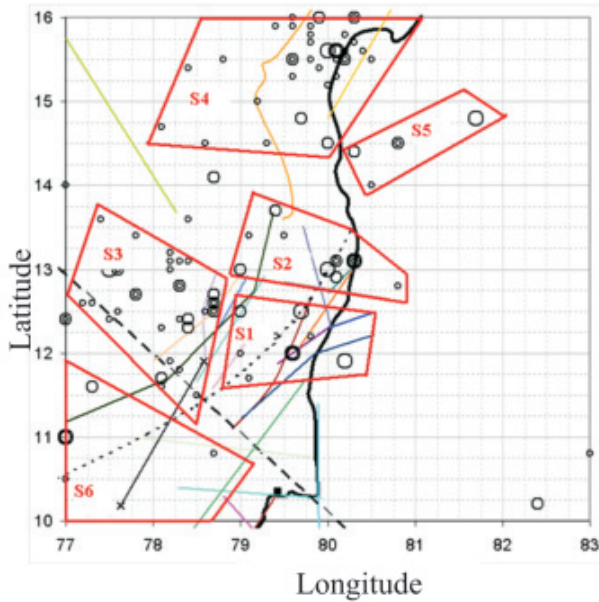


Fig. 8.1: One of the Source Models at PSHA of FBTR Site

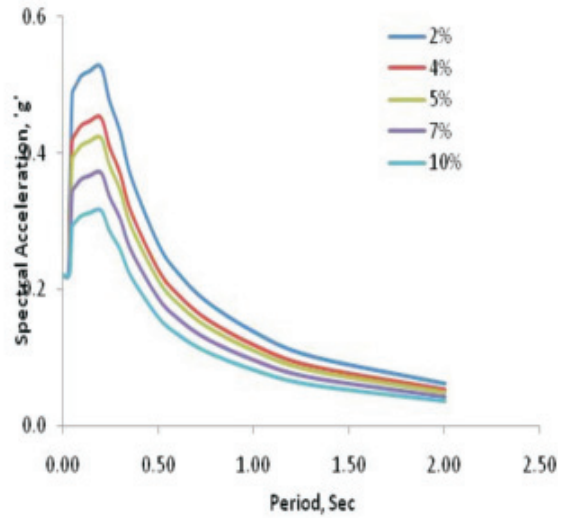


Fig. 8.2: Uniform Hazard Spectra of FBTR Site for various Values of Damping

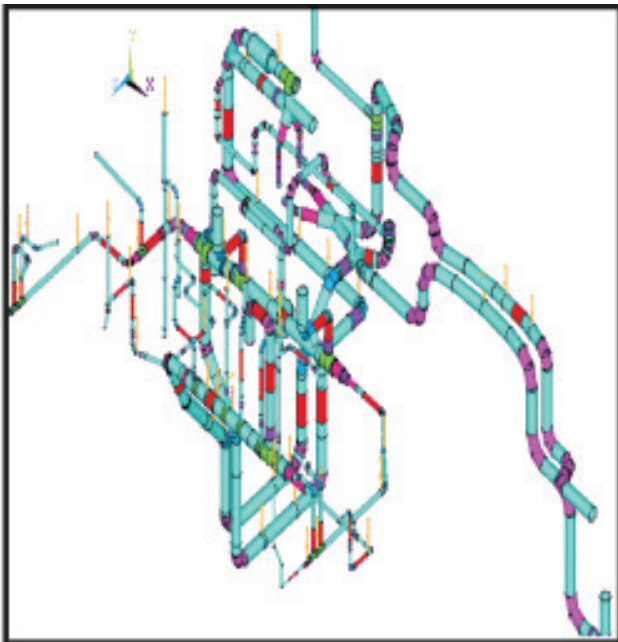


Fig. 8.3: Finite Element Model of a Mechanical System of FBTR



Fig. 8.4: Finite Element Model of BARCOM

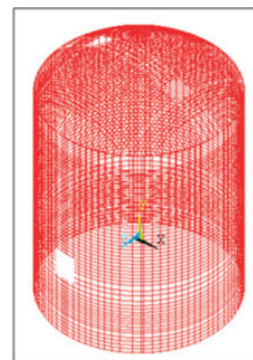


Fig. 8.5: Meshed Cable Elements of BARCOM

computer program developed in-house was used as input to the finite element model to carry out the pushover analysis of the structure. The results of pretest analysis were presented during the pretest analysis meeting held at Central Power Research Institute (CPRI) at Bangalore. The results of AERB compared well with the results obtained by other participating agencies. The AERB team also witnessed the testing of the actual model by incremental lateral loads till failure.

8.1.9 Round Robin Analysis of BARC Containment Model

AERB participated in round robin analysis on BARC Containment Model (BARCOM) test conducted by BARC. BARCOM test involves testing of a 1:4 scaled representation of a Pressurized Heavy Water Reactor (PHWR) pre-stressed concrete inner containment. The pre-test analysis stage of the round robin on BARCOM was completed. AERB carried out the pretest analysis using ANSYS. The 1:4 scaled containment model was transformed into a 3-D finite element model capable of predicting non-linear behaviors such as pre-stress cable yielding, concrete cracking and rebar yielding. Analysis was carried out for internal pressure up to the failure of containment structure. The predicted failure location was near main air lock opening area. A methodology for predicting leakage with respect to internal pressure was also developed. The findings were presented in the pretest analysis meeting held at BARC, Mumbai. Finite element model and meshed cable element of BARCOM are depicted in Figs. 8.4 and 8.5 respectively.

8.1.10 Reliability Assessment of Pre-stressed Concrete Containment Structure

Reliability assessment of prestressed concrete containment structure was carried out to evaluate the impact of prestressing losses on safety of containment structure. The formulation covered the assessment of reliability against the hoop tension failure mode considering the short and long-term loss of prestressing force. The work includes comparative studies of prestressing loss predicted by Eurocode, AERB/SS/CSE-1, ACI, RCCG, and USNRC practice. Outcome of the reliability assessment was used for finalization of AERB safety standard on 'Design of Concrete Containment Structures'.

8.1.11 Comparison of PSA Studies for PHWRs

In continuation of the agenda item on PSA assigned to India by the CANDU Senior Regulators Group (CSRG), the review of the responses received from CSRG countries like Argentina, Canada, China, India, Korea, Pakistan and Romania was taken up for comparison. The details of the comparison and progress so far are given below.

The responses were reviewed and an evaluation report was prepared. The 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. Few topics were identified for further discussion namely: regulatory use of PSA, scope of PSA,

regulatory reviews of PSA, definition of core damage, system success criteria, plant-specific data collection and some PSA modeling issues. 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 guidelines for the updated responses on PSA were prepared and sent to all CSRG members in January 2008. The evaluation of the additional response from the member countries is in progress

8.1.12 Review of PSA of NPPs

The review reports for Level-1 PSA for KGS-1&2 and RAPS-3&4 and Level-2 (internal events) PSA for KAPS-1&2 submitted by NPCIL were issued. Recommendations were made to improve PSA methodology. These include: harmonization of selection and grouping of initiating events for standard PHWRs, estimation of Indian PHWR-specific LOCA frequencies, collection of Indian PHWR-specific component data, re-examination of 'consequence categorization' using the plant-specific thermal-hydraulic analyses, use of detailed Human Reliability Analysis (HRA) event trees for estimation of pre-initiator human error probabilities and use of second generation HRA methods for dominant post-initiator human actions modeled in PSA and internal peer review of PSA reports before submission to AERB.

8.1.13 Reliability Analysis of NAPS Reactor Protection System

The document on 'Reliability Analysis of NAPS Reactor Protection System' was reviewed which had the proposal for segregation of ion chambers for Primary Shutdown System (PSS) and Secondary Shutdown System (SSS) such that the RRS ion chambers are used for functioning of SSS also. The fault trees for the PSS and SSS were reviewed. Some of the salient points that were brought out were human factor in calibration errors, error in calculation of unavailability values of basic events and error in calculation of CCF need to be considered in the analysis.

8.1.14 Review of Reliability Analysis of ECCS and CIS for KAPS -3&4 (700 MWe)

The review of the reliability analyses for emergency core cooling system (ECCS) and containment isolation system (CIS) for KAPS#3&4 was taken up. During the review, a technical note on CCF probability estimation using the generic a-factors given in NUREG/CR-5801 was prepared. The examples included in the note indicate that a-factors estimated for components with different testing schemes must be different. The note concludes that if plant-specific CCF data are available, detailed CCF analysis should be carried out for dominant contributors. When plant-specific CCF data is not available, generic a-factors values should be used for CCF analysis.

8.2 RESEARCH AND DEVELOPMENT

8.2.1 Development of Space Time Kinetics Code

TRIKIN Code Without Feedback:

Induction of large loosely coupled LWRs in Indian nuclear program had necessitated the need of development of space-time kinetics code to analyze a wide spectrum of transients. Consistent with this objective, a joint activity was initiated by AERB with IIT Bombay and BARC to develop a space-time kinetics code. For this purpose, NEUT code of IIT Bombay, which was previously developed for heavy water reactors under AERB sponsored project, has been modified for VVER reactor geometry and configurations by adding BARC core physics code, TRIHEX-FA as shape solver. Space-time kinetics approach is based on flux factorization method employed by Improved Quasistatic (IQS) approach whereas shape solutions is based on simple centre mesh finite differencing scheme with uniform fine triangular meshes. Space-time kinetics code, named as TRIKIN has been validated against an international AER (Atomic Energy Research) benchmark problem, AERDYN001. The problem is asymmetric control rod ejection transient without any feedback. The worth of the ejected rod is just below the prompt critical value. The initial power is near to zero and power rise is not too large to affect core thermal state. Therefore transient can be treated without feedback. The transient is terminated by reactor SCRAM. Results obtained using TRIKIN model on the benchmark problem are in good agreement with other international code systems.

TRIKIN Code With Feedback:

The capability of model is extended beyond kinetics by incorporating a lumped heat transfer multichannel model to represent the core thermal hydraulics. This thermal hydraulics model is mainly developed for incorporating reactivity feedback effects in TRIKIN code. This feedback capability has added extra dimension to the accuracy of the code for the transients at higher power operations. Thermal hydraulic model is based on simultaneous solutions of fuel-clad heat conduction equations with coolant dynamics equations iteratively. Model is also capable of predicting safety parameters like fuel/clad temperatures, MDNBR (Minimum Departure from Nucleate Boiling Ratio) with reasonable accuracy. Coupled space-time kinetics and thermal hydraulics model has been validated against AER (Atomic Energy Research) benchmark problem, AERDYN002. This benchmark is to assess the Doppler feedback (which is prominent feedback in PWRs) capability of the code system under rapid transients. The problem is asymmetric control rod ejection transient with simple adiabatic Doppler feedback. The initially critical reactor experiences a power excursion without any reactor SCRAM. The power of the reactor is limited by the continuous accumulation of heat in the fuel. Results obtained using TRIKIN with feedback model are in good agreement with other international code systems.

Validation:

In addition to the validation of the computer code in stages against the benchmark problems like AERDYN001 without feedback and AERDYN002 with feedback, the validation work is continuing further against benchmark problem AERDYN003, which includes rod ejection accident scenario with complete fuel and coolant feedback. This verified dynamics code system can be used to analyse a variety of transients in large reactor systems.

8.2.2 Comparative Kinetics Study of Nuclear Reactors

Reactivity initiated transients have been analyzed to investigate major differences in the kinetics behavior of various reactor systems under different operating conditions. Three systems, light water reactors (PWRs), heavy water reactors (PHWRs) and fast breeder reactor (FBRs) are considered for the sake of analysis. Parameters governing the kinetics behavior of core are studied under different core states. A point kinetics code 'PKOK' is developed for this purpose. The code is capable of carrying out kinetics calculation without and with reactivity feedbacks. It uses generalized Runge-Kutta method to solve systems of kinetics equations. A methodology is also developed to fix the safety limits on reactivity insertion rates in power reactors and the upper safe limits for reactivity insertion rate in different reactor systems have been determined. Typical criteria considered for fixing the limits are: Consideration of startup accident, Operational consideration like start-up time and reactor period while raising the power of the reactor. Other conditions considered are: Reactor should not attain prompt criticality, while raising power, period should not fall below a threshold within a few seconds so that unnecessary trip can be prevented, rate of power rise should be slow enough, so that reactor SCRAM is ensured before any of the design safety limit is crossed (criteria on power rise/overshoots). A few guidelines are also derived to project the possible kinetics trends in next generation reactors.

8.2.3 Stability of Nuclear Reactors

Basic directive principle followed in the design of any system is to make it intrinsically safe and the system should remain stable under the disturbances. Nuclear reactors are also designed with this philosophy. One of the necessary but not sufficient condition for the reactors is that the power coefficient of reactivity of the reactor should be negative. In PHWRs, power coefficient decreases with burn up due to generation of plutonium. Therefore, one of the objective of stability analysis is to estimate the limiting value (negative) of power coefficient at which the reactor is stable. One of the methodology to study this is by analyzing the response of nuclear reactors to sinusoidal reactivity input.

The computer code, PKOK has been suitably modified to study the above. The response of the reactor has been studied without considering any reactivity feedback.

The computer code, PKOK has been suitably modified to study the above. The response of the reactor has been studied without considering any reactivity feedback. As expected, the system is found to be unstable essentially due to delayed neutron effects, as the response of reactors

is not similar for negative and positive reactivity input. The response of the system with reactivity feedback is stable as can be seen from Fig. 8.6. The work on determination of the limiting value of power coefficient is in progress.

