Annual Report
2000-2001

ATOMIC ENERGY
REGULATORY BOARD
MUMBAI

GOVERNMENT OF INDIA

ATOMIC ENERGY REGULATORY BOARD

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

AERB is supported by the Safety Review Committee for Operating Plants (SARCOP), Safety Review Committee for Applications of Radiation (SARCAR) and Advisory Committees for Project Safety Review (ACPSRs). ACPSR recommends to AERB issuance of authorisations at different stages of plants of the Department of Atomic Energy (DAE), after reviewing the submissions made by the plant authorities, based on the recommendations of the associated Design Safety Committees. The SARCOP carries out safety surveillance and enforces safety stipulations in the operating units of the DAE. The SARCAR recommends measures to enforce radiation safety in medical, industrial and research institutions which use radiation and radioactive sources.

AERB also receives advice from the Advisory Committee on Nuclear Safety (ACNS). This Committee is composed of experts from AERB, DAE and institutions outside the DAE. ACNS advises the Board on generic issues. The administrative and regulatory mechanisms which are in place ensure multi-tier review by experts in the relevant fields available nation wide. These experts come from reputed academic institutions and governmental agencies.

The AERB Safety Research Institute set up at Kalpakkam organises several activities to promote safety research. Besides carrying out research in various safety related topics, SRI holds seminars, workshops and discussion meetings of specialists. AERB Secretariat has eight divisions. The Heads of Divisions constitute the Executive Committee which meets every month with Chairman, AERB in the Chair and takes decisions on important policy matters related to the management of the Board Secretariat.

AERB enforces the following Rules issued under the Atomic Energy Act 1962:

* Radiation Protection Rules, 1971
* Atomic Energy (Working of Mines, Minerals and Handling of Prescribed Substances) Rules, 1984
* Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987
* Atomic Energy (Factories) Rules, 1996
* Atomic Energy (Control of Irradiation of Food) Rules, 1996

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GOVERNMENT OF INDIA
ATOMIC ENERGY REGULATORY BOARD
NIYAMAK BHAVAN
MUMBAI 400 094.

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(From April 1, 2000 To May 19, 2000)

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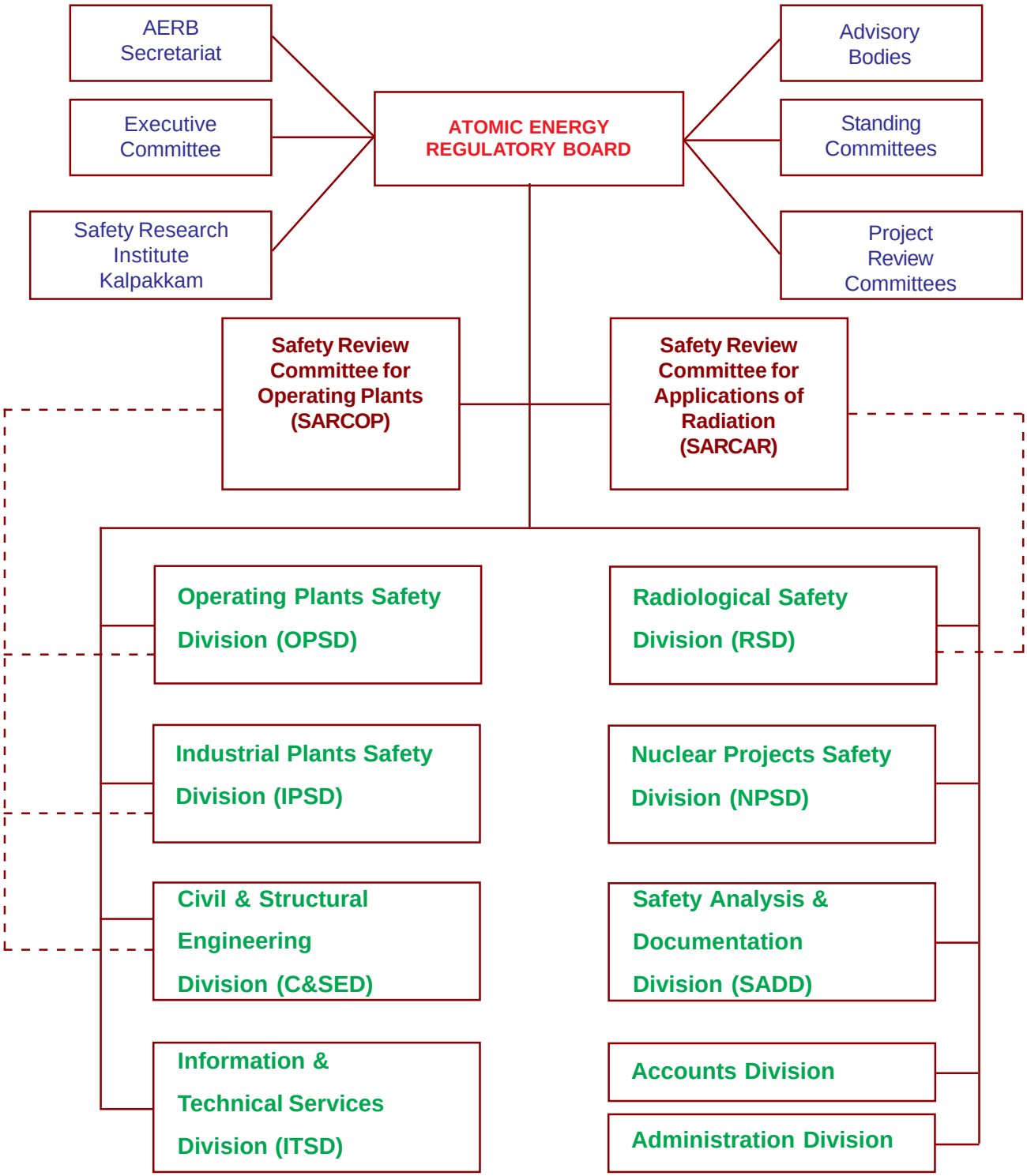
2.	Shri. G.R. Srinivasan Executive Director, OPSD Chairman, Safety Review Committee for Operating Plants (SARCOP) AERB	...	Ex-officio Member
3.	Dr. R.D. Lele Consultant Physician and Formerly Director of Nuclear Medicine, Jaslok Hospital & Research Centre, Mumbai.	...	Member
4.	Dr. S. S. Ramaswamy Formerly Director General, Factory Advice Service & Labour Institutes, Mumbai.	...	Member
5.	Dr. K.S. Parthasarathy Head, Scientific and Technical Services Division, AERB	...	Secretary

COMPOSITION OF THE BOARD
(From May 19, 2000)

1.	Prof. S. P. Sukhatme	...	Chairman
2.	Shri. G.R. Srinivasan Executive Director, OPSD (From May 19, 2000 to January 1, 2001) Vice Chairman, AERB (from January 1, 2001) Chairman, Safety Review Committee for Operating Plants (SARCOP).	...	Ex-officio Member
3.	Dr. R.D. Lele Consultant Physician and Formerly Director of Nuclear Medicine, Jaslok Hospital & Research Centre, Mumbai.	...	Member
4.	Dr. S. S. Ramaswamy Formerly Director General, Factory Advice Service & Labour Institutes, Mumbai.	...	Member
5.	Prof. J.B. Joshi, Professor and Director, University Department of Chemical Technology (UDCT) University of Mumbai, Mumbai.	...	Member
6.	Dr. K.S. Parthasarathy Head, Scientific and Technical Services Division, AERB	...	Secretary

1.2 ORGANISATION CHART

ATOMIC ENERGY REGULATORY BOARD



1.3 SUMMARY

During the year 2000-2001, the activities of the Atomic Energy Regulatory Board, the Board's Secretariat and its specialists' technical committees covered the following chartered functions of the Board:

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

The Atomic Energy Regulatory Board met five times during the year. The Board authorised the Nuclear Power Corporation of India Limited (NPCIL) for the continuous operation of two nuclear power reactors, Unit-2 of the Kaiga Generating Station and Unit-3 of the Rajasthan Atomic Power Station. Two other important events of the year are the permissions given to start Unit-1 of the Kaiga Generating Station and Unit-4 of the Rajasthan Atomic Power Station. These units are working at 100% Full Power. Authorisations for continuous operation will be given after studying the operational history for a period of 90 days at full power. These reactors are pressurized heavy water reactors of 220 MWe capacity. These four reactors have several advanced safety features and meet current international design safety standards.

AERB has approved the site to install the Prototype Fast Breeder Reactor (PFBR) of 500 MWe capacity at Indira Gandhi Centre for Atomic Research at Kalpakkam. A site evaluation committee set up by the Board reviewed the proposal with the help of seven specialist working groups before recommending authorisation. Safety review prior to awarding construction licence is in progress.

During the year, AERB reviewed the status of safety of the Nuclear Fuel Complex (NFC) at Hyderabad. This review was similar to that conducted by the Operational Safety Review Team (OSART) of the International Atomic Energy Agency.

On the basis of a detailed review of the functions of its various technical Divisions, AERB was reorganised during the year. The main purpose of the reorganisation was to combine the functions of safety review, inspection, licensing of personnel and enforcement of stipulations for a unit and assign it to the extent possible to a single Division. This is expected to increase the regulatory effectiveness. Currently AERB has seven Technical Divisions.

The safety status of operating plants of the Department of Atomic Energy was continually monitored by AERB and the Safety Review Committee for Operating Plants (SARCOP). SARCOP met 25 times during the year. All the NPPs, the HWPs and other nuclear and radiation facilities in India were operational except for HWP, Baroda and RAPPCOF. HWP, Baroda was shut down for modifications and RAPPCOF remained closed for major safety upgradation pending renewal of authorisation.

AERB/SARCOP reviewed the status of all the Nuclear Power Plants (NPPs) in India, in the aftermath of the severe earthquake near Bhuj on January 26, 2001. All the plants continued to operate normally during and after the event. The strongest tremors were felt at KAPS, which was nearest to the epicentre of the quake. NPCIL inspected the structures in all their plants including KAPS & TAPS after the seismic event and did not find any damage/defect attributable to the seismic events.

The systems and structures at TAPS and the new NPPs, NAPS, KAPS, Kaiga (KGS) and RAPP-3&4 are designed based on Operating Basis Earthquake (OBE) and Safe Shut down Earthquake (SSE), arrived at, taking into account the seismic potential of the sites. AERB asked NPCIL to examine the older plants (TAPS, MAPS and RAPS 1&2) in the light of currently available seismic information.

Units 1 & 2 of Tarapur Atomic Power Station, Madras Atomic Power Station, Kakrapar Atomic Power Station, Narora Atomic Power Station and Unit 2 of Rajasthan Atomic Power Station operated normally during the year. Unit 1 of Rajasthan Atomic Power Station worked till September 26, 2001. Following a tube leak in moderator heat exchanger 1, the unit was shut down.