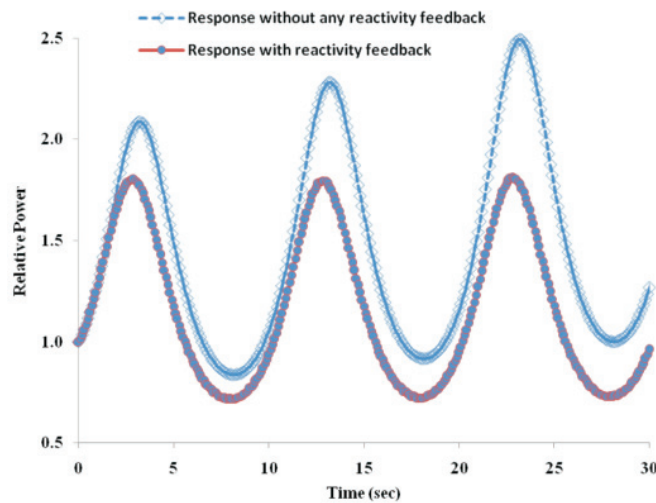


Fig. 8.6: Kinetics Response of Reactor under Sinusoidal Reactivity Input

8.2.4 Neutronic Coupling Analysis

Neutronic decoupling or loose coupling is a typical phenomenon in large nuclear reactors which leads to dynamic spatial instabilities like xenon induced oscillations. An optimum core geometry design is essential to address spatial instability by appropriate control system. The spatial neutronic coupling aspects of power reactors are therefore investigated using Eigenvalue Separation (EVS) methodology. Higher harmonics eigenvalues are calculated by the method of mode subtraction. EVS for a typical 1000 MWe PWR is calculated. Parametric studies of EVS as a function of core size and shape is carried out. It is demonstrated quantitatively that Height to Diameter (H/D) ratio should be optimized to

suppress either an axial or azimuthal mode to enable ease in designing spatial flux control algorithm. It is also shown that core with very large H/D ratio, results in reduction in the contribution of azimuthal or radial harmonics. This feature makes the core more susceptible to the first harmonic mode led instability. Hence the core should be optimized with appropriate H/D ratio. An H/D ratio between 1.1 to 1.3 is recommended for PWRs based on the analysis performed. A similar study has been carried out for Indian PHWRs and it has been discovered that for large PHWR, an H/D ratio of less than 0.8 is adequate to suppress the possible axial modes of oscillations. By this analysis of the design, the control system of the reactor can be simplified to a great degree.

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
- Reliability and Probabilistic Safety Analysis
- Reactor Physics and Radiological Safety Studies
- Fire and Thermal Hydraulic Studies
- Environmental Safety Studies

9.1 NUCLEAR SAFETY STUDIES

9.1.1 Reliability and Probabilistic Safety Analysis

(i) Seismic Re-evaluation of Fast Breeder Test Reactor (FBTR)

(a) Fragility Analysis

The fragility analysis was carried out by finalizing the fault trees and event trees based on the plant walk-down observations and AERB review committee recommendations. A procedure was developed to assess the capacity of each component in terms of a single parameter called High Confidence of Low Probability of Failure (HCLPF) capacity. The HCLPF capacity is represented in term of acceleration due to gravity (g).

After the review and finalization of system fault trees and event trees and identification of the accident sequences for all the initiating events, system HCLPF was computed by using the component HCLPF capacity. By deterministic analysis, the seismic margin of FBTR was obtained with the dominant contributors identified, viz., Loss of Regulation (LOR) due to pump seizure due to sodium leak.

By probabilistic approach, seismic core damage frequency was estimated by using the component fragility. In view of the large number of components in Structures, Systems and Component list, grouping of components based on location was done for component fragility estimation. Wherever component fragility values are not available, generic data is used. The Boolean expression of the cut sets for system fault trees are solved and the system fragilities are obtained using RISK SPECTRUM software.

(b) Seismic Qualification Methodology

The seismic qualification methodology for all the 400 Seismic Structures, Systems and Components (SSSC) was identified. The SSSCs are grouped into three categories based on their structural and functional features for their qualification either by plant walkdown as per guidelines given in "Generic Implementation Procedure" of Department of Energy USA or by analysis or testing given in "Generic

Implementation Procedure" of Department of Energy USA or by analysis or testing.

(ii) Reliability Analysis of Passive Systems of PFBR

The functional reliability analysis of Safety Grade Decay Heat Removal System (SGDHRS) was revised to include additional parameters that contribute to the performance of the successful Decay Heat Removal. The nominal values of these additional parameters were calculated and the associated uncertainties were modeled using normal and lognormal distributions. The parameters of these distributions were determined by expert elicitation. For studying the interaction between the natural circulation loops and single phase natural circulation loop was modeled using finite difference method. To account for the effects of inter-wrapper flow, a modified system dynamic code, DHDYN was taken for this analysis and the influence of inter-wrapper flow on critical system temperatures was studied. The code is being further modified to propagate the uncertainties associated with input parameters. To determine the most severe category IV initiating events, different initiating events are being analyzed.

9.1.2 Reactor Physics and Radiological Safety Studies

(i) PWR Physics Analysis

(a) Integration of Thermal hydraulic Code with Neutronics Code

Few groups lattice database has been generated using EXCEL code for all types of fuel assemblies of KKNPP. After analyzing steady state behavior of KKNPP core, a program has been launched to develop computer codes required to study the dynamic behavior of a reactor core. For this, an interface program in Fortran-90 language has been written to integrate thermal hydraulics code RELAP with reactor physics TRIHEXFA code for analyzing transient behavior of the core by sequential execution of two codes through data exchange from one file to another.

(b) VVER-1000 MOX Fuel Analysis

In order to ascertain the suitability of Mixed Oxide (MOX) fuel as an alternative in lieu of Light Enriched Uranium (LEU) of 2.48 % average enrichment for VVER-1000 type reactors, analysis of the OECD/NEA benchmark 'A VVER-1000 LEU and MOX Assembly Computational Benchmark' (NEA, 2002) was taken up. Figures 9.1 and 9.2 show the schematic diagrams of profiled LEU and MOX fuel assembly. In the present analysis, the aforementioned calculations were performed for S1 state (operating poisoned state) with a power density of 108 MWt/m³ up to a burnup of 40 MWd/kgHM with sufficiently fine burnup

steps to provide accurate results, particularly till the burn out of the Gd absorber. The k_{∞} variation of LEU and MOX assemblies and isotopic compositions with respect to burn-

up were compared with international benchmark mean values and a good agreement was observed.

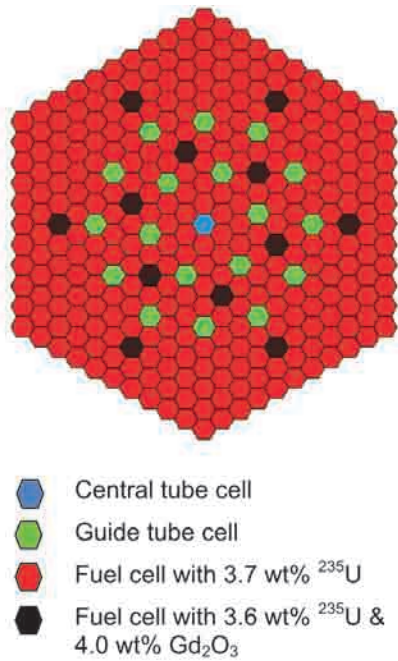


Fig. 9.1: Schematic Diagram of a Uniform LEU Fuel Assembly

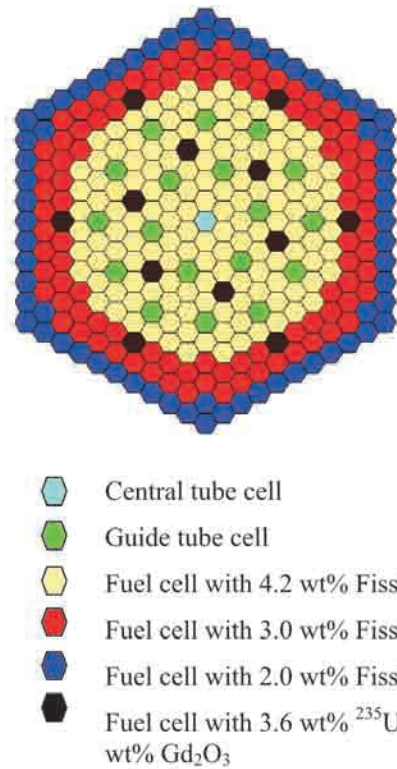


Fig. 9.2 : Schematic Diagram of a Profiled MOX Fuel Assembly

- (ii) **Radiological Safety**
- (a) **Computation of Dosimetric Parameters of Brachytherapy Sources**

Small needle sources are encapsulated with steel/platinum to avoid direct contact with the radiation sources in brachytherapy treatment, due to which anisotropy gets introduced in the dose distribution and is generally represented as radial dose functions. The radial dose functions were calculated using MCNP and IGSFIELD computer codes (in house developed code), in water for distances ranging from 0.5 cm to 10 cm. The dosimetric characteristics determined compared favorably with those of other international studies, thus confirming the suitability of the IGSFIELD code for medical dosimetry problems.

- (b) **Estimation of Neutron Dose Rates for Indian PHWR Spent Fuel Transportation Cask**

Generally neutron dose rates are insignificant compared to gamma ray dose rates for spent fuels. Hence, the shipping casks are designed to attenuate gamma rays adequately using suitable shield materials such as steel and lead. However, these materials do not attenuate appreciably

the neutrons generated in spent fuel. As an exploratory study, neutron dose rate, if any, on the outer surface of PHWR Spent Fuel Shipping cask of KARP, was carried out with MCNP code. The inventory of photon and neutron source strength was computed using the ORIGEN2 code. Dose rates on the shipping cask surface during the transportation of the 10 year cooled spent fuel indicated the presence of neutrons dose rate of $\sim 100\text{-}200 \mu\text{Sv/h}$ ($\pm 30\%$) and the gamma dose rate $< 1 \mu\text{Gy/h}$. The Monte Carlo computed dose rates for gamma and neutron were found to be in good agreement with the measured values. The computations brought out the importance of the burn-up and cooling period for better match between the computed and measured values.

- (c) **Code Development**

Commercially available brachytherapy treatment planning systems are based on point source approximations and do not account for source geometry, material, encapsulation, applicator structural details and ignore the heterogeneities existing in the source-tissue inter phase. To assess the effect of the above approximations, an interactive point kernel code (BrachyTPS) has been developed by taking

into account the above effects. Heterogeneities are accounted by using two regions build-up factors as proposed by Kalos. In addition to performing dose distribution calculations, this code package is capable of displaying an isodose distribution curves into the patient anatomy x-ray images. The computed dose at the reference points were compared with the relevant results of the Monte Carlo (MC) computations. The absolute doses computed by the developed code agreed well with the MC results.

9.1.3 Fire and Thermal Hydraulic Studies

(i) Fire Modeling Studies

Further to earlier simulations carried out for pool fire in a mechanically ventilated enclosure, studies related to fire in a naturally ventilated enclosure was taken up towards assessment of the capability of the code, Fire Dynamics Simulator (FDS) for such situations. Numerical studies were carried out with the code for two fuels having entirely different combustion behavior, i.e., ethanol and kerosene. Estimation of parameters such as fire duration, fuel mass loss rate, compartment oxygen depletion rate, ventilation

flow rate, compartment pressure and temperature transients, etc. were made for both the fuels.

(ii) Thermal Hydraulic Studies

In order to assess the capability of a commercially available CFD code to model the phenomena relevant to hydrogen stratification in reactor containments, simulations were carried out for distribution in an enclosure following release of hydrogen as a high velocity jet from a circular nozzle. The results were validated against experimental data. It was observed that although currently used CFD codes are able to model basic flow of gases in a confinement, they do not have models for steam condensation. Hence a finite volume code based on the SIMPLE (Semi implicit method for pressure linked equations) algorithm is being developed at SRI. In this code attempt is made to solve hydrogen distribution problems based on first principles. It will include necessary models for steam condensation and various mitigation strategies. In its present form, the code is validated for the release of laminar free jets. Fig.9.3 shows a contour plot of velocity magnitude for a plane laminar jet, obtained using the in-house developed code.

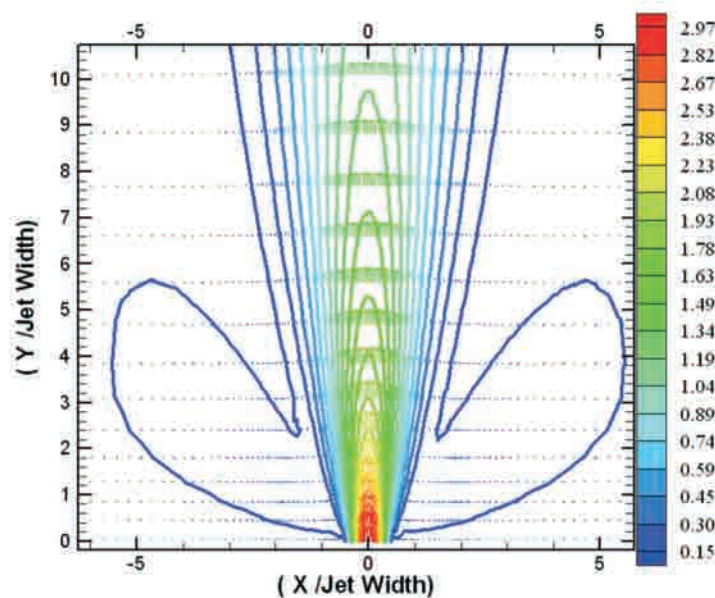


Fig.9.3: Contour Plot of Velocity Magnitude of Laminar Free Jet

9.2 ENVIRONMENTAL SAFETY STUDIES

9.2.1 RS-GIS Studies

- (i) Database Generation for Uranium Mining, Milling and Tailing Pond Area at Jaduguda

Environmental assessment of mining, milling and tailing pond area at Jaduguda was taken up by employing Remote Sensing and GIS technique. The necessary data were taken from topographic sheets of Survey of India, Ranchi, Geology maps from GSI, Kolkatta, Soil maps from NBSS & LUP, Nagpur and Satellite images from NRSC,

Hyderabad.

The study involves creation of baseline data such as road network, railway network, surface water bodies, drainages, geology, soil and land use/land cover in digital format amenable on GIS platform. By comparing the multi-temporal satellite data, the impact of the mining activity on the land use / land cover practices would be assessed. For Jaduguda area within 50 km radial zone from Jaduguda mines thematic maps on geology (Fig. 9.4), soil, and water bodies have been prepared and preparation of maps on road network and drainage network have been taken up.

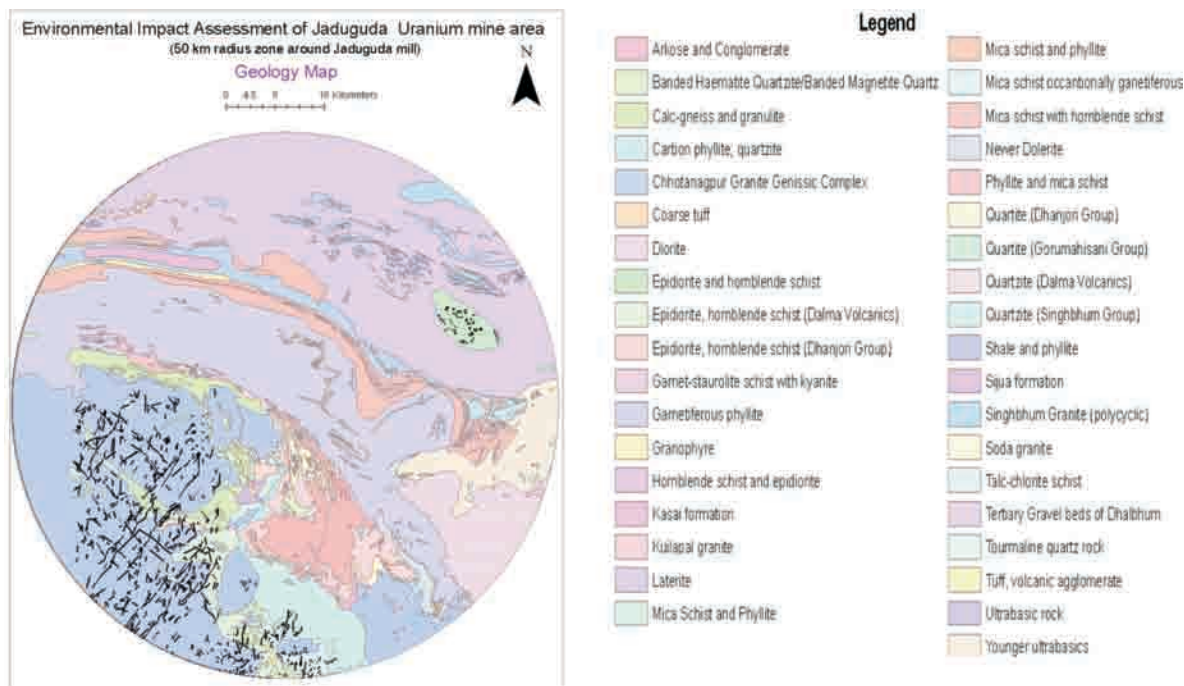


Fig. 9.4: Geology Map of Jaduguda Area (50 km Radial Zone from Jaduguda Mines)

Fig.9.4: Geology Map of Jaduguda Area (50 km radial zone from Jaduguda Mines)

(ii) Study on Impact Assessment of Tsunami Protection Wall at Kalpakkam Township

To assess the impact of Tsunami Protection Wall (TPW) within the township as well as at both adjoining villages, viz., Sadras in the north and Vayyali Kuppam in the south, baseline information on the coastal morphology was collected. Satellite images (IKONOS, aerial imagery

and Cartosat-1) were procured from National Remote Sensing Agency (NRSA), Hyderabad mainly to interpret the impact for pre- and post- construction of Tsunami wall at Kalpakkam. These images were geo-rectified and processed to highlight the coastal morphological features. Seven locations were identified in the study area and monthly measurement of high tide and low tide fluctuations were recorded with respect to the Tsunami wall. Preliminary analysis shows (Fig.9.5) that there is no perceivable impact on the Kalpakkam coast due to the construction of TPW.



Fig.9.5 : Temporal Variation of Beach Profile of a Typical Transect

(iii) Spatial Decision Support System for Flood Inundation

GIS based Spatial Decision Support System (SDSS) has been developed to find out the flood patterns caused by inundation due to tsunami/cyclones at Kalpakkam Plant site using RS-GIS techniques. A high resolution Digital Elevation Model (DEM) with 1 x 1 m spatial resolution and

0.01 m of vertical accuracy was generated and employed in SDSS to simulate inundation patterns. This SDSS provides visual simulations to analyze the scenarios for a specific sea level rise and provides tabular summary to estimate the impact with respect to land use/land cover and population. A typical simulation pattern for 3 m sea level is shown in Fig.9.6.

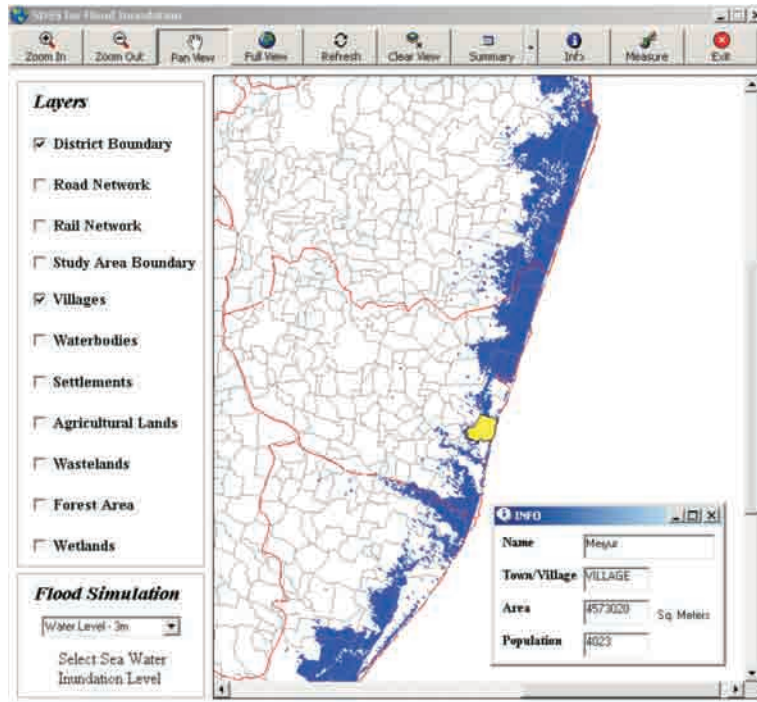


Fig. 9.6: Simulated Sea Water Inundation Pattern

9.2.2 Hydrogeological Investigations at Kalpakkam

(i) Groundwater Modelling using Visual MODFLOW Pro

A groundwater flow model was generated using (Version 4.2) Visual graphic user interface. The detailed study

of geology, subsurface lithology (Fig.9.7) and water table fluctuations in wells has helped to arrive at the conceptual model for the Kalpakkam nuclear site. The unconfined aquifer was divided into two sub layers due to variations in lithology and hydrologic characteristics.

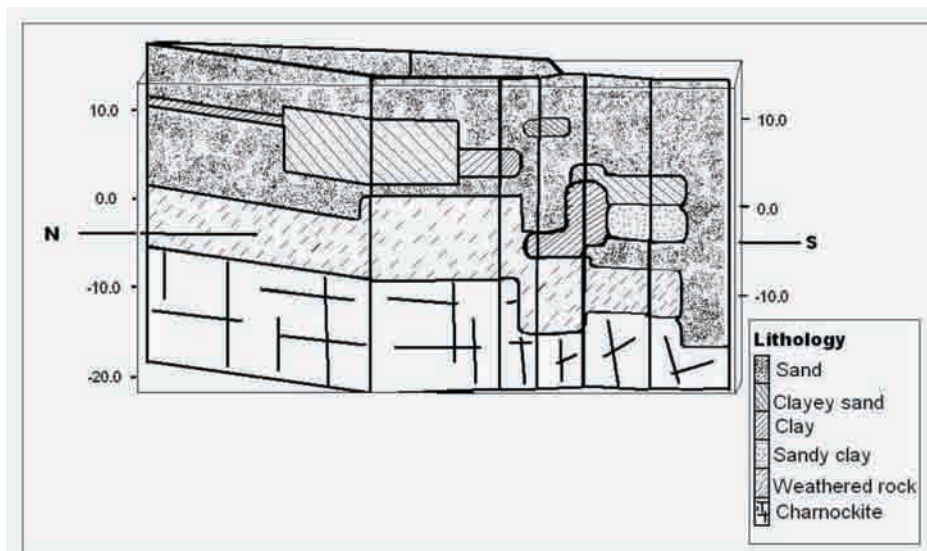


Fig.9.7: Sub-surface Lithology for Kalpakkam Site

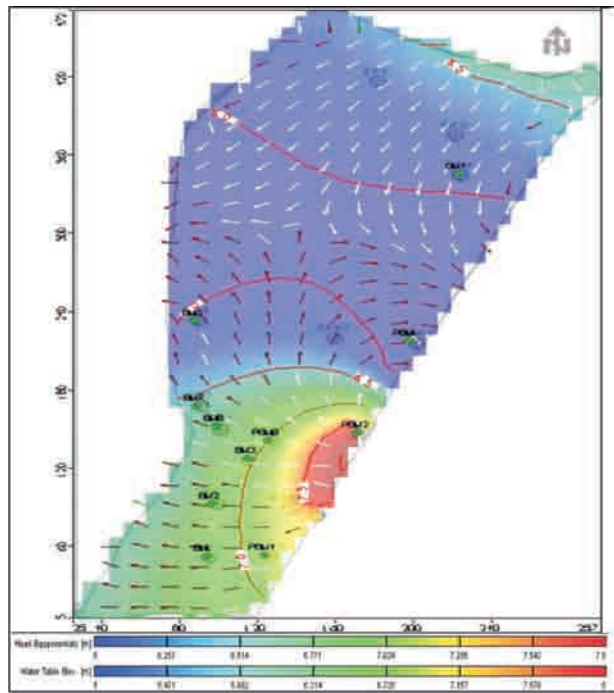


Fig. 9.8: Ground Water Flow Direction in Double-layer Model in Weathered Rock

The groundwater flow model was calibrated in two stages, viz., steady state flow and transient state flow. The model simulation and calibration was performed separately for single layer formation (sand) and double layer formation (sand and weathered rock) with a view to understand the precise range of saturated thickness of aquifer in the two sub-surface layers.

The model outputs revealed that groundwater flows predominantly towards the Buckingham canal in western part and it flows towards Bay of Bengal in eastern part (Fig.9.8) at Kalpakkam Site. Correlation co-efficient obtained for single layer and double layer are 0.981 and 0.985 respectively. The good agreement between predicted and observed water levels is depicted in (Fig.9.9) for transient conditions.

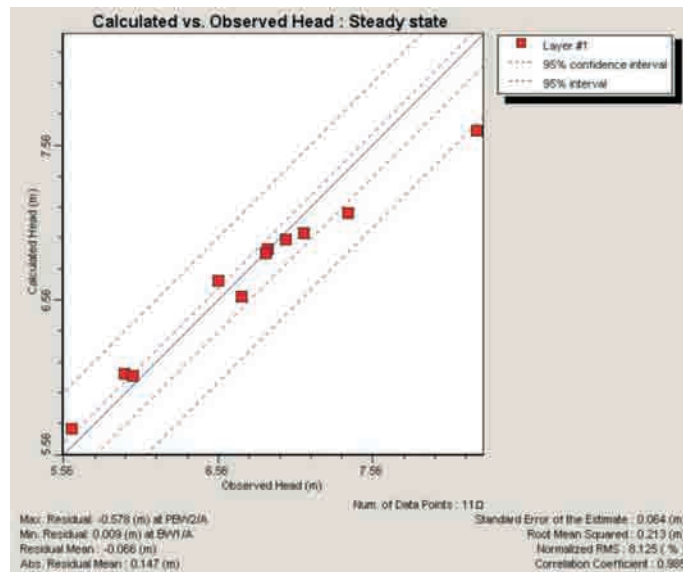


Fig. 9.9: Steady State Plot for Single-layer Model
(Comparison of Predicted vs Observed Heads)

The groundwater modeling helped to improve the understanding of the complex hydrodynamics of the unconfined aquifer system. The model formulated reasonably predicts groundwater flow in the study area.

(ii) Groundwater Chemistry and Geochemical Modeling

A study has been taken up to understand the groundwater geochemistry of the Kalpakkam site. The study will be useful in assessing the suitability of site for different applications. Periodical groundwater samples were taken from different bore wells covering the site and analyzed for various chemical parameters. While parameters such as pH, EC, TDS, salinity, etc were measured insitu using YSI probe. The analysis of various anions and cations were carried out at SRI.

Decrease of HCO_3/Cl ratio and increase of Mg/Ca ratio observed in bore wells near the Buckingham canal indicates the conversion of fresh water to saline indicating the incursion of saline water into these bore wells (Fig.9.10 and Fig.9.11). This fact was also corroborated with the high EC values in these bore wells compared to others. The analytical data were fed into the geochemical software, PHREEQC to understand the saturation indices of the possible minerals and also the salinity levels.

Initial studies have shown that carbonate minerals such as calcite and dolomite are dominant in the study area. The studies are in progress to find out the other minerals and also other geochemical aspects pertaining to the study area.