AERB directed Tarapur Atomic Power Station to carry out a comprehensive assessment and review of safety for its continued operation. The assessment should consider the actual condition of the plant vis-à-vis present day safety requirements and should cover design basis, safety analysis, feedback from operating experience, ageing and residual life assessment.

Unit-1 of RAPS has so far completed about 6.8 Effective Full Power years and is currently shutdown for repairs of cracks in the North end shield. NPCIL proposed to carry out trial replacement of a few pressure tubes in RAPS-1 and to operate the unit for a limited time to ascertain whether the repaired end shields can withstand the loads caused by the replacement of a few coolant channels. AERB agreed to the proposal and stipulated that RAPS-1 can be operated only up to 7 Effective Full Power years. This is sufficient to monitor the health of the end shields and to establish that the unit can be operated after en masse coolant channel replacement.

AERB staff inspected the operating nuclear power plants and research reactors periodically. The observations made during inspections were categorised into five categories for follow up. AERB issued 19 authorisations and licences during the year. These covered heavy water plants and nuclear power projects.

There were fifty-four safety related unusual occurrences in DAE units. All the events were either not in the International Nuclear Event Scale or of level 0 or 1. There were no events of level 2 or above.

AERB continued to monitor the implementation of the action plans for safety issues in DAE installations. As on February 27, 2001, 119 out of the 134 safety issues identified earlier have been resolved completely. Besides the initial assessment, the staff of AERB verifies whether the resolution of each issue is satisfactory or not during regulatory inspections and review meetings.

Consequent to the decision of the Government of India all regulatory and safety review functions related to Bhabha Atomic Research Centre and its facilities have been transferred from AERB to a safety committee of BARC in May 2000. All pending safety issues related to BARC and its functions were also transferred to BARC.

AERB monitored radioactive releases from various installations and reviewed the radiation exposures to radiation workers. The releases were within the limits prescribed by AERB. The radiation doses to radiation workers indicated near total compliance with the limits prescribed by AERB. For instance, there was only one instance of exposure greater than 30 mSv (the maximum limit prescribed by AERB) among the workers in nuclear power plants. This occurred at Narora Atomic Power Station where a worker received 47.12 mSv. The exposure was not unacceptably high in view of the nature of the work.

AERB administered the provisions of the Factories Act 1948 and Atomic Energy (Factories) Rules 1996 in the Units of the Department of Atomic Energy. Besides carrying out regulatory inspections, AERB also conducted safety promotional activities which includes giving away awards for industrial safety, green site and for fire safety.

As far as non DAE facilities are concerned, Type Approval Certificates were issued, on the basis of extensive analysis, in respect of 296 radiation devices used in medical and industrial installations. AERB issued approval certificates in respect of 116 Radiological Safety Officers. AERB staff inspected nine gamma irradiation facilities and numerous other radiation facilities AERB cleared the sites for two proposed electron beam irradiators and medical accelerators.

During 2000-2001, AERB supported 11 new research projects and renewed 15 ongoing research projects in different institutions. These projects were in reactor kinetics, thermal hydraulics, development of high performance concrete, radiation dosimetry, diagnostic radiology, radiotherapy and radiobiology.

The activities of AERB Safety Research Institute registered good progress. The Institute funded four research projects, three related to atmospheric sciences and one in nuclear safety.

AERB published 11 safety guides during the year.

AERB staff actively participated in the activities of the International Atomic Energy Agency. These included two co-ordinated research projects and participation in Advisory Group Meetings and Technical Committee Meetings. ■

President of India, Shri K. R. Narayanan Conferring Padma Shree Award on Prof S. P. Sukhatme, Chairman, AERB.

SECTION 2

SAFETY SURVEILLANCE OF NUCLEAR FACILITIES

2.1 NUCLEAR POWER PROJECTS

2.1.1 Project Safety Review

Tarapur Atomic Power Project 3&4

The staff of AERB reviewed the Preliminary Safety Analysis Reports for TAPP 3&4 pertaining to the following:

- Containment
- Primary Heat Transport
- Emergency Core Cooling
- Small Leak Handling
- Boiler Pressure Programme
- Reactor Regulation
- Fuel Design

AERB reconstituted the Project Design Safety Committee for TAPP 3&4 in March 2001.

Besides insisting on compliance with AERB Codes and Guides in the respective design basis reports, the Project Design Safety Committee proposed changes in the design of the reactor control system, emergency core cooling system and improvement in the reliability of neutron detector system.

Prototype Fast Breeder Reactor, Kalpakkam

AERB staff started reviewing the design safety of the Prototype Fast Breeder Reactor (PFBR), at Kalpakkam. AERB committee reviewed the Preliminary Safety Analysis Reports related to the following:

- Analysis of postulated events which have a direct bearing on safety
- Quality control in construction and design
- Instrumentation and control
- Reactor operation
- Engineered safety features
- Fire protection system
- Design life of components

AERB set up subcommittees and specialist groups to review all the relevant design documents before issuing authorisations.

Kudankulam Project

The Advisory Committee for Project Safety Review and the Coordination Group handling the project review formulated the methodology to review the relevant safety analysis reports.

The following are among the important recommendations:

- Nuclear Power Corporation was asked to check and certify Russian safety standards vis-a-vis their conformance with AERB's safety requirements, internationally accepted current standards and guidelines.

- The radiation dose limits for members of the public should be applicable at exclusion distance practised in India. Wherever dose limits prescribed by Russian Federation are more restrictive than those prescribed by AERB, the Russian limits should be adhered to.

- Requirements of the latest Quality Assurance Codes and Guides of the International Atomic Energy Agency should be satisfied.

Review of waste management facility for Kudankulam NPP is in progress.

Kaiga Generating Station 1&2 and Rajasthan Atomic Power Project 3&4

The staff also carried out safety review during the design and construction of Kaiga Generating Station (KGS – 1&2) and Rajasthan Atomic Power Project (RAPP– 3&4).

Civil Engineering Safety

AERB reviewed the work related to TAPP 3&4, Kaiga 1&2, Kaiga 3&4 and Prototype Fast Breeder Reactor (PFBR) and the documents related to siting of the plants, excavation, analysis and design and constructability aspects of reactor buildings. On the basis of the review, permission was accorded for commencement of construction of reactor building of TAPP 3&4 above raft level except calandria vault structure, which is under review. Permission to commence the construction of reactor building raft and some other safety related civil engineering structures of TAPP 3&4 had already been accorded. Various dynamic analysis and design reports of safety related civil engineering structures of TAPP 3&4 were also reviewed.

2.1.2 Project Authorisations

KGS Unit-2, which had earlier been authorised for 100% full power operation was given permission to operate at this power level for a period of three years on April 26, 2000.

RAPP Unit-3 which had been earlier permitted to operate at 50% of full power was authorised to raise power up

to 75%, 90% and 100% full power operation in steps. Permission for 100% full power operation for three years was issued on October 31, 2000.

A number of safety applications were cleared during the year. The clearances and authorisations included renewal licences. The following list provides the details of the clearances/ authorisations:

1. Authorisation for continuous operation of Kaiga Generating Station Unit-2 (KGS#2) at 100% FP. (April 26, 2000).

2. Authorisation for Raising Reactor Power of RAPP-3 upto 100% FP. (May 31, 2000).

3. Authorisation for First Approach to Criticality (FAC) and Low Power Physics Experiments for Kaiga Generating Station (KGS) Unit-1 (September 25, 2000).

4. Site Authorisation for Locating 500 MWe Prototype Fast Breeder Reactor at Kalpakkam (October 9, 2000).

5. Authorisation for Continuous Operation of RAPP-3 at 100% F.P. (October 11, 2000).

6. Authorisation for Synchronising, Raising of Reactor Power up to 50% F.P. & Conducting of Associated Phase-C Tests of KGS-1. (October 12, 2000).

7. Authorisation for Heavy Water Addition in RAPP Unit-4. (October 19, 2000).

8. Authorisation for Raising of Reactor Power of Kaiga Unit # 1 beyond 50% and up to 75% F.P. (October 25, 2000).

9. Authorisation for Continuous Operation of RAPP-3 at 100% F.P. (October 31, 2000).

10. Authorisation for First Approach to Criticality (FAC) and Phase-B Low Power Physics Experiments for Rajasthan Atomic Power Project Unit No. 4 (November 1, 2000).

11. Authorisation for Raising of Reactor Power of KGS#1 beyond 75% FP and up to 90% FP. (November 3, 2000).

12. Authorisation for Dry Storage Facility at RAPS (November 8, 2000).

13. Authorisation for Synchronising, Raising of Reactor Power up to 50% F.P. & Conducting of Associated Phase-C Tests of RAPP-4. (November 9, 2000.

14. Permission for Continuous Operation of RAPP Unit-3 November 15, 2000).

15. Authorisation for Raising Reactor Power of RAPP Unit # 4 beyond 75% F.P. and up to 90% F.P. (December 22, 2000).

16. Authorisation for Raising of Reactor Power of Rajasthan Atomic Power Project (RAPP) Unit # 4 up to 100% F.P. (December 29, 2000).

17. Authorisation for Raising of Reactor Power of Kaiga Generating Station (KGS) Unit # 1 up to 100% F.P. (December 29, 2000).

2.1.3 Tests Conducted

Commissioning Tests: Commissioning of unit includes tests of important safety systems related to core cooling, containment, power supply and reactor protection. Procedures for the tests were reviewed and approved by AERB.

***Containment Test*:** The proof and the integrated leakage rate test are done by pressurising the containment to the full design pressure. These tests were carried out for the containment systems of Kaiga Unit-1 and RAPP Unit-4. The limits on leak-rates from containment are approved by AERB.

2.1.4 Regulatory Inspection: Projects

AERB conducted sixteen site inspections covering various stages of construction at TAPP 3&4, examined the status of implementation of the stipulations of AERB relating to construction activities of TAPP 3&4 and followed up with NPCIL to ensure implementation. Personnel from AERB conducted inspections of Kaiga 1&2 and RAPP 3&4 for the verification of Construction Completion Certificates (CCC) of Kaiga 1&2 and RAPP 3.

Various civil engineering aspects of operating plants were reviewed. An inspection of the containment structures of KAPS was conducted. AERB constituted a task force for seismic safety assessment of existing plants. The task force carried out a review of documents submitted to AERB in relation to the development of review basis ground motions and the seismic qualification of structures.

2.1.5 Industrial Safety

Regulatory inspections on industrial safety aspects were carried out during 2000-2001 under the Factories Act, 1948 and Atomic Energy (Factories) Rules, 1996 in the following Nuclear Power Projects:

a) Rajasthan Atomic Power Project 3&4, Kota 7-8 August 2000

b) Tarapur Atomic Power Project 3&4, Tarapur 19-20 December 2000

Chairman AERB at RAPS 3&4

Chairman's discussion with NPCIL officials at TAPS 3&4 Tarapur

Chairman AERB at RAPS

Preliminary meeting before Regulatory Inspection

Chairman, AERB (Second from left) and Shri. V.K.Sharma Senior Executive Director, NPCIL examining a Sample of the Stressing Cable

The Board meets the senior officials of Nuclear Fuel Complex, (from left to right -Shri S.M. Rao, Dr S.S. Ramaswamy, Shri C. Ganguly, Prof.Sukhatme, Dr .K.S. Parthasarathy, Dr. R.D. Lele, Prof. J.B. Joshi, Shri G.R. Srinivasan,Shri. B. Prakash)

Dr C. Ganguly, Chairman and Chief Executive, Nuclear Fuel Complex briefs the members of the Atomic Energy Regulatory Board.

AERB Visit to NFC on 5-12-2000 & 6-12-2000 NUOFP Control Room

2.2 NUCLEAR POWER PLANTS AND RESEARCH REACTORS

2.2.1 Tarapur Atomic Power Station

TAPS Units-1&2 operated normally during the period April 2000 – March 2001. There were no unplanned automatic SCRAMs (automatic shut down of the units) in both the units. There were also no safety related unusual occurrences in the station during the year.

The systems and structures at TAPS are designed based on Operating Basis Earthquake (OBE) and Safe Shut down Earthquake (SSE), arrived at, taking into account the seismic potential of the site. AERB/SARCOP had asked NPCIL to review/analyse the design/design basis of structures/equipment of the older plants at TAPS to ascertain the extent of seismicity these plants can withstand and to identify the need for strengthening and retrofitting for seismic qualification at these plants. Presently these reviews are in progress. Based on these reviews, it will also be possible to identify the seismic instrumentation required to be incorporated at these units.

Continued Long-Term Operation of TAPS

TAPS Units-1&2 have completed more than thirty years of operation so far. The safety standards for nuclear power plants have undergone considerable evolution and development since these plants became operational in 1969. Therefore, AERB directed TAPS to carry out a comprehensive assessment and review of safety for continued long-term operation of TAPS. This assessment should take into account the actual condition of the plant vis-a-vis present day safety requirements and cover design basis, safety analysis, operating feed back experience and ageing and residual life assessment. Taking into account the quantum of work and the time commitment for this comprehensive assessment and reviews, AERB had issued an interim authorisation for operation of TAPS for a period of two years, up to May 31, 2002.

Core Shroud Inspection in TAPS

AERB had directed TAPS to take up inspection of the welds of core shrouds of TAPS units. (Core shroud in Boiling Water Reactors like TAPS, is an integral structure of the reactor that gives alignment to the fuel bundles and separates the incoming cooling water from the hot water at reactor outlet). This directive was issued in light of the information that cracks occurred in the core shrouds of some of the Boiling Water Reactors in USA in the early 1990s. Pursuant to this directive, TAPS had been carrying out inspection of the accessible welds of core shrouds in both the units of TAPS during their refuelling outages since 1996. During the 16th refuelling outage of TAPS unit-2 from July 16, 2000 to September 13, 2000, the accessible welds of the core shroud were inspected by visual and ultrasonic testing. No abnormalities have so far been noticed in core shrouds of either units of TAPS.

2.2.2 Rajasthan Atomic Power Station

RAPS Unit-1 operated normally till September 26, 2000. Unit-2 operated normally through out the year 2000-2001.

Following a tube leak in moderator heat exchanger-1 in September 2000, RAPS Unit-1 was shut down. Subsequently during shut down, on October 4, 2000, the north side end shield of this reactor developed a light water leak. Investigation on the leak and rectification of the water leak from end shield are in progress and pending this, the reactor continues to be under shut down.

The systems and structures at RAPP-3&4 are designed based on Operating Basis Earthquake (OBE) and Safe Shut down Earthquake (SSE), arrived at, taking into account the seismic potential of the sites. However, in the older plants at RAPS, the ground motion considered as design basis is not known. AERB/SARCOP had asked NPCIL to review/analyse the design/design basis of structures/equipment of the older plants at RAPS to ascertain the extent of seismicity these plants can withstand and to identify the need for strengthening and retrofitting for seismic qualification at these plants. Presently these reviews are in progress. Based on these reviews, it will also be possible to identify the seismic instrumentation required to be incorporated at these nuclear power plants.

Cracks in the End Shields in RAPS Unit-1

The end-shields in Pressurized Heavy Water Reactors (PHWR) perform the dual function of supporting the coolant channels and providing radiation shielding on both sides of the reactor. The end shields of RAPS Unit-1 are made of 3.5% Nickel-Carbon Steel. The south end shield of RAPS Unit-1 had developed cracks on the calandria side tube sheet on a few lattice locations during 1981-89, after the reactor had operated for about 3.6 Effective Full Power Years (EFPY). These cracks had resulted in leakage of light water from the end shield cooling system into the calandria vault. The cracks were attributed to radiation embrittlement of the calandria side tube sheet end of the shield and the residual stress caused by the local repairs carried out at certain lattice locations, at the time of construction. After repair of the leaks with special seal plugs, RAPS Unit-1 operated at a reactor power level of 50% full power, to minimise the stress levels in the end shields. Since 1989 (4.28 EFPYs) no further cracks have developed in the south end shields. From 1997 onwards RAPS Unit-1 was operated at 75% FP after detailed assessments.

After operation of the unit for about 6.8 Effective Full Power-Years (EFPYs), on October 04, 2000 when the unit was under shut down condition, a new leak developed in the north end shield of RAPS Unit-1. Two cracks were found in the calandria side tube sheet of the north end shield ligaments between certain lattice locations. These locations in the north side end shield were also subjected to local repairs earlier at the time of construction. Rectification of the water leaks by

installing suitable seal plugs on the cracks is now in progress. On satisfactory completion of repairs and other jobs related to life management of coolant channels, the unit can be restarted.

NPCIL/RAPS has developed sufficient experience and know-how for installing sealing plugs on the end shield cracks and carry out the necessary repairs. The leaks from the end shield have not posed a safety problem so far. However, they contribute to the down time of the reactor and loss of lattice positions in the reactor core due to installation of plugs.

Apart from RAPS Unit-1, two other reactors i.e. RAPS Unit- 2 and MAPS Unit-1 employ end shields of 3.5% Nickel-Carbon Steel material which is prone to irradiation embrittlement. However, NPCIL has clarified that no local repairs had been carried out in the end shields of RAPS Unit-2 or MAPS Unit-1, and as such chances of development of cracks in these end shields are remote.

Tube Leak in Moderator Heat Exchanger of RAPS Unit-1 on 26.9.2000

During the period 2000-2001, there was one incident of release of tritium activity (about 43 curies) from RAPS to Rana Pratap Sagar (RPS) lake, on September 26, 2000. Following the incident, the unit was shut down and the leaky heat exchanger was isolated. The activity released was well within the limits stipulated by AERB for discharge of radioactivity from RAPS to RPS lake. As a follow up of this incident and the earlier recommendations, AERB reviewed the state of health of heavy water heat exchangers and the action plan for replacement of degraded heat exchangers at RAPS. The procurement action to replace a number of heat exchangers is in progress and will be completed by 2002.

Status of Pressure Tubes in RAPS Unit-1

In Pressurized Heavy Water Reactors (PHWRs), the fuel bundle and the heavy water coolant are contained in Pressure Tubes (also called Coolant Channels). The RAPS reactors employed pressure tubes of zircaloy-2 material, which after prolonged use, are prone to degradation due to embrittlement caused by hydrogen pick up in reactor environment. The zircaloy pressure tubes may have a maximum life of about 12 to 15 reactor full power years, if the pressure tube and the associated calandria tube do not contact each other. If contact occurs, the pressure tube could be at risk of failure even at an earlier stage, through the phenomena of blister formation and cracking. This necessitates periodic assessment of health of pressure tubes in the reactor by in-service inspection, post irradiation examination of some pressure tubes removed from the reactor and theoretical estimation of hydrogen pick up and blister growth in the pressure tubes.

RAPS Unit-1 has so far completed about 6.8 EFPYs of operation and is presently remaining shut down for repairs of cracks in the north end shield. So far no in-service inspection or life assessment of pressure tubes has been carried out in RAPS Unit-1. Moreover, the initial hydrogen content of the pressure tubes in RAPS Unit-1 is not known. In view of this, 'En-masse Coolant Channel Replacement' is identified as the only meaningful life management strategy for coolant channels of RAPS Unit-1. Nuclear Power Corporation has proposed to carry out trial replacement of a few pressure tubes in RAPS Unit-1 during the current shut down and operate the unit for a limited time to ascertain whether the repaired end shields can withstand the loads caused by the replacement of the few coolant channels, before taking up en mass coolant channel replacement. AERB agreed to this proposal stipulating that RAPS-1 can be operated only up to 7 EFPYs. It is considered that operation of the unit for a limited period of a few months may be sufficient to monitor health of the end shields and to establish feasibility of post coolant channel replacement operation of the unit.

2.2.3 Madras Atomic Power Station

During the year MAPS Unit–1 completed 8.1 EFPYs and operated normally, MAPS Unit-2 also operated normally.

MAPS Unit-1 was shut down on January 2, 2000 to undertake extensive pressure tube life management activities such as inspection, scrape sampling, garter spring repositioning etc. After completion of these activities and necessary assessments, the unit was restarted on June 03, 2000 and is presently operational.

The systems and structures at the new NPPs, are designed based on Operating Basis Earthquake (OBE) and Safe Shut down Earthquake (SSE), arrived at, taking into account the seismic potential of the sites. However, the ground motion considered as design basis of MAPS is not known. AERB/SARCOP had asked NPCIL to review/analyse the design/design basis of structures/equipment of MAPS, to ascertain the extent of seismicity these plants can withstand and to identify the need for strengthening and retrofitting for seismic qualification at these plants. Presently these reviews are in progress. Based on these reviews, it will also be possible to identify the seismic instrumentation required to be incorporated at these nuclear power plants.

Health of Pressure Tubes

By end of March 2001, MAPS Unit 1&2 have completed about 8.6 and 8.0 EFPY of operation respectively.

Based on extensive review of the results of the pressure tube life management activities carried out in MAPS Unit-1, during January – May 2000, which included in-service inspection (ISI), post irradiation examination, pressure tube life extension achieved through garter spring repositioning and the assessment of fitness of pressure tubes for service, AERB cleared operation of MAPS Unit-1 up to 9 EFPY. MAPS Unit-2 may complete 9 EFPY in July 2001.

Based on the results of in-service-inspection (ISI) of coolant channels and health assessments carried out in MAPS Unit-2 in March- April 1999, SARCOP had cleared operation up to 7.5 EFPY. After MAPS Unit- 2 had completed 7.5 EFPY

of operation in July 2000, the status of health of coolant channels was re-assessed based on the results of the earlier ISI and the new inputs from post irradiation examination of coolant channels and Non Intrusive Vibration Diagnostic Testing of MAPS Unit-2 coolant channels. Based on these reviews, AERB extended the permission for operation of MAPS Unit-2, in two stages, up to 8.0 EFPY.