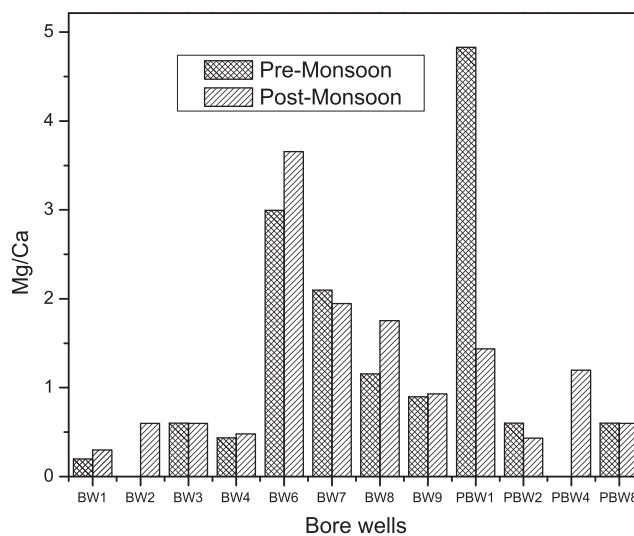


Fig. 9.10: Variation of Mg/Ca for Different Borewells in Pre- and Post- monsoon

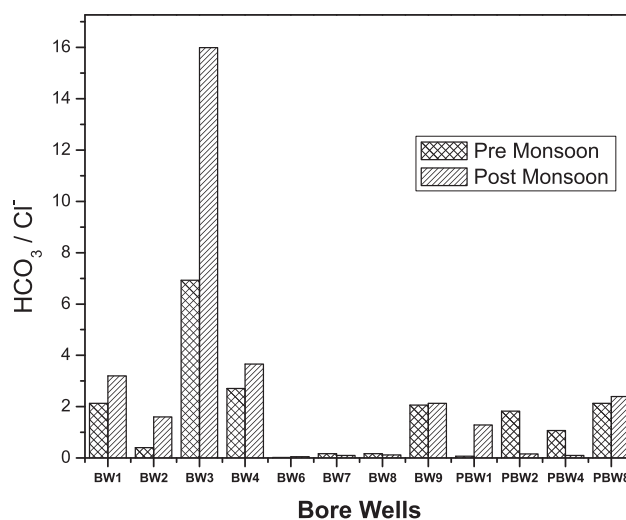


Fig. 9.11: Variation of HCO3/Cl- for Different Borewells in Pre- and Post- monsoon

(iii) Colloidal Transport of Radionuclides in Groundwater

The study of colloidal facilitated transport of radionuclides in sub-surface is being continued. To determine whether the mineralogy of groundwater colloids is reflective of aquifer mineralogy, soil samples were collected at chosen depths in the subsurface within the study area where clay fractions are predominant. Colloidal clay fractions were separated to characterize them for their size, shape, morphology, elemental composition and zeta potential. Pho-

ton correlation spectroscopy, scanning electron microscopy, energy dispersive X-ray analysis, X-Ray diffraction technique and zetasizer were used to characterize the colloidal particles.

The detailed characterization and analysis has revealed that clay mineral present in the subsurface at Kalpakkam is kaolinite with minor traces of illite. The occurrence of kaolinite in the study area is attributed to the decomposition of feldspar of the gneisses that occurs plentifully in the Archean system of rocks, viz, charnockites.

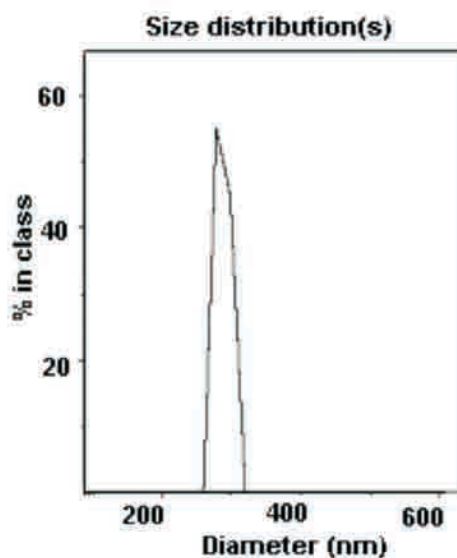


Fig. 9.12: Particle Size Distribution for Clay Colloid

The size of the clay samples was found to vary in a small range between 235 nm and 241 nm (Fig. 9.12). The comparable range of particle size obtained for the four clay samples suggest similar weathering pattern in the study area.

The clay samples (Clay I to Clay IV) were having a mean elemental composition of 21.96 % aluminium, 56.25

% silicon, 16.69 % iron, 2.32 % potassium, 1.52 % calcium and 1.26 % titanium. Based on morphology and elemental composition (Fig. 9.13), the predominant clay mineral in all the four clay samples were identified as kaolinite.

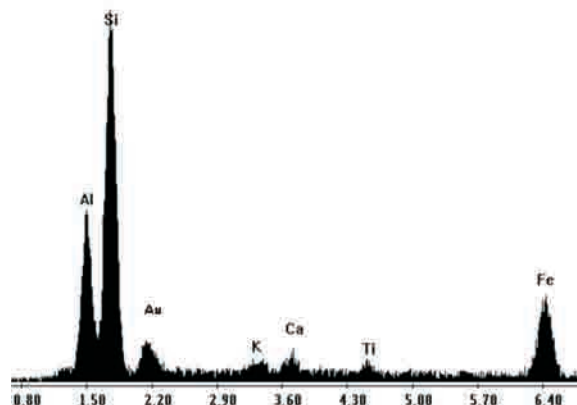
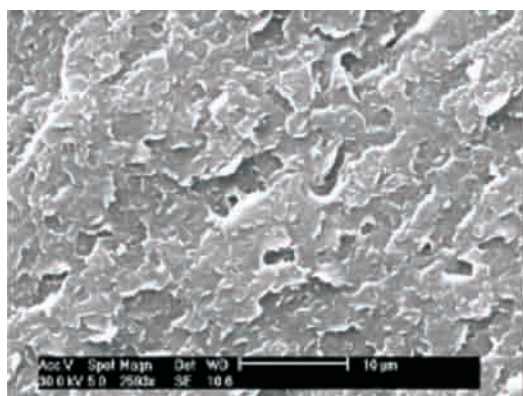


Fig. 9.13: SEM/EDX of Clay Colloids

(iv) Performance/ Safety Assessment of Near Surface Disposal Facilities of Kalpakkam Site based on the IAEA-ISAM Approach

The Performance / Safety Assessment of Near Surface Disposal Facilities of Kalpakkam Site has been taken up based on IAEA-ISAM approach. The first step involves site-specific construction of all Features, Events and Processes (FEPs) that could directly or indirectly influence the disposal system and the migration and fate of radionuclides within it. These FEPs for normal evolution scenario (design basis scenarios) have been identified after applying certain exclusion criteria for the Kalpakkam disposal system. The relative importance of each FEP has been reviewed often using expert judgments. Screening of FEP's for Kalpakkam Near Surface Disposal Facilities shows that ground water pathway is the major pathway for release of radionuclides to the surrounding environment. As part of this, a detailed site-specific databases are generated including the site layout and topography, saturated and unsaturated zone hydrogeology, waste inventory, etc.

(v) Radionuclide Migration Studies in the Unsaturated Zone

Towards understanding of radionuclide migration

in the unsaturated zone, monitoring of monthly moisture movement with depth under the influence of rainfall during one hydrological cycle was initiated by manually collecting soil samples with the help of Auger soil sampler during July 2008. Moisture monitoring at various locations in the vicinity of SRI was taken up from surface down to a depth of about 1 m with a depth interval of 10 cm. During the period ended September 2008 the moisture levels ranged between 2.71 % (10 cm) and 10.59 % (90 cm). The periodical moisture profile along with rain fall data will be used to delineate the monitoring locations and to assess the limitations of hand held soil sampler.

9.2.3 Photocatalytic Effluent Degradation Studies

Studies are in progress for the development of environmentally benign methodologies for the oxidative degradation of effluents containing organics in water. Nano sized anatase titania was synthesized in coordination with CLRI, Chennai and has been characterized using XRD, SEM, TEM, DRS, etc. Photocatalytic degradation experiments are in progress by utilizing the synthesized catalysts for the degradation of disinfection byproducts in water such as halomethanes.

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. The following press releases were issued during the year.

- A four-member delegation of ASN, the French Nuclear and Radiation Regulatory Organization, led by Mr. Guillaume Wack, Head of the Nuclear Power Plants Department of ASN visited AERB during May 27 - 29, 2008. This visit was under the Nuclear Safety Co-operation Agreement between the two organizations that was signed in July 1999. During the visit, a seminar on 'Nuclear Reactor Safety' was organized during which the topics of reactor containment, reactor pressure vessel and periodic safety review were discussed. Large number of scientists and engineers from AERB, NPCIL, BARC and IGCAR participated in the seminar. The presentations and discussions held in the seminar led to a better appreciation of regulatory practices and safety review approach, evolution of design and engineering of reactor containment, periodic safety review practices and aspects like operational experience feedback, non-destructive testing, and neutron embrittlement, irradiation monitoring program and ageing management of the reactor pressure vessel that are followed in India and France. The previous seminar under this information exchange programme was held in May 2007 in Mumbai.
- Recently, a few incidents of presence of low level radioactive contamination in steel products exported from India to some European countries have been reported. AERB has investigated these incidents and has also taken measures to prevent their recurrence. The radioactive contamination was of very low level and insignificant to cause any health hazard to the personnel involved in manufacturing and handling these products or to the public at large. However, such incidents need to be prevented. Also, these incidents have economic impact on the Indian exporters as sometimes such consignments are not accepted by the importers and are returned. The metal recycle industry in India imports large quantities of steel scrap which is melted and used for manufacturing various steel products. Such incidents occur due to lost or abandoned radioactive sources used in industry which sometimes get mixed with steel scrap. Even though a Government of India notification exists requiring all imported material to be free of radioactivity, it appears

that some of the steel scrap exporters abroad are not checking the material carefully. AERB has advised all concerned industries in India to carry out a thorough radiation check on incoming metal scrap as also on the finished and packaged products before releasing them for export. This has been done through awareness programmes conducted by AERB with the help of industry associations like the All India Induction Furnace Association, Engineering Export Promotion Council of India and the Leather Export Council of India. Information articles on the subject by AERB staff have also been published in the newsletters of some of the associations. Steps have also been initiated to install portal radiation monitors at all entry ports of the country to detect any presence of radioactive material in imported consignments.

- AERB presents Industrial Safety Awards to the DAE Units that achieve high levels of performance in Industrial Safety every year. The Industrial Safety Awards for the year 2008 were presented at a function held on March 6, 2009 at AERB Auditorium, Mumbai. Shri Apurba Saha, Executive Director (Mumbai High), Oil and Natural Gas Corporation Limited presented the Awards. The Kaiga Generating Station 3&4, in Construction Group, Heavy Water Plant, Manuguru and Madras Atomic Power Station, in Production Units-I Group, Nuclear Fuel Complex, Hyderabad, in Production Units-II Group and Indira Gandhi Centre for Atomic Research, Kalpakkam, in Research Units Group were the winner units. On this occasion, Shri S. K. Sharma, Chairman, AERB released a compilation entitled "Industrial Safety Statistics - 2008 of DAE Units". This compilation provides analysis of industrial safety incidents and number of injuries and man-days loss caused by various factors. The data is also compared with units outside DAE. It is seen that Industrial Safety performance of DAE Units is significantly better as compared to other similar industries in the country. Shri S. K. Chande, Vice Chairman, AERB gave welcome address and Shri R. Bhattacharya, Head, Industrial Plants Safety Division, AERB proposed vote of thanks.

10.2 AERB NEWS LETTER

AERB News Letter covers AERB press releases, important national and international news, safety reviews of plants / projects, authorizations issued to nuclear and radiation facilities, activities related to training, workshops, colloquia, seminars, symposiums, etc., The Newsletter also carries expert views regarding safety of nuclear and radiation

facilities. AERB Newsletters Vol. 21 No.1 and 2 covering the period from January to June, 2008 and July to December, 2008 were published in English and Hindi during the year 2008.

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 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 use of radiation

in medicine, industry and research for societal benefits and beach sand mineral industries has also been put on the website. This includes the applicable acts, codes and rules, regulatory and safety documents and regulatory application forms related to issuance of licenses, authorizations and registration etc. Recently, the website design and layout has been given a face lift and the information search has been made easy. Work on posting of AERB regulatory documents on the website has been initiated.

10.5 INTERACTION WITH MEDIA

Queries raised by media are replied by phone and e-mails as well as during press meets by the senior officers of AERB.

10.6 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. Thirty-three queries received from various applicants under RTI Act were replied during the year.

CHAPTER 11

INTERNATIONAL COOPERATION

11.1 INDIA'S PARTICIPATION IN 4TH REVIEW MEETING OF THE CONTRACTING PARTIES TO THE CONVENTION ON NUCLEAR SAFETY (CNS)

An eighteen member delegation of senior officers from AERB, NPCIL, BARC and India's Permanent Mission in Vienna, led by Chairman, AERB participated in the 4th Review Meeting of the Contracting Parties to the CNS during April 14 - 25, 2008, Vienna. India signed the convention in 1994 and ratified it in March, 2005. In 2005, India attended the 3rd Review Meeting as an observer, as India had ratified the CNS before less than 3 months of the start of the 3rd Review Meeting, as per CNS rules. Presently, there are 61 Contracting Parties to the convention which include all the 30 countries which operate nuclear power plants. The CNS is an incentive convention that seeks to maintain a high level of safety in NPPs worldwide through an exhaustive peer review process conducted every three years. The national report on safety of our NPPs was submitted in September 2007 for review by Contracting Parties. The report demonstrates, through self assessment, how India fulfills its obligations under articles 6 to 19 of the convention. These articles deal with topics like legislative and regulatory framework, regulatory body, responsibility of licensee, human and financial resources, siting, design and construction, assessment and verification of safety, radiological protection, emergency preparedness and quality assurance.