Failure of a Dry-Quarantined Pressure Tube in MAPS Unit-1

One of the coolant channels of MAPS Unit-1, channel O-14 was removed from service after the In service Inspection (ISI) campaign in 1998, as this channel got some scratches while attempting repositioning of garter springs. The channel was removed from service by dry quarantining, i.e. leaving the reactor core in dry condition after defueling.

During the outage of MAPS unit-1 in January – March 2000, the status of the channel O-14 was monitored. An abnormal elongation by about 60 mm was observed. Hence it was decided to remove this channel from the reactor. When the channel was being cut and removed, it broke into pieces while it was still inside the reactor. The broken pieces and the debris of the failed coolant channel were retrieved from the reactor after developing special procedures and tools. These activities had resulted in collective dose of about 1.40 person Sv. The reason for failure of this pressure tube is suspected to be the extensive oxidation of the pressure tube material during reactor operation. This failure, however, did not have any implication with respect to safety of continued operation of the reactor.

Steam Generator Tube Leak

On June 16, 2000, when MAPS Unit-1 was operating at 175 MWe, a tube leak occurred in one of the heat exchangers of Steam Generator (SG) # 1. The leak-rate was estimated to be about 1.25 kg/hr. About 113.5 Curies of tritium activity was estimated to have been released to the environment through liquid route due to this tube leak. After isolating the leaky heat exchanger, the boiler was put back in service.

Earlier, AERB/SARCOP reviewed the incidents of steam generator tube leaks in MAPS reactors. There have been 25 incidents of leak from steam generator. (None of these leaks resulted in environmental release of radioactivity above the limits prescribed by AERB) The metallurgical examinations carried out in some of the leaked tubes showed that there was under deposit corrosion and pitting leading to thinning of walls and tube leaks. MAPS has implemented continuous blow down of steam generators and installed on line monitors to detect tube leak promptly. Further, MAPS is working out a scheme to replace affected heat exchangers.

2.2.4 Narora Atomic Power Station

Both the NAPS units operated normally during the year.

The systems and structures at NAPS are designed based on Operating Basis Earthquake (OBE) and Safe Shut down Earthquake (SSE) arrived at, taking into account the seismic potential of the sites.

Leakage of Heavy Water from Moderator System in NAPS-2

On April 15, 2000, when NAPS Unit-2 was operating, about 7 tons of tritiated heavy water leaked out of the moderator system into the reactor building. The leak occurred due to failure of gasket of a flange joint in the moderator system piping, due to vibration. The unit was shut down and the leak was isolated promptly. Personnel involved in recovery of the spilled heavy water received significant uptakes of tritium activity. However, only one person received radiation exposure beyond the AERB limit of 30 mSv on annual radiation exposure. The persons who received significant uptakes were temporarily re-deployed to prevent them from taking up jobs in radiation areas. The releases of tritium through gaseous route increased temporarily following the incident, though they were well within the limits prescribed in the technical specifications. There was no increase in tritium releases through the liquid route due to this incident.

After investigations on the incident, the station implemented corrective measures to obviate such failures in future. These included instituting periodic checks on the health of the flange joints and pump supports, stiffening and providing additional supports for pumps and pipelines for reducing vibration levels etc. An emergency operating procedure has also been prepared for handling such incidents if they occur without resulting in significant exposures to personnel.

Failure of Sluice Gate of Narora Barrage Resulting in Shut down of NAPS

One of the sluice gates of the Ganga Barrage at Narora failed on November 28, 2000, resulting in lowering of water level in the Barrage. This resulted in non-availability of raw water make up to NAPS, forcing shut down of NAPS Unit-1, which was operating at 220 MWe. NAPS Unit-2 was already under shut down.

The failed sluice gate of the Barrage was restored by the State Irrigation Department by installing a temporary gate. With this, water supply to NAPS was resumed on December 09, 2000. Subsequently, NAPS units were restarted and are operational. The UP State Irrigation Department will take up installation of a regular sluice gate instead of the temporary one presently installed, in April 2001.

2.2.5 Kakrapar Atomic Power Station

Both the KAPS units operated normally during the year.

The systems and structures at KAPS are designed based on Operating Basis Earthquake (OBE) and Safe Shut down

Earthquake (SSE) arrived at, taking into account the seismic potential of the sites.

Light Water Seepage from Calandria Vault in KAPS Unit-1

Since 1998, seepage of light water from the calandria vault to the north side fuelling machine service area is experienced in KAPS Unit-1. This is attributed to weld defects in the liner plates of the vault. The leakage remained in the range of 150-300 kg/day during the last three years. The water is presently coming out in the north fuelling machine service area. The leakage point is inaccessible. This seepage does not have any immediate safety concerns.

Effects of this seepage on the life of the concrete structures, if any, are being studied. Investigations to locate the leakage path are in progress. Schemes are also being worked out to plug the leak paths by "reverse grouting" with a suitable material.

Status of Pressure Tubes

The coolant channel assemblies in PHWR (Pressurised Heavy Water Reactor) employ a set of shock absorbers. These are meant to prevent uncontrolled ejection of pressure tube parts/fuel bundles, in case of a postulated double ended rupture of pressure tube. The movement of these nuts which occurred in 1998-99, had resulted in insufficient margins for free expansion/contraction of the pressure tubes during heat up/ cool down, pressure expansion, creep etc. Hence, AERB directed NPCIL/KAPS to:

- Carry out rigorous analysis on the effect of the extra loading.
- Carry out In-Service inspection of Coolant Channels.
- Restore the necessary margins for free expansion / contraction of all pressure tubes.

The analysis on the effect of the extra loading indicated that the effect on the life of the pressure tube is marginal and the problem may not be of immediate concern. In the annual shut down of KAPS Unit-2, ISI was carried out on nine coolant channels. No flaws in the pressure tubes were detected. The pressure tube wall thickness in all the inspected channels was normal and the garter springs were located at their expected positions. A theoretical analysis has indicated that forces due to restricted expansion cannot create any deformation and presence/absence of low gaps needs to be confirmed by repeat inspection with specially developed tools. NPCIL is developing these tools.

In KAPS Unit-2, sufficient margins for free expansion/ contraction of pressure tubes has been restored by repositioning the shock absorber nuts. This job will be taken up in KAPS Unit-1 in the annual shut down of the unit in 2001.

Status of Tritium Activity Build-up in Plant Environment at KAPS

From 1997 onwards, presence of a small amount of tritium activity in the process water as well as domestic water used in the plant was experienced at KAPS. This was due to partial re-circulation of effluents discharged from the station, to the adjacent Moticher Lake. Sufficient flow of fresh water was not available in the Moticher Lake, due to excessive weed growth, which results in the fresh water flow through the feeder canal bypassing the lake. To overcome this problem, a cross bund was constructed by the State Irrigation Department in Moticher Lake for diverting the canal flow towards plant water intake resulting in the desired dilution and direction of flow. Also de-weeding of the lake is now taken up regularly. These activities have improved the flow in the lake and as a result, the tritium activity level in the domestic water system has dropped below detectable levels.

2.2.6 Indira Gandhi Centre For Atomic Research

Fast Breeder Test Reactor

The Fast Breeder Test Reactor (FBTR) at Kalpakkam was operational up to a maximum power level of 12.9 MWt.

Power Fluctuations in FBTR

During 1998-99, the power of the fast breeder test reactor was found to fluctuate without any movement of the control rods when the reactor was operating at power levels of 7-8 MWt during a special campaign to irradiate Zirconium-Niobium samples for pressurized heavy water reactors. Thorough investigations including a number of experiments and analysis were carried out to ascertain the reasons for the power fluctuations and its implications with respect to safety and stability of the reactor. The power fluctuation phenomenon is found to be reversible, repeatable and self-limiting. The fluctuations were found to occur only under certain combinations of reactor power and primary sodium flows. Geometrical changes of the reactor core existing only under certain process conditions related to primary sodium flow and the temperature gradient across the reactor core appear to be the reason for the power fluctuations observed. These combinations of sodium flow and temperature gradient across the core are not likely to exist during normal operation of the reactor, and hence do not have any implications with respect to regular safe operation of the reactor.

Extension of Burn-up Limit for FBTR Fuel

The fuel used in FBTR consists of a mixture of Plutonium Carbide and Uranium Carbide. Since the experience on performance of this fuel is very limited, irradiation of this fuel is being carried out with utmost care and regular monitoring of the fuel performance. Post irradiation examination (PIE) of irradiated fuel sub-assemblies is being carried out regularly to study the in-reactor behaviour of the fuel and to ascertain the

permissible safe life of this fuel. Based on the results of these studies and assessment of safety margins, the limits on allowable 'fuel burn-up' are extended in steps and AERB/SARCOP has extended the burn-up limit on FBTR fuel up to 88,000 MWd/t.

Industrial Safety

Regulatory inspection on industrial safety aspects was carried out during 2000-2001 in the Fast Breeder Test Reactor.

2.2.7 Regulatory Inspections of Operating Nuclear Power Plants and Research Reactors and Enforcement Actions

Regulatory inspections of operating nuclear power plants and research reactors are carried out periodically. The inspections are of three types.

i) Periodic Inspections covering all areas of operation,

ii) Special Inspections for particular areas of interest, and

iii) Un-announced Surprise/Special Inspect-ions.

These inspections are meant to:

- Check for any unsafe conditions existing at NPP/RR;
- Confirm plant operation as per the approved Technical Specifications and AERB directives;
- Confirm proper maintenance of records/documentation.

During the year, a total of 12 regulatory inspections were carried out on the Operating Nuclear Plants and Research Reactors as summarized in **Table 1**.

Table-1 Regulatory Inspections of Operating Nuclear Power Plants and Research Reactors during 2000-2001

Plant Site	Unit	No. of Inspections
Nuclear Power Plants	TAPS 1&2	2
	RAPS 1&2	2
	MAPS 1 &2	3
	NAPS 1&2	2
	KAPS-1&2	1
Research Reactors	FBTR & KAMINI	2
Total		12

The observations during these inspections were categorized as follows, to facilitate enforcement and follow up.

Category- I Violation of Safety Directives including requirements laid down in Technical Specifications and various Codes/Guides/Standards developed by AERB.

Category - II Safety Review-Related Observations

Category - III Design-Related & Generic Deficiencies

Category - IV Inadequacies in Procedures & their Compliance, Deficiencies in Equipment/Quality Assurance.

Category - V General Observations.

A summary of the various items identified under each category by the inspection teams is given in **Table-2**.

Table- 2 Categorisation of the Findings in Regulatory Inspections

	Cat-I	Cat-II	Cat-III	Cat-IV	Cat-V
TAPS	Nil	6	3	37	35
RAPS	3*	2	2	50	18
MAPS	Nil	8	14	64	52
NAPS	2*	11	8	48	13
KAPS	Nil	Nil	9	34	26
FBTR/ Kamini	Nil	Nil	12	11	32

* Explained in the text.