Shri S.K. Sharma, Chairman, AERB briefing the Board Members and Senior Scientists of PFBR on CNS after the Board Meeting in Kalpakkam

A total of 143 questions were raised by 20 countries on the Indian report and detailed responses to these were provided before the meeting. In the Review Meeting the national report was orally presented which was followed by

a discussion session. The presentations made by the Indian delegation, were:

- Historical development aspects of the Indian nuclear power programme, its strengths including comprehensive capability for the entire fuel cycle, human resource development, strong R&D support and regulatory structure in the country.
- Siting of NPPs, seismic and flood/tsunami considerations and current R&D work on structural integrity.
- Safety Analysis and Radiation Protection.
- Design, Construction and Operation of NPPs and update since the submission of the National Report to CNS.
- Regulatory Review Process in India and Thematic responses to the questions on the national report posed by the Contracting Parties.
- Concluding remarks highlighting the good practices followed in the country, challenges faced and future activities for enhancement of safety.

Based on the national report, the presentation in the Review Meeting and the discussion held thereafter, a summary was prepared in which the following good practices, challenges ahead and planned measures to improve safety in India were highlighted.

The good practices include: (i) conduction of brief reviews every five years between two Periodic Safety Reviews, (ii) presence of a dedicated radiological environmental survey laboratory at each NPP site that starts its activities well before plant operation starts, (iii) dose limits for contract workers that are half compared to regular staff, (iv) systematic collective dose reduction programme, (v) utility's internal safety review mechanism and corporate peer review mechanism following closely the World Association of Nuclear Operators (WANO) methodology, (vi) review of siting aspects during PSR, and (vii) strong experience feedback mechanism that is in place, both in the utility and the regulatory body.

The challenges are:

Recruitment and training of about 100 additional experts to strengthen AERB within the next 5 years for future activities and identify the key areas of concern such as (i) Reliability and Safety of Digital I&C, (ii) Licensing of the New Designs for upcoming plants and (iii) Reliability of Passive Systems.

The planned measures to improve safety are:

- Severe Accident Management (SAM) Programmes,
- PSA (Level 2, Shutdown State, External Events)
- Technical improvements in the areas such as (i) EMCCR of NAPS-2 and KAPS-1; (ii) Life Management of Zr-Nb Coolant Channels, (iii) Feeder thinning, Flow Assisted Corrosion (FAC) of Secondary Piping, (iv) Safety of Digital I&C, (v) Development of a Seismic Qualification Programme by Experience Data Base, and (vi) Assessment of the Reliability of Digital I&C for Safety Functions.

India's report was well received in the Review Meeting and the various safety practices and effective Regulatory Review Structure followed in India were appreciated by the Contracting Parties.

11.2 IAEA INTERNATIONAL CONFERENCE ON TOPICAL ISSUES IN NUCLEAR INSTALLATION SAFETY

An International Conference on Topical Issues in Nuclear Installation Safety: Ensuring Safety for Sustainable Nuclear Development during November 17-21, 2008, Mumbai was organized by AERB. The objective of the conference was to foster the exchange of information on topical issues in nuclear safety, especially on issues that ensure safety for sustainable nuclear development. The participants in the conference represented a broad range of experts in the area of nuclear safety, including professionals from the different disciplines involved in the safety of nuclear power plants, installations in other parts of the fuel cycle and research reactors and experts from regulatory bodies as well as senior policy makers. A total of 93 delegates from 37 countries abroad and about 200 delegates from India participated in the conference. The topics covered in conference were International Harmonization of Nuclear Safety, Safety Infrastructure for Nuclear Programmes, Safety Management and New Construction Experience Feedback, Relationship between Safety and Security. The President of the conference was Dr. A.-C. Lacoste, Chairman, ASN (French Nuclear Regulatory Body). The conference was inaugurated by Dr. Anil Kakodkar, Chairman, AEC and Secretary, Department of Atomic Energy. The Chiefs of Regulatory Bodies of several countries including USA, Finland, South Africa, and UK attended the conference. Participants from IAEA and other International Organizations such as World Association of Nuclear Operators (WANO), and the Organisation for Economic Co-operation and Development (OCED) / Nuclear Energy Agency (NEA) attended the conference.

The Conference provided an opportunity to share experiences and expectations related to nuclear safety, as well as the challenges for sustainable and safe nuclear power

development. Participants also exchanged the lessons learned and operational experience from current nuclear power programmes, along with discussion of experiences with new nuclear power plant construction. Other important subjects such as opportunities for the nuclear industry and protection of nuclear installations against malevolent acts were also discussed during the conference. The conference provided important recommendation on key issues related to nuclear installation safety.

11.3 USNRC-AERB MEETING

The USNRC-AERB technical discussion meeting was held on 24-25 November 2008 to discuss the progress of work on the two standard problem exercises (TMI-2 accident and ISP-42, PANDA test) and to finalize the draft report. The programme started with the opening remarks by Shri S. K. Sharma, Chairman AERB and Dr. Dale E. Klein, Chairman USNRC. This was followed by presentations on sensitivity and uncertainty analysis of TMI-2 accident scenario from AERB and USNRC experts. The results of the simulation of the experiments (Phases A-F) conducted in the PANDA test facilities were also presented. Simulation of Phases A-F using RELAP5, simulation of Phases A-C using ASTEC and RELAP5 and simulation of Phases D-F using RELAP5 were presented by experts from AERB and BARC respectively. Extensive discussions took place on all the presentations.



US-NRC and AERB Meeting in Progress

(L to R: Dr. Dale E. Klein, Chairman, US-NRC, Shri S. K. Sharma, Chairman, AERB and Shri S. K. Chande, Vice-Chairman, AERB)

11.4 AERB-ASN SEMINAR ON NUCLEAR REACTOR SAFETY

A four member delegation of ASN, the French Nuclear and Radiation Regulatory Organization, led by Mr. Guillaume Wack, Head of the Nuclear Power Plants Department of ASN visited the Atomic Energy Regulatory Board during May 27 - 29, 2008. This visit was under the Nuclear Safety Co-operation Agreement between the two organizations that was signed in July 1999. During the visit, a seminar on 'Nuclear Reactor Safety' was organized during which the topics of reactor containment, reactor pressure

vessel and periodic safety review were discussed. A large number of scientists and engineers from AERB, NPCIL, BARC and IGCAR participated in the seminar. The presentations and discussions held in the seminar led to a better appreciation of regulatory practices and safety review approach, evolution of design and engineering of reactor containment, periodic safety review practices and aspects like operational experience feedback, nondestructive testing, and neutron embrittlement, irradiation monitoring program and ageing management of the reactor pressure vessel that are followed in India and France. The previous seminar under this information exchange programme was held in May 2007 in Mumbai.



AERB and French Regulatory Body, ASN Delegates in a Meeting After the AERB-ASN Seminar on Nuclear Reactor Safety

(L to R: Dr. Om Pal Singh, Dr. P. C. Basu, Shri S. K. Chande, Shri G. Wack, Shri Claude Barbalat, Ms. Anne Claude Benoit, Mr. Arnauld Laverie, Shri R. I. Gujarathi and Shri R. Venkatraman)

11.5 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 and the work related to development of Safety Standards, Coordinated 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. The meeting was held in Canada, Vienna, Austria during Oct 13-17, 2008. In 2006, India 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 Yerevan in Armenia, July 3-5, 2007 at Dubna, near Moscow in Russia and July 7-9, 2008 in Kyiv in Ukraine.

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 number of radiation facilities in the country. 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 2006 joined AERB in August 2008.
- Seven officers, four from training school of BARC, two from training school of IGCAR and one from training centre of NPCIL, joined AERB in September 2008.
- Nine officers joined AERB through inter-unit transfer; Six from BARC, one from DAE, one from DPS and one from HWB.
- Three students, two in IIT Madras and one in IIT Bombay were sponsored for M.Tech in August 2008.

During the year 2008 - 09, 21 personnel joined AERB and 8 retired. As on 31-03-2009, the total staff strength in AERB is 206 comprising 167 scientific and technical and 39 supportive staff.

12.2 TRAINING

12.2.1 AERB Orientation Course for Regulatory Processes

The AERB Orientation Course for Regulatory Processes (OCRCP-2009) was conducted during January and February 2009 for the scientists/engineers inducted in AERB. The course covered important regulatory and safety topics. Site visits were organized to TAPS-1&2, TAPS-3&4, Advanced Fuel Fabrication Facility (AFFF) at Tarapur to familiarize the trainees with the systems of Boiling Water Reactor (BWR) and Pressurized Heavy Water Reactor (PHWR), and also the steps involved in the fuel fabrication. The valedictory function for the Course was held on 17th March 2009, in which the certificates were distributed to the trainees. The feedback from the trainees was quite encouraging and the feedback from the trainees and suggestions from senior officers of AERB for improvement will be incorporated in the future courses.



Shri S. K. Sharma, Chairman, AERB Distributing Certificates at the Valedictory Function for AERB OCRP-2009

(L to R: Kum. D. Jayalakshmi, Shri Manoranjan Dash, Trainee and Shri S.K. Sharma, Chairman, 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 (NTC) of NPCIL

- Two engineers cleared Licensing examination for control engineers (L-III) at TAPP-3&4.
- One engineer is undergoing training at Nuclear Training Centre, RAPS on PHWR systems
- Three engineers are undergoing training specific to VVER type reactors at Kudankulam site.
- One engineer is under training on Fast Breeder Reactor Technology, IGCAR, Kalpakkam.

12.3 REFRESHER COURSES

Two Refresher Courses were organized for AERB staff on "VVER Reactors" and "Acts & Rules Applicable to AERB" during the year.

The Refresher Course on VVER Reactors included the topics on 'Plant Layout & Design of Structures, System and Components', 'Reactor Coolant System & Associated Systems', 'Reactor Assembly & Core Physics', 'Engineered Safety Features', 'Instrumentation & Controls' and 'Accident Analysis'. The Refresher Course on "Acts and Rules applicable to AERB" included the topics on 'Atomic Energy Act, 1962', 'Factories Act and Atomic Energy (Factories) Rules, 1996', 'Water Act & Air Act and Rules', 'Environment

Protection Act and Rules there under', 'Radiation Protection Rules, 2004, 'Safe Disposal of Radioactive Wastes Rules, 1987', and 'Control of Irradiation of Food Rules, 1996'.

12.4 DEPUTATION ABROAD

One officer has been deputed to University of Texas for post doctoral fellowship to work on 'Physics Modeling of Generic Fast Breeder Reactor Core Analysis'.

12.5 AERB COLLOQUIA

Following AERB colloquia were organized.

- Convention on Nuclear Safety (CNS) by Shri R. Venkatraman, Shri J. Koley and Shri Deepak Ojha from AERB. The talks covered the following aspects related to CNS.
 - Background, Objectives and Review Process
 - India's National Report and Peer Review by other Countries.
 - Highlights of the 4th Review Meeting of CNS and Future Activities.
- 'Indian Innovation: From Gandhi to Gandhian Engineering' by Dr. R. A. Mashelkar, FRS and Former Director General, CSIR. 'Gandhian engineering' is essentially linked to Gandhian philosophy of simple living, tranquility, self-reliance and resource-poor people orientation. The lecture showed as to how the survival of the civilian society in the twenty first century will depend on how creatively 'Gandhian Engineering' is used in shaping our lives, both in the developing part of the world as well as the developed part of the world.
- 'Insight into Theories of Turbulence and Heat Transfer' by Prof. J.B. Joshi, Director, Institute of Chemical Technology, University of Mumbai and Member of AERB Board. The talk covered the methodologies and applications of various experimental fluid dynamics (EFD) techniques (namely, point measurement techniques such as hot film anemometry, laser Doppler anemometry, and planar measurement techniques such as particle image velocimetry (PIV), high speed photography, Schlieren shadowgraphy, and the recent volume measurement techniques such as holographic PIV, etc.), and the computational fluid dynamics (CFD) techniques (such as direct numerical simulation and large eddy simulations). The presentation also dealt with the heat transfer aspects of single phase Jet Loop Reactor (JLR) and multiphase Condensation Jet Reactor (CJR).
- 'Early Detection and Screening for Cancers: Lessons Learnt' by Dr (Smt.) K. A. Dinshaw, Ex-Director, Tata Memorial Centre and Member of AERB Board. The talk addressed the aspects on recognizing possible

warning signs of cancer and taking prompt action that could lead to early diagnosis. The talk also addressed on screening, which refers to the use of simple tests across a healthy population in order to identify individuals who have disease, but do not yet have symptoms.

- 'Recent Advances in Chemical Accident Modeling' by Dr. K. V. Raghavan, INAE Distinguished Professor, Indian Institute of Chemical Technology (IICT), Hyderabad and Member of AERB Board. The talk addressed the modelling of chemical release and post release events involving fires, explosions and toxic gas dispersions with examples drawn from the first ever Indian effort in modeling the major gas cracker accident that took place in 1990 in Indian Petro Chemical Limited (IPCL), Nagothane, Maharashtra.
- 'EPR, AP-1000 and VVER Reactor Designs' by Shri J. Arunan, Shri Utkarsh C. and Shri J. Koley of AERB. The talks addressed the salient design aspects of EPR, AP-1000 and VVER type reactors.
- 'Introduction to Incore Monitoring System in Kudankulam Reactors' and 'Algorithms to Calculate Linear Heat Generation Rate (LHGR) and Departure from Nucleate Boiling Ratio (DNBR) in Kudankulam Reactors' by Shri Y. K. Pandey Light Water Reactor Design Group, NPCIL. The presentation gave details of algorithms used to calculate the Linear Heat Generation Rate (LHGR) and Departure from Nucleate Boiling Ratio (DNBR) for VVER-1000 reactors of Kudankulam NPP. The presentation also described the monitoring of Kudankulam core using SPND signals from In Core Monitoring System (ICMS) and transforming the readings to evaluate the core parameters, viz., LHGR and DNBR.

12.6 KNOWLEDGE MANAGEMENT

A 'Knowledge Portal' has been 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.