Some of the major findings during the inspections and the follow-up actions taken are as follows:

1. The frequency and requirements for surveillance/ testing of the safety related equipment/systems of NPPs are stipulated in the Technical Specifications. Some of these tests can be carried out only during shut down of the Unit. Of late, due to continuous stable operation of many of the NPPs for extended periods of time, some of the surveillance tests could not be carried out as per the frequency stipulated in the Technical Specifications. Such instances of non-compliance were brought out during the Regulatory Inspections. Taking note of the number of instances of non-compliance, AERB/SARCOP reviewed this issue in detail and directed NPCIL and all NPPs to (a) make

provisions for carrying out the tests wherever possible, and (b) examine the feasibility of changing the surveillance frequencies where it can be demonstrated that such changes do not affect safety and equipment reliability.

The periodic testing of Relief Valves is a mandatory requirement. There were three instances of non-compliance at RAPS-2 during the year. SARCOP considers that such violations can be condoned if the station submits an application providing suitable justification and assurances by the station. However in the above cases, the Station did not obtain condonation from SARCOP. These three instances are listed as Category-I violations.

2. During one of the regulatory inspections at MAPS, it was found that the performance test of fuelling machine supply pumps had not been carried out for a long time, as the procedure for such testing was not existing. As a result of the follow-up actions taken by the Inspection Team, the Station has prepared necessary procedures and the tests are now being carried out as stipulated.

3. In NAPS, the AERB inspection team noticed that relief valves were not installed on one of the accumulator tanks in the Emergency Core Cooling System (ECCS), even though the design of the accumulator envisaged a relief valve. After this was brought out during the Regulatory Inspection, the Station installed the necessary relief valves on these accumulators. This violation is considered to belong to Category-I. Yet another Category I violation noted at NAPS was that the nitrogen tank pressure of the Emergency Core Cooling System was being maintained at a value less than what was required, due to operational problems. This aspect was reviewed and suitable actions were taken.

4. Based on the recommendations of AERB, NPCIL assessed the corrosion in the pre-stressing cables of reactor buildings of KAPS. The cables were found to be healthy. AERB also recommended grouting of the stressing galleries of KAPS. NPCIL finalised the procedure for this and completed grouting of a quadrant of the stressing gallery.

2.2.8 Waste Management

Atomic Energy Regulatory Board issued new authorisations to 28 DAE installations belonging to NPCIL, UCIL, NFC and BRIT for safe disposal/transfer of radioactive waste, under Atomic Energy (Safe disposal of radioactive wastes) Rules, 1987. Waste disposal authorisation records pertaining to 25 installations coming under BARC were handed over to BARC for processing. Regulatory inspections were carried out to ensure that safe radioactive waste management practices were followed and to verify the waste disposal records. Annual returns of radioactive wastes disposed by the installations or transferred to waste management agencies were reviewed. Authorisations were issued for special radioactive waste disposal campaigns as per the requirements.

2.2.9 Licensing of Operating Staff for Operating Plants and Projects

As part of the responsibility of the regulatory body, operating staff of operating plants is licensed/re-licensed for a specific period to ensure that competent and qualified personnel man these plants. A total of 214 operating personnel were licensed during 2000-2001. As per the directive from AERB, operating personnel for the new generation NPP i.e. Kaiga and RAPS-3 are required to undergo training on a Simulator at Kaiga. The details of the licensing committee meetings are given in **Table-3.**

2.2.10 Periodic Safety Review

Since 1993, AERB has been reauthorising the NPPs every five years based on the review of performance of the NPPs on the preceding five years. The reauthorisation process was governed by the guidelines issued under the name " Safety Assessment Report for Renewal of Authorisation" (SARRA).

Based on the feed back experience of SARRA and to keep in line with other international developments, AERB has now decided to replace SARRA by a Periodic Safety Review (PSR). The guidelines for PSR were issued under Safety Guide titled, "Renewal of Authorisation for operation of NPPs" (AERB/SG/O-12). The requirements of PSR are more exhaustive than SARRA and in addition to review of operational performance include aspects such as:

- Comparison to current standards
- Ageing management
- Safety analysis with latest tools.

The periodicity of such exhaustive PSR was prescribed as nine years unless otherwise warranted by specific circumstances. Accordingly, AERB has issued directives to NPCIL to submit such PSR sequentially as per the schedule laid down. The PSR will commence with the report to be submitted by MAPS 1 & 2 in December, 2001.

2.2.11 Activities of AERB in the field of PSA

Probabilistic Safety Analysis (PSA) has been accepted all over the world as an important tool to assess the safety of a facility. PSA studies the low probability events with high consequences that are beyond the scope of deterministic analysis. The insights obtained from PSA are useful to the regulatory body in taking **risk-informed decisions**. The present policy of AERB is to integrate the PSA based study results into regulatory decision-making in an evolutionary and gradual manner.

Nuclear Power Corporation of India Limited (NPCIL) has submitted PSA studies for Kaiga Generating Station as a part of licensing requirement. Regulatory evaluations of these PSA results are in progress. Similarly, regulatory review of the report on Probabilistic Analysis of electrical supply with

Table-3. Number of Candidates Licensed in Different Capacities

	No. of candidates cleared (Licensing and relicensing)						Licensing committee meetings
	Management	SCE	ASCE	ASCE (F)	CE	CE (F)	
TAPS	-	3	6	-	2	-	2
RAPS	-	4	3	-	12	4	3
MAPS	-	4	5	3	13	1	3
NAPS	-	7	5	2	8	3	2
KAPS	1	8	6	3	7	2	3
KGS	4	7	9	4	14	3	2
RAPS 3&4	-	7	4	3	14	2	3
FBTR/ Kamini	-	4	1	-	6*	-	2
TOTAL	5	44	38	15	76	15	20

Abbreviations used:

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

* In FBTR, the personnel are designated as Control Room Assistants (CRA). Apart from the power plants and research reactor personnel, 42 operating personnel belonging to Heavy Water Plants at Kota, Manuguru, Tuticorin and Thal were also licensed.

augmented Station Black Out Diesel Generator set, for Tarapur Atomic Power Station -1&2 was also carried out. NPCIL is presently carrying out the necessary changes in the PSA report after receiving feedback from AERB.

AERB has constituted a PSA group for developing the regulatory policy on PSA. After taking cognisance of the present developmental work of PSA in India, the state of the art and plant specific failure data, this group prepared a draft approach paper on PSA for regulatory use. This will be finalised into an action plan in consultation with NPC.

2.2.12 Significant Events

Unusual Occurrences and INES Scale Events

In an operating plant, an event resulting in the degradation of function of the structure, system, component or software important to safety and leading to a situation affecting or having the potential to affect the health and safety of the plant personnel and/or the public is called a safety related unusual occurrence. When such an event occurs, the plant has to submit a Safety Related Unusual Occurrence Report on the event (SRUOR). During the period, **54** SRUORs were received from the Nuclear Power Plants. These SRUORs were analysed using the coded watch-list of the Incident Reporting System (IRS) of IAEA for easy correlation and to study the trend, pattern and root causes of these events. This is done to disseminate the summarised information to the concerned plants and for providing operational experience feed back to improve overall safety. A pie diagram showing system-wise break-up in the format of the Incident Reporting System (IRS) developed by the IAEA for NPPs is given in **Figure-1**

The SRUORs received from the operating Indian NPPs are also being analysed on the International Nuclear Event Scale (INES). Feedback information is given to the NPPs in case there is discrepancy in the ratings given by the station and the ratings given by AERB. The break-up of the number of SRUORs and their levels on INES, for the periods, 1998-99, 1999-00 and 2000-01 are given in **Table-4**. Level-1 on INES indicates an anomaly beyond the authorised operating regime which may be due to equipment failure, human error or procedural inadequacies. [The International Atomic Energy Agency classifies nuclear events on the International Nuclear Events Scale (INES) scale of levels 1 to 7. It may be noted that the INES has seven levels of ratings with the highest being 7. The events are classified as incidents or accidents. Events at Levels 1, 2 and 3 are categorised as incidents. Events above 3 are considered as accidents. The accident at Chernobyl Nuclear Power Plant Unit 4 involving core melt down with the consequence of large off-site radioactivity release is considered Level 7. Industrial accidents having no bearing on nuclear safety are not rated on INES and are designated 'out of scale'.

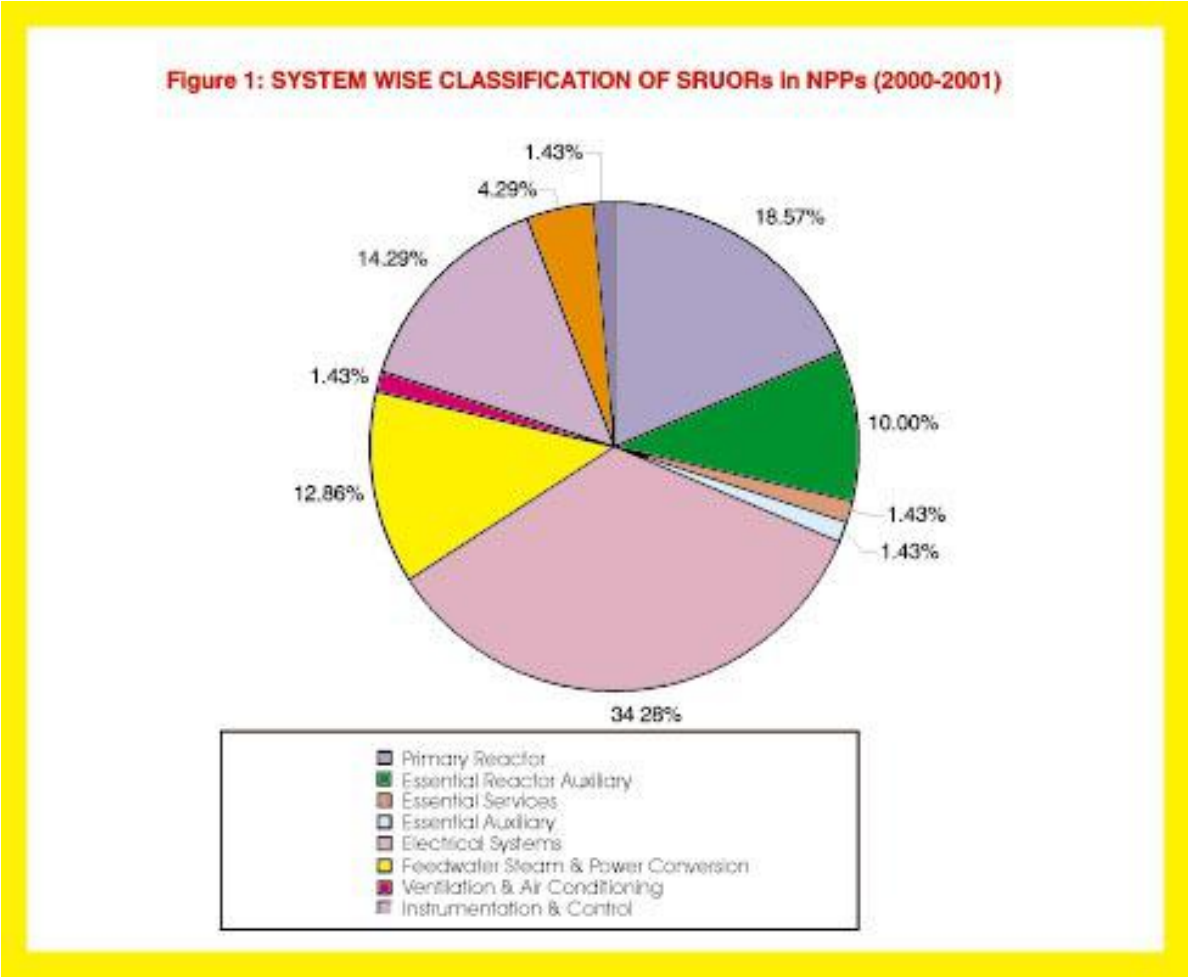


Table - 4 Classification of SRUORs in NPPs as Related on INES

INES Levels	1998-99	1999-2000	2000-2001
Not in the scale	3	3	2
0	22	16	42
1	5	2	10
2	1	0	0
3	0	0	0
>3	0	0	0
Total	31	21	54

Table 4 shows that all the SRUORs in 2000-2001 were either not in the INES scale or of level 0 or 1. There were no SRUOR of level 2 or above.

The Level-1 Incidents are briefly described below:

1. Plant: RAPS-1 Date of Incident: 26/09/2000
   Moderator Heat Exchanger Tube leak (See under Item 2.2.2)

2. Plant: MAPS-2 Date of Incident: 18/12/2000
   Spurious actuation of Emergency Core Cooling System.

During a routine monthly surveillance test, the Emergency Core Cooling System (ECCS) and the associated logic got spuriously actuated. This caused the closure of the Reactor Building Ventilation dampers. On resetting the ECCS, two out of four dampers did not open automatically due to faulty logic relay. After repair, the dampers were checked to be working normally and the system was normalised.

3. Plant: NAPS-2 Date of Incident: 15/04/2000
   Heavy Water Leak from Moderator System
   (See under item 2.2.4)

4. Plant: NAPS Date of Incident: 23/05/2000
   Non-installation of Relief Valve on light water tank in ECCS. (See under item 2.2.7)

5. Plant: NAPS-2 Date of Incident: 16/11/2000
   Obstruction to downward movement of fuelling machine.

After refuelling a coolant channel, the empty fuelling machine during its downward movement hit the bottom shield, and was incapacitated. This could have been a serious incident if the fuelling machine were carrying radioactive spent fuel. The root cause of this incident was a procedural lapse. A safety interlock, which was temporarily made ineffective prior to refuelling for solving another problem, was not normalized. Subsequently, the plant made a permanent modification to avoid repetition of the incident.

6. Plant: NAPS-2 Date of Incident: 21/11/2000
Heavy water leak from seal plug of coolant channel

The unit was in a shut down condition with Pressurized Heat Transport (PHT) system in a cold and depressurised state. It was noticed that heavy water was leaking from a coolant channel due to a defective seal plug. During this incident, two tonnes of heavy water leaked out of the system. A modified temporary blank was inserted to arrest the leak.

7. Plant: NAPS-2 Date of Incident: 01/01/2001
Drifting of spent fuel bundle from magazine chamber to snout of Fuelling Machine

During one of the refuelling campaigns, the hot spent fuel bundle drifted from its position in the fuelling machine magazine to the snout of the machine, which is an abnormal situation. After conducting mock up exercises, the fuel bundle was retrieved and safely discharged into the spent fuel bay.

8. Plant: KAPS-2 Date of Incident: 03/01/2001
Over pressurisation of PHT System during reactor start-up

During start up, failure of pressure control system of Primary Heat Transport caused the system to get pressurized. This resulted in the opening of the Relief Valves.

9. Plant: KAPS-1 Date of Incident: 27/01/2001
Heavy water leak from fuelling machine supply pump

During unit operation, when refuelling of a channel was completed, about five tonnes of heavy water leaked out from the Fuelling Machine supply pump, due to failure of pumps gland. The heavy water spill caused an increase in the tritium activity levels in the accessible areas of the Reactor Building. The leak was arrested immediately and the spilled heavy water was recovered.

10. Plant: KGS-2 Date of Incident: 26/07/2000
Non-Availability of Auxiliary Boiler Feed Pump (ABFP) during restart of reactor.

The Technical Specifications require that both these pumps should be available during start-up. However, in one instance, the unit was started up when one of the ABFP was under maintenance. This amounted to a violation of Technical Specifications. The pump was made operable a day after the start-up.

The plant wise classification of SRUORs (total no 54) for NPPs on INES scale is given in **Table-5.** The number of SRUORs at Kaiga were more because of the initial phase of operation as is normally observed.

Table-5 Classification of SRUORs in Individual NPPs (2000 –2001)

Plant	Not in the scale	International Nuclear Event Scale					
		0	1	2	3	>3	Total
TAPS		0	0	0	0	0	0
RAPS		1	1	0	0	0	2
MAPS		3	1	0	0	0	4
NAPS		7	5	0	0	0	12
KAPS		8	2	0	0	0	10
KGS	1	19	1	0	0	0	21
RAPS3-4		4	0	0	0	0	4
TAPS3-4	1	0	0	0	0	0	1
Total	2	42	10	0	0	0	54

2.2.13 Industrial Safety

Regulatory inspections on industrial safety aspects were carried out during 2000-2001 under the Factories Act, 1948 and Atomic Energy (Factories) Rules, 1996 at the Nuclear Power Plants at Tarapur Atomic Power Station 1-2 and at Madras Atomic Power Station 1-2.

Fire safety inspections were conducted at :

i) TAPS 1-2, PREFRE, WIP and AFFF at Tarapur
ii) RAPS 1-2, RAPP 3-4 and HWP at Rawatbhata

A review of the Fire Protection Systems of NPPs at KAPS and TAPS was also conducted.

2.2.14 Safety Up-gradations in DAE Installations

During the year, AERB continued to monitor the implementation of the action plans for safety issues in DAE installations. The Board reviewed the progress in this activity during its 66th meeting held on May 4, 2000 and its 70th meeting held on February 27, 2001.

On 25.4.2000, Chairman Atomic Energy Commission, issued an office memorandum stating that the regulatory and safety functions at BARC and its facilities will be carried out through an internal safety committee within BARC. Accordingly the pending issues pertaining to BARC were transferred to BARC and are being pursued by BARC.

As on February 27, 2001, 119 out of the 134 safety issues have been resolved completely. The process of implementing the action plan for the remaining safety issues is progressing satisfactorily. The monitoring of the safety status of the installations of DAE is a continuing process. In addition to the initial assessment, the staff of AERB verifies whether the resolution of each issue is satisfactory or not during regulatory inspections and review meetings.

The pending issues coming under the purview of AERB have been classified into four categories.

Category 1: Hardware Related Issues requiring replacement of defective components (3*).

Category 2: Ageing related issues needing elaborate studies to assess the healthiness of various components as well as possible replacement of components which have been showing signs of deterioration(1*).

Category 3: Issues involving analytical studies or computer based calculations on certain systems to assure that the earlier designs are safe (0*).

Category 4: Upgradation Related Issues – Plants that have been built to earlier safety standards require an upgradation according to the current safety standards and this may involve an assessment and modification (6*).

* Number of pending issues

2.3 NUCLEAR FACILITIES OTHER THAN POWER PLANTS/PROJECTS

AERB staff carried out the safety review of various other nuclear facilities and enforced safety provisions in them. These included NFC Hyderabad, Heavy Water Plants, the facilities of the Indian Rare Earths Limited at Orissa, Chavara, Manavalakurichi, Udyogamandal, and UCIL.

2.3.1 Nuclear Fuel Complex, Hyderabad

The plants at NFC Hyderabad operated normally during the year. Fire safety inspections were conducted at NFC, Hyderabad. Some of the safety issues relating to NFC plants identified for follow-up are as follows-

High Airborne Uranium Levels in the Uranium Plants

Some of the plants in NFC carry out processing of uranium and fuel fabrication of nuclear fuel for the reactors. These jobs involve handling of large quantity of uranium oxide power and pellets. Airborne uranium levels in working areas inside these plants have remained high for significant periods, requiring use of respiratory protection to the persons working in these areas. The reasons for this high airborne uranium levels are (a) inadequacies in primary ventilation, (b) manual handling of uranium oxide powder in the open areas (c) insufficient enclosure to the equipment, etc. NFC has initiated certain measures for improving the process and ventilation systems besides mechanization of uranium powder and pellet handling.

Effluent Management

The non-process effluents comprising mainly floor washings, washroom effluents etc. are used for gardening purposes within NFC premises. These effluents are not permitted to be released outside NFC premises, as they are likely to contain traces of impurities such as uranium, nitrates, fluorides etc. Taking this into account, limits have been laid down on the impurities that can be permitted in the garden water. NFC has been directed to ensure that release of water into public domain should be done only after monitoring and ensuring that they conform to the limits stipulated by AERB and the Pollution Control Board. NFC was also asked to upgrade the system and practices for management of these effluents. NFC is working out action plans for improvement of this system.

Resumption of Operations in Zirconium Sponge Plant (ZSP)

The structures and equipment in Zirconium Sponge Plant built and commissioned in 1971 had undergone significant degradation due to corrosion caused by exposure to chemicals. Hence, NFC shut down operations in this plant in April 2000 and had taken up extensive investigations and repair works. NFC completed the repairs.

AERB reviewed the structural integrity of the rehabilitated plant-building and recommended confirmatory study of the repair work and procedure for periodic structural monitoring of the building. NFC implemented these recommendations. AERB permitted resumption of operation in ZSP for a limited period of three years by which time a new plant is expected to be built.

Criticality Safety: Follow-up after the Tokaimura Criticality Accident

After the criticality accident at Tokaimura Fuel Fabrication Plant in Japan on September 30, 1999, AERB reviewed this accident and its relevance in the Indian context, in particular to the plants engaged in fuel fabrication and spent fuel reprocessing. It was noted that these plants in India are designed conservatively with adequate safety margins to ensure that criticality incidents do not occur during operation. These plants are operated by well-trained operators, as per approved procedures and strict administrative controls. However, AERB/SARCOP directed all such plants to carry out an exhaustive

review of design, procedures, documentation, internal audit as well as internal safety review mechanisms, training, administrative controls etc. as a prudent measure. Such reviews have been completed and necessary improvements have been implemented at all the concerned plants.

As a part of this exercise, NFC reviewed the operation of Enriched Uranium Oxide Plant (EUOP) and Enriched Fuel Fabrication Plant (EFFP) at Hyderabad. Based on a preliminary design review, some remedial measures were implemented at EUOP. Out of the three batch precipitation tanks of 900 litres capacity which are located close to each other and used for handling enriched uranium, the middle tank has been removed to maintain a safe distance between the tanks. Water jackets around these precipitation tanks have also been punctured to increase safety margins from any accidental criticality. No modifications were deemed necessary at other plants.