A well-equipped library is maintained in AERB. A total of 67 new publications have been added during the period and with this, the total collection of publications has gone up to 9908. In addition, 24 Journals have been subscribed during the period. 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. Table of contents of new issues of important journals available in Science Direct is regularly circulated by email.

CHAPTER 13

SAFETY PROMOTIONAL ACTIVITIES

13.1 SAFETY RESEARCH PROGRAMME

One of the objectives of 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, and recommend grants for the research projects and to monitor their progress periodically. The Committee also recommends financial

assistance to universities, research organizations and professional associations for holding symposia and conferences of interest to AERB. The CSRP met two times during the year and deliberated on 13 new project proposals and recommended Grant-in-Aid for 6 new projects as given in Table 13.1. It also approved the renewal of 5 ongoing projects as given in Table 13.2. In addition, financial support was provided to 27 seminars, symposia and conferences.

Table 13.1: New Research Projects Approved

Sr. No.	Project Title	Principal Investigator	Institution
1.	Experimental Investigations on Transient Critical Heat Flux	Dr. S.V. Prabhu	IIT Bombay, Mumbai
2.	Development of a TLD based on Borate Glass: Implication to Clinical Dosimetry	Dr. A. Nabachandra Singh	Thoubal College, Manipur
3.	Microbial Biofilm Formation and Corrosion of Firewater Pipelines in Nuclear Power Plants	Prof. S. Jayachandran	Pondicherry University, Pudicherry
4	Hydrogeochemical Modeling of Coastal Aquifers in and around Kalpakkam: An Integrated Approach	Dr. S. Chidambaram	Annamalai University, Annamalai Nagar
5	Evaluation of Tensile Properties of Zircaloy-4	Dr. R. Ganesh Narayanan	IIT Guwahati, Guwahati
6	Dispersion of Hydrogen-Steam Mixture in Containment	Dr. S. Kannan Iyer	IIT Bombay, Mumbai

Table 13.2: Research Projects Renewed

Sr. No.	Project Title	Principal Investigator	Institution
1.	Evaluation of Patient Specific Dose for Optimised X-ray Diagnostic Imaging Systems in a Rural Setup	Dr. V.S.K. Vijaykumar Raju	Mahatma Gandhi Memorial Medical Trust, Bhimavaram
2.	Prediction of Oceanic Dispersion of Radionuclides Released from MAPS into the Coastal Waters of Kalpakkam	Dr. Usha Natesan	Anna University, Chennai
3.	Development of Optical CT-Gel Dosimetry	Dr. E.J. Jebaseelan Samuel	Vellore Institute of Technology, Vellore
4.	Enhancement of Durability of Concrete Structures using Microbes	Prof. A. Mukherjee,	Thapar University, Patiala
5.	Transfer Coefficient of Radiostrontium in Food Crops	Dr. A. Raja Rajan,	Tamil Nadu Agricultural University, Coimbatore

13.2 WORKSHOPS/SEMINARS

13.2.1 Workshop on Regulatory Control on Diagnostic X-ray Equipment and Installations for X-ray Machine Manufacturers/Suppliers held on 09-05-2008

The main objective of workshop was to familiarize manufacturers/suppliers of medical X-ray machines on current radiation safety requirements in the diagnostic X-ray installations and their roles and responsibilities in implementing radiation protection programme. The

programme comprised of lectures on topics related to radiation protection standards, techniques and dose limits. There was a demonstration of radiation detection and measurement techniques. In the feedback session, presentations were made by five leading manufacturers of the units on the system followed by them in the implementation of the AERB regulations.



Panel Discussion at the Workshop on Regulatory Control of Diagnostic X-Ray Equipment and Installations

(L to R: Shri Girish Kumar, Adonis Medical Systems, Chandigarh, Shri V.K. Shirva, RASD, AERB, Shri S.P. Agarwal, Head, RSD, AERB, Shri K.V. Ramani, Seimens India Ltd., Mumbai, Shri R.K. Narang, M/s. Allengers Medical Systems Pvt. Ltd., Chandigarh, Shri Anil Jathar, WIPRO GE Medical Systems, Mumbai and Shri Vinod G. Vorn, M/s. Meditronix Manufacturing Company Pvt. Ltd., Ambarnath.)

13.2.2 Awareness Programme on Radiation Safety for Safe Transport of Radioactive Material for Air and Sea Carriers held on 03-06-2008

It had come to the notice of AERB that most of the air and sea carriers in India have an apprehension in accepting consignments containing radioactive material for export. It was also learnt that most of the carriers have a misconception on the risk involved in handling packages containing radioactive material during the transport of radioactive material. Therefore, a one day awareness programme on the safe transport of radioactive material for the managerial levels of the airlines, airport operators and port authorities in the country was conducted on June 3, 2008. The objective of the program was to allay fear of risk in handling packages containing radioactive material which in turn would help in reducing the number of denials of shipment by carriers. The programme comprised of lectures on safe transport of radioactive material relevant to the carriers, demonstration on radiation detection and measurement, procedures for accepting the consignment, feed-back session and discussions. A demonstration was also organized on radiation detection and measurement techniques. The feedback session followed by panel discussion provided an opportunity to the participants to express themselves. The program helped the carriers to review their policies for acceptance of shipment of radioactive material.

13.2.3 Awareness programme on Radiation Safety for Operators of X-ray Baggage Inspection systems at the airports, held on 05-06-2008

In view of the security threat all over the world, the checking of personal baggage of air travelers and air cargoes have become very important. The most commonly deployed method for such checking is screening of the baggages and cargoes through X-ray baggage inspection systems. These X-ray baggage inspection systems have been installed in large numbers at the airports.

During inspection by AERB at an international airport for x-ray baggage systems, it was noticed that large number of x-ray operators are operating the x-ray baggage system at the airports without the basic knowledge of radiation safety. In order to impart basic knowledge on the safe operation of these units from the radiological safety point of view, a one day awareness programme for the operators on the safe operation of the x-ray baggage inspection systems was conducted by AERB on June 5, 2008, at AERB, Mumbai. The programme comprised of lectures on basic knowledge in radiation safety and Dos and Dents for safe operation of X-ray baggage system followed by feed-back session and discussions. There was a demonstration of radiation detection and measurement techniques. The program helped in bringing awareness among operators of x-ray baggage system and minimizing radiation doses to operators and public.

13.2.4 Workshop on "Establishment of Directorate of Radiation Safety in the States"

In order to review the status on the formation of Directorate of Radiation Safety (DRS) in each State, AERB conducted review meeting on Jan. 2, 2009 with the representatives of States. Twenty two States represented the workshop. Status of DRS in each State was reviewed and method of formation of DRS was discussed again. It was noticed that though there is progress in some of the



Panel Discussion during the workshop on 'Establishment of Directorate of Radiation Safety in the States' in Progress in AERB

(L to R: Dr. Y.S. Mayya, Head, RPAD, BARC, Dr. Om Pal Singh, Director, ITSD, AERB Shri S.P. Agarwal, Head, RSD, AERB and Dr. R. Kannan, RSD, AERB)

States for the formation of DRS, more efforts are needed on the formation of DRS in other States. All the representatives of States were asked to take further necessary action in this regard.

13.2.5 Discussion Meet on Emergency Exercises at NPP Sites - Site and Off Site: Challenges and Constraints

A two day Discussion Meet on "Emergency Exercises by NPPs - Site and Off-Site: Challenges and Constraints" was organized at SRI, Kalpakkam during June 12-13, 2008. The objective of the Discussion Meet was to identify and address challenges and constraints faced while conducting the emergency exercises and also to identify and implement measures to harmonize procedures/practices among nuclear power plants.

The Meet was inaugurated by Additional Collector, Kanchipuram District and presided over by Vice Chairman AERB. In his presidential address, Vice-Chairman focused on the role of AERB relevant to emergency, its present status and aspects for improvement. There were two key note addresses: one given by Director (O), NPCIL, and the other by Director, OPSD, AERB. The Station Directors from NPPs made the presentations on their experiences in conducting plant, site and off-site emergency exercises. The Meet concluded with the talks by Shri K.Muralidhar, Secretary, AEC and Shri V.P.Raja, Principal Advisor and Chairman CMG, DAE. Three senior delegates of AERB gave their comments/ views in the feed back session. At the end, Director, OPSD summed up the highlights of the Meet.

The Meet brought out several important issues related to the topic. Some of them are: optimisation of the frequency of exercises in multi NPPs site, personnel

accounting, decontamination of large areas in public domain and evacuation of people at odd hours. Some of the suggestions made were: feasibility of posting a Liaison officer by NPCIL at the District Collector Office, feasibility of conducting modular exercises and making use of local NGOs such as milk-cooperatives for communications with public during off site emergency, etc.



Inaugural Session of the Discussion Meet on Emergency Exercises by NPPs-Site and Off-Site: Challenges and Constraints

(L to R: Dr. S.E. Kannan, Director, SRI, Kalpakkam, Dr. V.M. Pingale, IAS, Additional Collector, Kanchipuram, Shri S.K. Chande, Vice-Chairman, AERB, Shri G. Nageshwara Rao, Director (O), NPCIL, Shri P.Periah, Supt. Of Police, Kanchipuram and Shri R. Venkataraman, Director, OPSD, AERB)

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.

No.	Document No.	Document Title
1.	DS 44	Criteria for Use in Preparedness to a Nuclear or Radiological Emergency
2.	DS 412	Ageing Management for Research Reactors
3.	DS 422	Evaluation of Seismic Hazards for Nuclear Installations
4.	DS 355	Safety Case and Safety Assessment for Radioactive Waste Disposal
5.	DS 367	Safety Classification of Structures, Systems and Components in Nuclear Power Plants
6.	-	Computer Security at Nuclear Facilities
7.	DS 388	Chemistry Programme for Water Cooled Nuclear Power Plants
8.	DS 416	Licensing Process for Nuclear Installations
9.	DS 413	Safety of Nuclear Power Plants - Operation
10.	DS 409	Radiation Safety of Gamma, Electron and X-ray Irradiation Facilities
11.	DS 408	Radiation Safety in Industrial Radiography
12.	DS 415	Governmental and Regulatory Framework for Safety
13.	DS 371	Storage of Spent Fuel
14.	DS 393	Development and Application of Level-2 Probabilistic Safety Assessment for Nuclear Power Plants

13.4 REVIEW OF BUREAU OF INDIAN STANDARDS (BIS) DOCUMENTS

Shri R. Bhattacharya, Head, IPSD has been appointed as Convener of Chemical Hazards Subcommittee, Chemical Department 8:2 and a member of the CHD 8 for revision of document related to chemicals and occupational health and was entrusted to revise the IS 4209:1987 (Code of Safety in Chemical Laboratory).

Dr. P.C. Basu, Director, CSED has been nominated as a member of the BIS Cement and Concrete Sectional Committee (CED-2), Earthquake Engineering Sectional Committee (CED-39), Structural Safety Committee (CED-37) and certain associated subcommittees, which are entrusted with preparation of Standards on respective subjects.

13.5 PREPARATION OF THE DOCUMENT ON "HARMONIZED RISK ASSESSMENT STANDARD" ON BEHALF OF THE MINISTRY OF ENVIRONMENT & FORESTS

Ministry of Environment & Forests (MoEF) entrusted AERB to prepare a national document on "Risk Assessment Guidance Manual and Risk Acceptance Criteria". Chairman, AERB constituted a Task Force to complete the assigned job. The Task Force studied the different approaches available nationally and internationally for hazard identification, international risk acceptance criteria, the statistical data on road accident and natural accident like lightning in India and worked on estimation of consequences, estimation of frequencies, risk computation

& characterization. The final report of the Task Force was submitted to the MoEF in December 2008. Shri R. Bhattacharya, AERB briefed the committee about the document prepared during the 8th meeting of Central Crisis Group at Paryavaran Bhavan, MoEF, New Delhi.

13.6 OTHERS

An expert committee was constituted by the Government of Maharashtra to enquire into the explosion & fire incident that took place at the M/S Modi Apparel Industries Limited, Ghatkopar, Mumbai resulting in 8 fatalities and 19 injuries. Shri R. Bhattacharya, AERB was a member of the expert committee for identifying root causes of the incident and carried out consequence analysis and based on that the committee has suggested the remedial measures to prevent the recurrence of similar accidents in future.

Important recommendations are inventory of inflammable substances shall be kept minimum, metal containers shall be used for storage, no hazardous material other than that required for manufacturing process shall be stored / kept in gala.

AERB staff reviewed the draft document of Government of India on 'Coastal Management Zone Notification, 2008' and offered comments on the same.

An Expert Committee constituted by the Govt of Maharashtra to prepare security control Rules for public buildings against man - made disasters. Dr. P. C. Basu, AERB is a member of the committee has submitted its report to the Government of Maharashtra.

CHAPTER 14

OFFICIAL LANGUAGE IMPLEMENTATION

AERB continued its efforts to ensure effective implementation of official language policy and ensure the use of Hindi in official work.

An Inspection team constituted by Official Language Implementation Committee (OLIC) carried out inspection to check the progress of use of Hindi in official work in AERB. This effort has led to increased use of Hindi in official communication.

Efforts were continued to prepare scientific and technical literature in Hindi and make the same available to DAE Units, other institutions and to the public. This year 3 AERB safety documents have been translated and published in Hindi. These are Safety Guide on "Radiation Protection during Operations of Nuclear Power Plants", Technical Manual on "Methods for the Measurement of Radon Thoron and their Progeny in Dwellings" and Safety Manual on "Atlas of Reference Plans for Medical Diagnostic X-ray Installations. With these, 35 documents have been translated in Hindi.

To encourage the use of Hindi by the officers and staff in AERB, Hindi competitions such as story writing, essay writing, scientific and technical translation, noting and drafting, extempore speech, cross - words and slogans etc., were organized and prizes were distributed to the winners. Hindi Quiz competition was also organised in September 2008. On the occasion of "Hindi Diwas", messages of Hon. Union Home Minister and Chairman, AEC were read and a lecture on "Right to Information Act-2005" was organized in Hindi.