2.3.2 Bhabha Atomic Research Centre

Consequent to the decision of Government of India, all regulatory and safety review functions related to Bhabha Atomic Research Centre (BARC) and its facilities have been transferred from AERB to a safety committee structure of BARC in May 2000. All pending safety issues were also transferred to BARC for further follow-up. With this the safety review responsibility of the BARC facilities located at Trombay, Tarapur, Kalpakkam, etc., are transferred to BARC.

2.3.3 Rajasthan Atomic Power Project Cobalt Facility (RAPPCOF)

Operations at RAPP Cobalt Facility (RAPPCOF) remained suspended as directed by AERB after an incident of excessive radiation exposure took place in 1999-2000. The investigations into this incident indicated gross deficiencies with respect to hardware, safety provisions, administrative controls, etc. Taking note of these, AERB directed that operations at the facility should be resumed only after safety upgradation/ improvements and a thorough review and authorisation of the facility. Presently the safety upgradation activities are in an advanced stage of completion.

2.3.4 Accelerator Facilities

Regulatory inspections on industrial safety aspects were carried out during 2000-2001 under the Factories Act, 1948 and Atomic Energy (Factories) Rules, 1996 at the following DAE facilities:

a) Centre for Advanced Technology, Indore

b) Variable Energy Cyclotron Centre, Kolkata

2.3.5 Heavy Water Plants

The Heavy Water Plants at Kota, Manuguru, Tuticorin, Thal and Hazira were operational during 2000-2001.

Heavy Water Plant (Baroda) Revival Project

The Heavy Water Plant at Baroda has been shut down since December 1998 due to non-availability of feedstock of synthesis gas from the Gujarat State Fertilizer and Chemicals Ltd (GSFC). GSFC supplied synthesis gas at 600 kg/cm^2 through their A-1 and A-2 plants. GSFC had shut down these plants and has taken up modernisation. Now GSFC can supply synthesis gas only at low pressure and it is not feasible to operate the heavy water plant with this. Hence the Heavy Water Board had proposed to set up a front-end facility (designated as the phase II of the Baroda Revival Project) which will be coupled to the existing heavy water plant.

After preliminary safety review, AERB accorded in-principle clearance for the HWP Baroda Revival Project (BRP).

2.3.6 Indian Rare Earths Limited (IREL)

IREL plants located at Udyogamandal, Chavara, Manavalakurichi and Chhatrapur were in operation throughout the year. The Thorium plant at Trombay was under decommissioning. The Synthetic Rutile Plant and the Acid Regeneration Plant at IRE, OSCOM remained shut down.

The plants at Chavara and Manavalakurichi are involved in mining and mineral separation, whereas the Udyogamandal plant carries out chemical processing of the mineral sand for production of thorium, rare earths and uranium. The OSCOM (Orissa Sand COMplex) plant at Chatrapur mines the minerals, separates them and processes the thorium concentrate received from Udyogamandal to produce commercial grade thorium nitrate. Earlier at IRE, Manavalakurichi, air-tables and wind-tables were in use for mechanical separation of mineral sand. This was a dry process and used to result in air-borne dust in the working areas. Based on recommendations of AERB, some of these air and wind tables have been taken out of service to control the dust concentration in working areas.

At IRE, Chavara out of the two Minerals Recovery Plants one was operating.

At IRE, OSCOM, a new pilot plant for production of Zirconia has been commissioned.

The number of reportable injuries in IREL plants has come down as compared to previous years. No employee in IREL plants during this period crossed the limit of radiation dose of 30 mSv/yr. The Manvalakurichi plant remained an accident free unit for the last three years and received the AERB Industrial Safety Award for the best Industrial Safety Performance.

2.3.7 Uranium Corporation of India Limited (UCIL)

AERB told UCIL to take action to prevent entry of unauthorised persons in the tailings pond. The tailings pond

must not be accessible to animals. UCIL should fence the entire tailings pond area. This work in progress and is likely to be completed by the end of 2001.

AERB asked UCIL to install a high capacity ventilation fan to improve the ventilation inside the Jaduguda mine. The installation of the fan is in progress.

Currently dosimeters are provided to 600 miners. By the end of 2001, total 1000 dosimeters will be issued. The goal is to cover all miners.

AERB has asked UCIL to identify the source of manganese in the effluent from UCIL and to take appropriate action to treat the effluent.

2.3.8 Industrial Safety Licences, Authorisat-ions and Clearances Issued

a) Licence under the Factories Act, 1948

Licence to Heavy Water Plant, Baroda to produce 52 MT/year of Potassium was renewed on April 4, 2000.

UCIL was issued license on April 27, 2000 to produce magnesium di-uranate

b) Permission for Operation of Di-2-Ethyl Hexyl Phosphoric Acid (D2EHPA) Plant at Heavy Water Plant, Talcher

Heavy Water Plant (HWP), Talcher was visited and based on the Safety Report, inspection of D2EHPA Plant on its premises was carried out in connection with the Grant of Permission for its Operation.

Based on observations and discussions with the personnel of HWP, Talcher, AERB staff prepared a report recommending revision of the Safety Report of the plant.

c) Heavy Water Plant, Baroda Revival Project

Construction clearance for the Project was granted by SARCOP after review of the Design Basis Report subject to certain stipulations. Baroda Revival Project is a technology demonstration project based on Ammonia – Water front end necessitated by the delinking of gas from Gujarat State Fertilizer Corporation.

2.3.9 Significant Events

Fatalities due to Industrial Accidents

There were two work-related fatalities due to industrial accidents during 2000 – 2001 in DAE units. Unit-wise break up is given in the **Table 6** below:

Table-6 Fatalities due to Industrial Accidents in 2000-2001

Unit	No. of Fatalities	Cause
Kaiga Generating Station	1- Contractor's worker	Fall of worker from height
Tarapur Atomic Power Project 3&4	1- Contractor's worker	Fall of object (sliding of excavated soil) on worker.

AERB staff reviewed the investigation reports of the fatal accidents submitted by the concerned DAE Units and the reports submitted by the fatal accidents assessment committee after visiting the accident sites. Guidelines to investigate work-related accidents have been prepared.

b) Incident at IRE, Udyogamandal

IRE, Udyogamandal was directed to carry out an investigation under Atomic Energy (Factories) Rules, 1996 into an incident which occurred in the plant on 24th March 2000 and the plant has submitted a detailed investigation report to AERB. While lifting a monazite container weighing 4 tons by an Electric Hoist, the wire rope of the hoist snapped and the container fell down from a height of 11 m. The incident was investigated by AERB during regulatory inspection in April 2000. Recommendations like providing redundancy in limit switches for automatic stoppage of hoist and using trained rigger/operator were made and have been complied with by the plant.

2.3.10 Licensing of Plant Personnel

a) Approval of Competent Persons under the Factories Act, 1948

Approval was granted to act as 'Competent Persons' in the plant under various sections of the Factories Act, 1948 to two persons nominated by Heavy Water Plant, Hazira.

b) Licensing of Operating Staff for Operating Plants

Officers from AERB participated in the meetings of Plant Level Authorisation Committees of Heavy Water Plants for authorisation and qualification of staff at the job positions of Senior Operators and Junior Operators of Heavy Water Plants at Manuguru, Kota and Tuticorin.

2.3.11 Industrial Safety: Regulatory Inspections

Regulatory inspections on industrial safety aspects were carried out during 2000-2001 under the Factories Act, 1948

and Atomic Energy (Factories) Rules, 1996 in the following DAE units:

Indian Rare Earths Ltd., (OSCOM Plant), Chhatrapur

Indian Rare Earths Ltd., Udyogamandal

Indian Rare Earths Ltd., Chavara

Indian Rare Earths Ltd., Manavalakurichi

Indian Rare Earths Ltd., OSCOM

Uranium Corporation of India (UCIL) (Mills at Jaduguda and Mines at Jaduguda, Bhatin and Narwapahar)

Heavy Water Plant, Tuticorin

Heavy Water Plant, Kota

Heavy Water Plant, Hazira

Heavy Water Plant, Manuguru

Heavy Water Plant, Baroda

AERB recommended revision of Technical Specifications Manuals, Safety Manuals, Fire Orders, Strengthening of Fire Safety Organisation, Laying / Updating layout of fire-hydrant lines, guarding of the Old Dredge Pond, etc. in respect of IREL plants.

AERB recommendations to UCIL included strengthening of the Fire Safety Organisation, preparation of Safety Policy, installation of additional ventilation fan, fencing the entire tailings pond area etc.

AERB asked Variable Energy Cyclotron Centre, Calcutta to set up a dedicated safety and fire organisation, preparation of Safety Manual and Fire Order, periodic testing of pressure vessels, introduction of Safety Work Permit system for hot jobs, etc.

2.3.12 Structural Safety

AERB inspected the condition assessment and maintenance of the civil structures of NFC and IREL plants (Udyogamandal, Chavara, Manavalakurichi and Orissa Sand Complex) and asked the managements to prepare manuals for maintenance, in-service-inspection and quality assurance. AERB asked the managements to implement these procedures. ■

Tarapur Atomic Power Project 3&4

SECTION 3

RADIOLOGICAL SAFETY SURVEILLANCE OF RADIATION FACILITIES

3.1 MEDICAL, INDUSTRIAL, AGRICULTURAL AND RESEARCH FACILITIES

Radiation Safety in Medical Diagnostic X-ray Installations

During the year, AERB completed the programme to register medical diagnostic X-ray installations with the support of CSIR and DRDO and reviewed the data in the registration forms of various X-ray installations received from Industrial Toxicology Research Centre (ITRC), Lucknow, Central Scientific Instruments Organisation (CSIO), Chandigarh, Central Building Research Institute, Roorkee, Defence Laboratory, Jodhpur, Defence Research and Development Establishment (DRDE), Guwahati and CSIO, Delhi. AERB recommended remedial measures for obvious deficiencies observed.

Radiological Protection Surveys of five diagnostic X-ray installations in Nagpur and one installation at Guhagar in Maharashtra were carried out and recommendations made to improve the overall safety of the installations to the parties concerned.

3.2 INDUSTRIAL RADIOGRAPHY

Incidents involving violations of regulatory provisions stipulated for industrial gamma radiography, which were noticed during unannounced inspections of industrial radiography sites located in Gujarat (Baroda and Ahmedabad), Maharashtra (Pune, Nashik, Thane, Vikhroli and Nagpur), Himachal Pradesh (Mangalgad) and Haryana (Panipat) were reviewed.

Major violations observed include inadequate security for the source storage room, exposure devices kept in unlocked condition, delay in reporting loss of the exposure device during transportation, non-provision of personal monitoring badges to radiography staff, non-functioning radiation survey meters, improper maintenance of log books and inappropriate source storage facilities.