Annual Reports and Newsletters of AERB are published in Hindi and English and are distributed to DAE Units, educational institutes, press media, hospitals and industrial units. Press releases are also issued in Hindi and English.

Hindi Software ' Aaj Ke Shabd ' was purchased and is being displayed at display panel of AERB and the work of AERB Website in Hindi has been initiated.

All necessary steps are being taken continuously to implement Official Language Hindi successfully in AERB.



**Invocation by AERB Ladies in the Official Language Prize Distribution Function
Shri S.P. Agarwal and Shri S.K. Chande, AERB seen on the Dais**

CHAPTER 15

MISCELLANEOUS

15.1 SILVER JUBILEE CELEBRATIONS

On November 15th 2008, AERB organized a function to celebrate completion of 25 years since it was established on November 15, 1983. Among others the function was attended by Prof. A. K. De and Shri S. D. Soman, former Chairmen, Shri S. V. Kumar and Shri G. R. Srinivasan, the former Vice-Chairmen of AERB, M. S. R. Sarma, former Chairman, SARCOP and Dr. Anil Kakodkar, Chairman, AEC. Also present were Dr. S. Banerjee, Director BARC, Dr. S. K. Jain, CMD, NPCIL and Shri A. L. N. Rao, CEO, HWB. The function started off with a soulful rendition of a devotional song by Smt. S. Bhattacharya, former scientific officer, AERB. The Silver Jubilee History book, "AERB: 25 Years of Safety Regulation", was released by Prof. A. K. De. Chairman AEC released two monographs, prepared by AERB staff on siting and seismic safety of Nuclear power plants respectively. The mood in the auditorium turned nostalgic during the addresses by former Chairmen and Vice Chairmen. Chairman AEC honoured them with a shawl, a memento and a copy of the Silver Jubilee book. Chairman AEC shared his thoughts on the important role that AERB had played and also asked AERB to gear up for the challenges in the days to come. This function was marked by a larger gathering with participation by present as well as retired members of AERB. All the retired staff members were presented a memento and a copy of Silver Jubilee book and the two monographs as token of remembrance and affection. Later, in the evening AERB staff club organized a cultural programme with in-house as well external participation.

AERB Silver Jubilee year celebrations had started in November 2007 with a small function which was attended by Chairmen AEC, past Chairmen of AERB, Directors/ Heads of Divisions of AERB, Chairmen of the various committees of AERB and AERB Staff. The new building of AERB, Niyamak Bhavan-B was inaugurated by Prof. A. K. De, the first Chairman of AERB. To treasure the memories of the day, the addresses of Chairman AEC and former Chairmen and Vice Chairmen AERB, were transcribed and included in the AERB Silver Jubilee book. The AERB Code of Ethics and a monograph on Probabilistic Safety Assessment prepared by AERB Staff were released during that function.

Many important activities were organized all through the Silver Jubilee year. During the DAE Safety and Occupational Health Professionals Meet in 2007, a monograph on 'Construction Safety' was released. A seminar on 'Challenges and Innovation in Fire Safety' was organized during the annual fire safety award distribution function. A

monograph on "Fire Safety" was also released during the seminar. A two-day discussion meet on 'Emergency Exercises by NPPs-Site and Offsite: Challenges and Constraints' was organized at SRI Guest House, Kalpakkam.



A view of the audience at the function to celebrate AERB Silver Jubilee Year

(Seated in front row, L to R: Dr. S.K. Jain, CMD, NPCIL, Dr. S. K. Banerjee, Director, BARC, Dr. Anil Kakodkar, Chairman, AEC & Secretary, DAE and Shri. S. K. Sharma Chairman, AERB)

A series of bilateral meetings were organized during the year between AERB and International Regulatory Bodies. In the month of February 2008, AERB - USNRC Safety Discussion Meet was organized under the on-going nuclear safety co-operation programme between the two regulatory bodies. A workshop on Information Exchange on Nuclear Safety between AERB and Rostaknadzor, the regulatory body of Russian Federation, was organized in March 2008. In the month of May 2008, as part of AERB - ASN (French Regulatory Body) collaboration in reactor safety, a seminar on 'Pressurized Water Reactors' was organized.

AERB organized a series of special lectures by its Board Members. The first in the series was delivered by Prof. J. B. Joshi on "Insights into Theories of Turbulence and Heat Transfer". Dr. (Ms) K. A. Dinshaw delivered a lecture on "Early Detection and Screening of Cancers: Lessons Learnt" and Dr. K. V. Raghavan delivered a talk on "Recent Advances in Chemical Industries with the Case Study of Nagothane Explosion". In addition, there was also a thought provoking lecture by Dr. R. A. Mashelkar, former Director General, CSIR on "Indian Innovation : From Gandhi to Gandhian Engineering" which emphasized on the principle of producing more from less, and for more people.

Apart from these special events organized during for the Silver Jubilee year, several awareness programmes and workshops were also organized. To create awareness about consignments containing radioactive material, AERB

organized a one day awareness programme on radiation safety for safe transport of radioactive material for air and sea carriers. In order to educate the operators of X-ray baggage inspection system at airports on radiation safety aspects, AERB organized a one day awareness programme on the subject and also a one day workshop for X-ray machine manufacturers/suppliers on regulatory control of diagnostic X-ray equipment and installations. A workshop for paramedical staff was organized at NFC, Hyderabad.



Release of AERB Monographs on Siting & Seismic Safety of NPPs on the Occasion of AERB Silver Jubilee Year Celebration (L to R: Shri S.K. Sharma, Chairman, AERB, Shri S.D. Soman, Ex-Chairman, AERB, Dr. Anil Kakodkar, Chairman, AEC, Dr. A.K. De, Ex-Chairman, AERB and Shri S.K. Chande, Vice-Chairman, AERB)

As a culmination of the Silver Jubilee year celebrations of AERB that coincided with the start of the birth centenary year of Dr. H. J. Bhabha, an International Conference on "Topical Issues in Nuclear Installation Safety: Ensuring Safety for Sustainable Nuclear Development" was organized in collaboration with IAEA.

15.2 QUALITY MANAGEMENT SYSTEM (QMS) OF AERB

AERB has identified the following three processes under the scope of its Quality Management System (QMS)

- i) Consenting Process of Nuclear and Radiation Facilities
- ii) Regulatory Inspection of Nuclear and Radiation Facilities
- iii) Development of Safety Codes, Standards and Guides

QMS of AERB was awarded IS/ISO 9001:2000 certification on 15th November, 2006. AS per the requirement of the certification the following periodic monitoring and measures to improve QMS were taken.

Periodic Monitoring of QMS of AERB:

- Internal audits of different Divisions of AERB were carried out on May 14-16, 2008, November 10 -12, 2008 and

March 24-26, 2009. All the non-conformances and observations raised during the internal audits were discussed in the subsequent post audit meetings held after the audits. Issues which need management guidance were also discussed in the post audit meetings. Necessary actions were taken for compliance of the non-conformances and observations.

- Two management review meetings were held, one on October 29, 2008 and the other on December 16, 2008 to review the results of internal audits, client feedback and process performance of the QMS. In the review meetings, decisions like framing of measurable quality objectives, analysis of data, quarterly review of pending issues of consenting process and regulatory inspection process and preparation of minutes of safety committee meetings in standard format were taken.
- Second Surveillance audit of the QMS of AERB was carried out by Bureau of Indian Standard (BIS) on January 7-8, 2009.

Measures for improvement of QMS of AERB

- Two new Level-II documents, one on procedure for consenting process of new projects and the other on procedure for consenting process for operating plants/facilities have been issued.
- Safety committee meeting minutes are now being prepared in the standard format developed for the purpose.
- AERB has decided that feedback on consents issued will be obtained from the licensee after commissioning of a nuclear power project and nuclear fuel cycle facility. Feedback on regulatory inspection will be sought on selected installations once in a year. In case of radiation installations, feed back will be sought once in a year from a few randomly selected installations.
- A separate report will be prepared by individual Divisions for pending issues of regulatory inspection of different facilities at the end of the year and the same will be forwarded to the facility for necessary action.

15.3 AWARDS

Dr. R. M. Nehru, SO/F, ITSD has been awarded the Prof. Rathinasabapathi Endowment Oration and a Citation for the year 2008 for his contribution in the field of Medical Physics at the Annual Conference of the Association of Medical Physicists of India (Tamil Nadu & Puducherry-Chapter) held at Puducherry, Tamil Nadu on December 20, 2008.

APPENDIX

PUBLICATIONS

A. JOURNALS

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- M. Ramakrishnan, A. John Arul, S. Usha and C. Senthil Kumar, "Estimation of Station Blackout Frequency for Indian Fast Breeder Test Reactor", *Annals of Nuclear Energy*, Vol.35, Issue 12, 2008.
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- K. V. Subbaiah and R. Sarangapani, "IGSHIELD: A New Interactive Point Kernel Gamma Ray Shielding Code", *Annals of Nuclear Energy*, Vol. 35, pp2234-2242, 2008.
- T. Sajith Mathews, A. John Arul, U. Parthasarathy, C. Senthil Kumar, M. Ramakrishnan and K.V.Subbaiah, "Integration of Functional Reliability Analysis with Hardware Reliability: An application to Safety Grade Decay Heat Removal System of Indian 500 MWe PFBR", *Annals of Nuclear Energy*, Vol.36, Issue 2, 2009.
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- Munish Kumar, G. Sahani, R.K. Kher, Kanta Chhokra, "Studies on the Response of the TLD Badge for High Energy Photons", *Radiation Protection Dosimetry*, 128 (3),266-273, 2008.

B. INTERNATIONAL CONFERENCES

- S.K. Warriar, "Surveillance Programme for KK-NPP RPV Materials" in AERB-ASN Seminar held at AERB during May 27-29, 2008.
- S.K. Chande and R.I. Gujrathi, "Report of AERB", 15th Annual Meeting of WWER Forum, Kiev, Ukraine, Jul. 7-9, 2008.
- Ravi K, Ritu J. Singh and S.K. Gupta "Structural Integrity of Nuclear Fuel Bundle", Interquadrennial Conference of the International Conference Congress on the Fracture (IQCICF-2008), Aug. 2008
- R. Srinivasa Rao and S. K. Gupta, "Safety Assessment of Proposed Plant Modification for PHWR Containment with respect to Hydrogen Mitigation", J4-TM-33415-IAEA Technical Meeting on the Use of Safety Margins and Advanced Safety Assessment Methods in Plant Modifications Budapest, Hungary, Sep. 2008.
- R. B. Solanki, M. Prasad, S. K. Pradhan, U. K. Paul and S. K. Gupta, "Some Considerations of Probabilistic Safety Assessment in NPP Design", The 7th International Topical Meeting on Nuclear Reactor Thermal Hydraulics, Operation and Safety, NUTHOS-7, Seoul, Korea, Oct. 5-9, 2008.
- H. Seshadri, E. Jayashree, P. K. Sinha, and Veda Ramaswamy, "Photocatalytic Degradation of EDTA using Nanocrysatalline anatase titania". *International Conference on Frontiers in Chemical Sciences*, Chennai, Oct. 2-4, 2008.
- S.K.Gupta, Ritu.J.Singh and Ravi.K., "Core Disassembly Progression of PHWRs", *Technical Meeting on Severe Accidents, Accident Management and PSA Application for PHWRs*, Mississauga, Canada, Nov. 10-13, 2008
- R.I. Gujrathi and K. Suneet, "Regulatory Review of Novel Design Safety Features of Kudankulam NPP", 'IAEA International Conference on Topical Issues in Nuclear Installation Safety' , Mumbai, Nov. 17-21, 2008.
- G. Sahani, Munish Kumar, P. K. Dash Sharma, Kanta Chhokra and S. P. Agarwal, "Radiation Shielding for Helical Tomotherapy Facility" *International Conference on Engineering and Physical Sciences in Medicine and the Australian Biomedical Engineering*, Christchurch, New Zealand, Nov. 17-20, 2008.
- A.U. Sonawane "Response Studies of Three Different Dosimeters for Skin Entrance Dose Measurements using Diagnostic X-ray Machines", *International Conference on Medical Physics-2008 (ICMP-2008)*, Mumbai Nov. 26-29, 2008.

- P. Tandon "Dosimetry of a Newly Developed Y-90 Patch for Superficial Brachytherapy" International Conference on Medical Physics-2008 (ICMP-2008), Mumbai Nov.26-29, 2008.
 - K.V. Subbaiah, L. Thilagam "BrachyTPS: An Interactive Point Kernel Code for Brachytherapy Planning System", International Conference on Medical Physics and Radiation Safety, ICMP-2008, Mumbai, Nov. 26-29, 2008.
 - G. Sahani, Munish Kumar, Rajesh Kumar, P. K. Dash Sharma, S.D. Sharma, S. P. Agarwal and R. K. Kher, "Shielding adequacy and radiation safety performance of Bhabhatron-II Telecobalt Unit", International Conference on Medical Physics (ICMP-2008), Mumbai, Nov. 26-29, 2008.
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- C. NATIONAL CONFERENCES**
- Sunil Kumar, "Design of Passive and Active Neutron Monitors for Accelerator Application Using Monte Carlo" National Seminar on Radiation and Materials (NSRM08), Patiala, Mar. 10-11, 2008.
 - Dhanesh B. Nagrale, "Fire Analysis Of Lub Oil Storage Room Similar to that of TAPS-3&4 Using Fire Dynamic Simulator (FDS) Code", Seminar on 'Challenges & Innovations in Fire Safety', Mumbai Apr. 29-30, 2008.
 - R. Bhattacharya, "Environmental Awareness, Legislations and Regulations", Proceedings of 16th National Symposium on Environment, Jun. 2008
 - A.U. Sonawane, Amit Sen, D.M. Rane and Alok Pandey, "Regulatory Aspects and Radiological Surveillance for Industrial Radiography at Nuclear Power Plants / Projects", National Seminar on Innovations in Radiation Protection at Nuclear Power Plants and Nuclear Facilities, Tarapur, Jun. 18-19, 2008.
 - T.Uma Maheswaran, P. Sasidhar, and S.E.Kannan, "Modeling of unconfined aquifer at Kalpakkam plant site", Sixteenth National Symposium on Environment (NSE 16), Hissar, Jul. 16-18, 2008.
 - R. Deepthi Rani, P. Sasidhar and S.E. Kannan, "Characterization of Colloids Present in Kalpakkam Groundwater", Sixteenth National Symposium on Environment (NSE 16), Hissar, Jul. 16-18, 2008.
 - Om Pal Singh and Vaibhav P. Gholap "Knowledge Management in AERB", "Role of IT enabled Knowledge Management in Growth of India", Kalpakkam Jul. 24-26, 2008.
 - Vaibhav P. Gholap and Om Pal Singh "Development of Knowledge Portal and Knowledge Preservation Methods in AERB", Role of IT enabled Knowledge Management in Growth of India", Kalpakkam, Jul. 24-26, 2008.
 - Ajai S. Pisharady and Prabir C. Basu, "Approaches for Seismic Fragility", Indo-Japan Theme Meeting - 2008 on Earthquakes, Tsunami and Disaster Management, Bangalore, Aug. 28-29, 2008.
 - Shivaramu, N. Chitra, R. Indira, L. Thilagam and K.V. Subbaiah, "Monte Carlo Simulation of Gamma Ray Scattering for Evaluation of Embedded Corrosion of Mild Steel in Concrete", NDE-2008, Mumbai, Dec. 1-3, 2008.
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ANNEXURE

LIST OF ABBREVIATIONS

ACI&FS	: Advisory Committee on Industrial & Fire Safety	CESCOP	: Civil Engineering Safety Committee for Operating Plants
ACRS	: Advisory Committee on Radiological Safety	CFD	: Computational Fluid Dynamics
ACNS	: Advisory Committee on Nuclear Safety	CHF	: Critical Heat Flux
ACOH	: Advisory Committee on Occupational Health	CIIRI	: Committee for Investigation of Industrial Radiography Incidents
ACPSR	: Advisory Committee for Project Safety Review	CJR	: Condensation Jet Reactor
ACPSR-FCF	: Advisory Committee for Project Safety Review for Fuel Cycle Facilities	CLRI	: Central Leather Research Institute
AEC	: Atomic Energy Commission	CMD	: Chairman & Managing Director
AERB	: Atomic Energy Regulatory Board	CMG	: Crisis Management Group
AFFF	: Advanced Fuel Fabrication Facility	CNS	: Convention on Nuclear Safety
ALARA	: As Low As Reasonably Achievable	CORAL	: Compact Reprocessing of Advanced Fuels in Lead Cells
ALPAS	: Automatic Liquid Poison Addition System	CPRI	: Central Power Research Institute
AMD	: Atomic Minerals Directorate for Exploration and Research	CRCS	: Control Room Computer System
ASN	: Nuclear Safety Authority	CSED	: Civil and Structural Engineering Division
ATR	: Action Taken Report	CSRP	: Committee for Safety Research Programmes
BARC	: Bhabha Atomic Research Centre	CT	: Computed Tomography
BARCOM	: BARC Containment Model	DAE	: Department of Atomic Energy
BCD	: Bleed Condenser Device	DEM	: Digital Elevation Model
BDBA	: Beyond Design Basis Accident	DFRP	: Demonstration Fast Reactor Fuel Reprocessing Plant
BEXD	: Boron Enrichment Exchange Distillation	DG	: Diesel Generator
BHAVINI	: Bhartiya Nabhkiya Vidyut Nigam	DGCA	: Director General of Civil Aviation
BIS	: Bureau of Indian Standards	DGFS	: DAE Graduate Fellowship Scheme
BRIT	: Board of Radiation and Isotope Technology	DNBR	: Departure of Nucleate Boiling Ratio
BWR	: Boiling Water Reactor	DP	: Diversified Projects
CC	: Core Catcher	DRS	: Directorate of Radiation Safety
CCC	: Construction Completion Certificate	DSRC	: Design Safety Review Committee
CCF	: Common Cause Failure	EBP	: Extra Budgetary Project
CDA	: Core Disruptive Accident	ECCS	: Emergency Core Cooling System
CEO	: Chief Executive Officer	ECIL	: Electronics Corporation of India Ltd
CESC	: Civil Engineering Safety Committee	EFD	: Experimental Fluid Dynamics
		EMCCR	: En-Masse Coolant Channel Replacement
		EMFR	: En-Masse Feeder Replacement

EMTR	: Emergency Transfer	IICT	: Indian Institute of Chemical Technology
EPR	: Evolutionary Pressurised Water Reactor	INES	: International Nuclear Event Scale
ESL	: Environmental Survey Laboratory	IPCL	: Indian Petrol Chemical Ltd.,
EVS	: Eigenvalue Separation	IQS	: Improved Quasi Static
FAC	: Flow Assisted Corrosion	IREL	: Indian Rare Earths Limited
FBR	: Fast Breeder Reactor	IRS	: Incident Reporting System
FBTR	: Fast Breeder Test Reactor	IRV	: Instrumented Relief Valve
FCF	: Fuel Cycle Facility	ISI	: In-Service Inspection
FDS	: Fire Dynamics Simulator	ISO	: International Organisation for Standardization
FEP	: Features, Events and Processes	IPSD	: Industrial Plants Safety Division
FHA	: Fire Hazard Analysis	ITSD	: Information & Technical Services Division
FHI	: Fire Hazard Index	JHA	: Job Hazard Analysis
FHS	: Fuel Handling System	JLR	: Jet Loop Reactor
FM	: Fuel Machine	KAMINI	: Kalpakkam Mini
FOAK	: First Of A Kind	KAPP	: Kakrapar Atomic Power Project
FP	: Full Power	KAPS	: Kakrapar Atomic Power Station
FR.	: Frequency Rate	KGS	: Kaiga Generating Station
FT	: Fuel Transfer	KK-NPP	: Kudankulam Nuclear Power Project
FRFCF	: Fast Reactor Fuel Cycle Facility	LEU	: Low Enriched Uranium
FWPH	: Fire Water Pump House	LHGR	: Linear Heat Generation Rate
GIS	: Geographic Information System	LHS	: Linear Heat Sensing
HA	: Hydro Accumulator	LINAC	: Linear Accelerator
HCLPF	: High Confidence of Low Probability of Failure	LMC	: Lead Mini Cell
HEF	: Head End Facility	LOCA	: Loss of Coolant Accident
HTC	: Heat Transfer Coefficient	LOR	: Loss of Regulation
HWB	: Heavy Water Board	LPIS	: Liquid Poison Injection System
HWP	: Heavy Water Plant	LTTM	: Low Trajectory Turbine Missile
HX	: Heat Exchanger	LWR	: Light Water Reactor
IAEA	: International Atomic Energy Agency	MAPS	: Madras Atomic Power Station
ICMS	: In Core Monitoring System	MC	: Monte Carlo
ICSP	: International Collaborative Standard Problem	MDNBR	: Mini Departure from Nucleate Boiling Ratio
IDCT	: Induced Draft Cooling Tower	MIAS	: Multiple Input Alarm System
IFSB	: Interim Fuel sub-assembly Storage Building	MOX	: Mixed Oxide
IGCAR	: Indira Gandhi Centre for Atomic Research	MV	: Main Vessel
IGRED	: Industrial Radiography Exposure Device	MWTP	: Mine Water Treatment Plant
IGRPP	: Industrial Gamma Radiation Processing Plant	NAPS	: Narora Atomic Power Station
		NDT	: Non-Destructive Test

NEA	: Nuclear Energy Agency	QA	: Quality Assurance
NFC	: Nuclear Fuel Complex	QMS	: Quality Management System
NOC	: No-Objection Certificate	RADAS	: Radiation Data Acquisition System
NPCIL	: Nuclear Power Corporation of India Limited	RAPP	: Rajasthan Atomic Power Project
NPP	: Nuclear Power Plant	RAPPCOF	: RAPP Cobalt Facility
NPSD	: Nuclear Projects Safety Division	RAPS	: Rajasthan Atomic Power Station
NRSC	: National Remote Sensing Agency	RB	: Reactor Building
NSDF	: Near Surface Disposal Facility	RCC	: Reinforced Cement Concrete
NTC	: Nuclear Training Centre	R&D	: Research and Development
NUOFP	: New Uranium Oxide and Fabrication Plant	RI	: Regulatory Inspection
OCDF	: Orientation Course for DGFS Fellows	RPV	: Reactor Pressure Vessel
OCRP	: Orientation Course for Regulatory Processes	RRCAT	: Raja Ramanna Centre for Advanced Technology
OECD	: Organisation for Economic Cooperation & Development	RRS	: Reactor Regulating System
OJT	: On Job Training	RS	: Remote Sensing
OLIC	: Official Language Implementation Committee	RSD	: Radiological Safety Division
OPSD	: Operating Plants Safety Division	RSO	: Radiological Safety Officer
OSCOM	: Orissa Sand Complex	RTI	: Right to Information
OSEE	: Off-site Emergency Exercises	SADD	: Safety Analysis & Documentation Division
PCCS	: Passive Containment Cooling System	SAR	: Safety Analysis Report
PDSC	: Project Design Safety Committee	SARCAR	: Safety Review Committee for Applications of Radiation
PEE	: Plant Emergency Exercises	SARCOP	: Safety Review Committee for Operating Plants
PFBR	: Prototype Fast Breeder Reactor	SBLOCA	: Small Break Loss of Coolant Accident
PHRS	: Passive Heat Removal System	SC	: Safety Code
PHT	: Primary Heat Transport	SC	: Safety Committee
PHTS	: Primary Heat Transport System	SCR	: Supplementary Control Room
PHWR	: Pressurised Heavy Water Reactor	SCURF	: Safety Committee for Investigation of Unusual Occurrences in Radiation Facilities
PIV	: Particle Image Velocimeter	SCWR	: Super Critical Water Cooled Reactor
PPF	: Process Plant Facility	S/D	: Shutdown
PPP	: Primary Pressurising Plant	SDSS	: Special Decision Support System
PSA	: Probabilistic Safety Assessment	SEC	: Site Evaluation Committee
PSAR	: Preliminary Safety Analysis Report	SEE	: Site Emergency Exercise
PSR	: Periodic Safety Review	SER	: Site Evaluation Report
PSR	: Project Safety Review	SER	: Significant Event Report
PSS	: Primary Shutdown System		

SG	: Safety Guide	TD	: Technical Document
SG	: Steam Generator	TF	: Task Force
SG	: Specialists Group	TG	: Turbine Generator
SGDHRS	: Safety Grade Decay Heat Removal System	TMI	: Three Mile Island
SIMPLE	: Semi Implicit Method for Pressure Linked Equations	TPW	: Tsunami Protection Wall
SLHS	: Small Leak Handling System	Type B (U)	: Type B (Unilateral)
SM	: Safety Manual	UEP	: Uranium Extraction Plant
SPE	: Standard Problem Exercise	UHS	: Uniform Hazards Spectra
SPND	: Self Powered Neutron Detector	USC	: Unit Safety Committee
SRI	: Safety Research Institute	UCIL	: Uranium Corporation of India Limited
S.R	: Severity Rate	USNRC	: United States Nuclear Regulatory Commission
SREH	: Safety Related Electrical House	VECC	: Variable Energy Cyclotron Centre
SRPH	: Safety Related Pump House	VRSC	: VECC and RRCAT Safety Committee
SS	: Stainless Steel	VVER	: Water Water Energy Reactor
SSA	: Site Safety Assessment	WANO	: World Association of Nuclear Operators
SSSC	: Seismic Structures Systems and Components	WG	: Working Group
TAPS	: Tarapur Atomic Power Station	WIP	: Waste Immobilization Plant
		WWER	: Water Water Energy Reactor
		XRD	: X-ray Radiography

INTERNATIONAL NUCLEAR EVENT SCALE (INES)

Level/ Descriptor	Nature of the Events	Examples
7 MAJOR ACCIDENT	<ul style="list-style-type: none"> Major release: Widespread health and environmental effects 	Chernobyl NPP, USSR (now in Ukraine), 1986
6 SERIOUS ACCIDENT	<ul style="list-style-type: none"> Significant release: Likely to require full implementation of planned counter measures 	Kyshtym Reprocessing Plant, USSR (now in Russia), 1957
5 ACCIDENT WITH OFF-SITE RISK	<ul style="list-style-type: none"> Limited release: Likely to require partial implementation of planned counter measures Severe damage to reactor core/ radiological barriers 	Windscale Pile, UK, 1957 Three Mile Island, NPP, USA, 1979
4 ACCIDENT WITHOUT SIGNIFICANT OFF-SITE RISK	<ul style="list-style-type: none"> Minor release: public exposure of the order of prescribed limits Significant damage to reactor core/radiological barriers/ fatal exposure of a worker 	Windscale Reprocessing Plant, UK, 1973 Saint-Laurent NPP, France, 1980 Buenos Aires Critical Assembly, Argentina, 1983
3 SERIOUS INCIDENT	<ul style="list-style-type: none"> Very small release: public exposure at a fraction of prescribed limits Severe spread of contamination/ acute health effects to a worker Near accident, no safety layers remaining 	Vandellos NPP, Spain, 1989
2 INCIDENT	<ul style="list-style-type: none"> Significant spread of contamination/ over exposure of a worker Incidents with significant failures in safety provisions 	
1 ANOMALY	<ul style="list-style-type: none"> Anomaly beyond the authorized operating regime 	
0 DEVIATIONS BELOW SCALE	No safety significance	

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