AERB issued show cause notices to these institutions, ensured return of exposure devices to the Board of Radiation and Isotope Technology (BRIT), Mumbai for specified periods, recalled certificates of radiography personnel for necessary endorsement and obtained undertakings from the institutions affirming that they will not violate any safety provisions.

Inspection of Radiography Exposure Devices

The staff of AERB inspected the empty radiography exposure devices sent by radiography institutions to BRIT for source replenishment. This was to ascertain whether the devices can function safely. AERB staff and the staff of the Radiological Physics & Advisory Division (RPAD), BARC carried out the inspection.

3.3 TRANSPORT OF RADIOACTIVE MATERIALS

AERB contributed to the IAEA database on transport of radioactive materials during the year. Package design approvals were furnished to the IAEA, in the prescribed format, for inclusion in the IAEA PACKTRAM database. AERB renewed the Type Approval of GC-900, GC-4000A, COF-285, F-168 and Roli-1 as Type B (U) packages.

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

Shipment Approval Certificates under Special Arrangement were issued to transport radioactive materials (with operational controls stipulated in the shipment approval certificates) in respect of one irradiated natural uranium bundle, packages containing fuel pins, two irradiated coolant tubes, multiple shipments of spent natural uranium oxide fuel bundles in the spent fuel casks by road using tractor-trailer as the only mode of transport from origin to destination.

3.4 SAFETY REVIEW OF RADIATION EQUIPMENT

3.4.1 Type Approval of Radiation Equipment and Issuance of No Objection Certificates to Import Radioactive Material/Radiation Equipment

AERB issued type approval certificates to the manufacturers/suppliers of medical diagnostic X-ray units, X-ray tubes with tube inserts, medical simulators, telegamma therapy units, medical electron accelerators, industrial gamma radiography exposure devices (IGRED), industrial X-ray units, gamma knife, remote after-loading brachytherapy units, nucleonic gauging devices, ionisation chamber smoke detectors, baggage inspection systems and encapsulations for sealed radioactive sources. Type

approvals were issued for 296 devices and equipment during the year, viz.,

Medical diagnostic X-ray units	:	223
X-ray tubes with tube inserts	:	1
Medical simulators	:	3
Telegamma therapy units	:	3
Medical linear accelerators	:	2
Industrial gamma radiography exposure devices	:	3
Gamma chambers	:	2
Remote after-loading brachytherapy units	:	5
Nucleonic gauging devices	:	33
Ionisation chamber smoke detectors	:	1
Baggage inspection systems	:	2
Encapsulations for sealed radioactive sources	:	18

AERB renewed the type approval certificate in respect of the IGRED model Roli-1 and the gamma chamber model GC-4000A.

AERB reviewed the application for siting, design and design modifications etc. of the following facilities:

a) Design approval of the radiation cell of the 3 MV/50 mA electron beam irradiator system model Dynamitron at M/s Nicco Corporation Ltd., Kolkata;

b) No Objection Certificate for locating a 30 MeV/350 mA medical cyclotron model Cyclone-30 at the proposed site Mouga Digla opposite to the Indian Institute Campus and Gluconate Health Factory under South Dumdum Municipality, Kolkata;

c) No Objection Certificate for installation of a medical accelerator in the radiotherapy testing room of Medical and Industrial Accelerator Building, Centre for Advanced Technology, Indore; and

d) No Objection Certificate for installing 700 keV electron beam accelerator at the Ship Building Centre, Visakhapatnam.

No Objection Certificates were issued for the import of radioisotopes and radiation generating equipment for medical, industrial and research applications.

3.4.2 Approval of Radiological Safety Officers

During the year, the Competent Authority issued approval certificates in respect of 116 Radiological Safety Officers. The break-up is as follows:

RSO Level III (Medical)	:	48
RSO Level III (Industrial)	:	7
RSO Level II (Industrial)	:	22
RSO Level I (Industrial & Research)	:	39

(Radiological Safety Officers are categorised into three levels depending on the type of sources they handle and their hazard potential)

3.4.3 Enforcement of Atomic Energy (Control of Irradiation of Food) Rules, 1996

AERB issued Certificate of Approval for irradiation of spices to Shriram Institute for Industrial Research, New Delhi.

3.5 SURVEILLANCE OF HIGH INTENSITY GAMMA IRRADIATION FACILITIES

The Staff of AERB inspected the following high intensity gamma irradiator facilities as required under the Atomic Energy (Control of Irradiation of Food) Rules 1996:

1. SARC Irradiator Facility, Sriram Institute, New Delhi
2. FIPLY, BARC
3. Demonstration Facility for Irradiation of Spice, BRIT, Vashi

AERB conveyed the following recommendations, as applicable, to each installation:

- It should be demonstrated that the source handling facility is capable of withstanding unequal tension.
- The control switches should always remain functional.
- The printer connected to the control panel should be functional and indicate in the print out the status of the safety systems.
- A Local Safety Committee should be constituted.
- Detailed fire safety requirements should be prepared.
- It should be ensured that the emergency trip wire has proper tension.
- Additional area should be provided for storage of irradiated/unirradiated product boxes.

AERB staff inspected the sites for the following new gamma irradiation projects:

1. M/s. Vardaan Food Tech., Sonepat, Haryana

2. M/s. Agrosurg Irradiators (India) Pvt. Ltd., Mumbai

AERB asked the institutions to submit a compliance report on site criteria as per AERB Standard Specification on the Radiological Safety for Design and Installation of Land-based Stationary Gamma Irradiators and other relevant information about the proposed site.

The staff of AERB reviewed the safety status of operating gamma irradiators. The following aspects were analysed:

1. Design & operation related causes of the incident at the RAPP Cobalt Facility (RAPPCOF) & comparison of the safety systems available in high intensity gamma irradiators to prevent such incidents. (This was in light of an incident in which two workers were exposed to radiation doses in excess of the limits prescribed by AERB. The incident occurred at the RAPPCOF facility in 1999).

2. Corrosion rate of Co-60 Integral Source Units in the water pool with respect to conductivity of water.

AERB staff inspected the following nine gamma irradiation facilities (These were routine inspections).

1. Panoramic Batch Irradiation Technology (PANBIT), Thiruvananthapuram, Kerala.

2. Radiation Vulcanisation of Natural Rubber Latex (RVNRL), Kottayam, Kerala

3. PANBIT, Cannanore, Kerala

4. PANBIT, BRIT, Mumbai

5. Radiation Sterilisation & Hygenisation of Medical Products (RASHMI), Bangalore,

6. Shriram Applied Radiation Centre (SARC), Delhi

7. Food Irradiation & Processing Laboratory (FIPLY), BARC, Mumbai.

8. Demonstration Facility for Irradiation of Spice. BRIT, Vashi, Navi Mumbai.

9. Isotopes in Medicine (ISOMED), BRIT, Mumbai.

AERB gave several directions to improve the status of radiological and industrial safety at these facilities. These include periodic calibration of radiation survey instruments, removal of waste and inflammable materials from inside the irradiation cell & cell roof, updating of preventive maintenance records, provision of check source to personnel entrance door, constitution of local safety committees, replenishment of resin columns of demineralisation plant, etc. AERB Staff did not inspect Raksha Anusandhan Vikas Irradiator (RAVI), Jodhpur during the year as the facility was not functioning.

Quarterly safety status reports were received for all the four quarters in the year 2000. The occupational exposure in gamma irradiator facilities in the last five years did not exceed 6 mSv/year which is well below the prescribed dose limit of 20 mSv/year.

3.6 SAFETY OF RADIATION SOURCES

AERB appointed a task group to recommend measures to ensure safety of radiation sources and the security of radioactive materials. The Board adopted the recommendations of the task force for implementation.

3.7 LOSS OF A BRACHYTHERAPY SOURCE

A premier medical hospital lost a Cs-137 brachytherapy source of strength 73 mCi due to procedural lapses. The source could not be located in spite of systematic searches by using very sensitive radiation detecting instruments. These searches have assured that the source is unlikely to be present in any occupiable area. In that context the source poses an insignificant risk. AERB rated the incident at Level 2 in the International Nuclear Event Scale (INES) of the International Atomic Energy Agency.

In the light of this incident, AERB directed all institutions having brachytherapy sources to implement improved issue and receipt procedures for the sources. ■

SECTION 4
ENVIRONMENTAL AND OCCUPATIONAL SAFETY

4.1 ENVIRONMENTAL SAFETY

Environmental Surveillance of all operating plants under the DAE is done on a continuous basis and the Environmental Survey Laboratory of the Health, Safety and Environment Group; BARC assessed the environmental impact due to operation of these plants. The radioactivity released to the environment during the year from the operating units was well within the prescribed limits. **Figures 2a to 2e** show the various discharges from the plants.

Fig. 2 (a) : Liquid discharges from NPPs (Tritium).
Fig. 2 (b) : Liquid discharges from NPPs (Gross Beta).
Fig. 2 (c) : Gaseous discharges from NPPs (Tritium).
Fig. 2 (d) : Gaseous discharges from NPPs (Argon 41).
Fig. 2 (e) : Gaseous discharges from NPPs (Fission product noble gases)

Figures 3a and **3b** show the committed dose to members of the public. The estimation of the dose to a member of the public is done by measurements of radio nuclide concentrations in the items of his diet i.e. vegetables, cereals, milk, meat, fish, etc and intake of air and water. The dose to the public in the case of RAPS is higher than in other plants due to the discharge of a greater amount of Argon-41 from the stack. These releases were also within the limits prescribed by AERB. For instance, the total annual effective dose at the boundary of the exclusion zone of RAPS is 105.8 microSv as against the prescribed dose limit of 1000 microSv.

4.2 OCCUPATIONAL EXPOSURES

The annual dose limit to radiation workers prescribed by AERB is 30 mSv. A limit of 100 mSv is also prescribed over a consecutive period of five years. In order to enforce this Safety Directive on dose limits to radiation workers, AERB had appointed a committee on radiation exposures chaired by a Member of the Board. During 2000-2001, the Committee held 4 meetings and reviewed 2 cases of 1999 and 25 cases of 2000 from DAE units and 68 cases of 1999 (including 25 cases of cumulative exposures) and 32 cases of 2000 from non-DAE institutions. Whereas the cases from DAE units, reviewed in the meetings, were genuine ones, only 53 cases (28 single exposure cases and 25 cumulative exposure ones) out of the 100 cases for 1999 and 2000 from non-DAE units reviewed in these meetings were genuine ones.

A review of all the cases from DAE institutions during the period of the report reveals that number of cases reported during 1999 was comparatively quite high i.e. 106 out of about 21000 radiation workers monitored from DAE institutions (0.5%). Most of these cases were of planned exposure at power stations and accounted for almost 85% of all the DAE cases in 1999. At Power Reactor Fuel Reprocessing Plant (PREFRE) also there were 12 cases of planned exposure. The Committee showed concern over these cases but was satisfied with the explanation from the respective investigation committees. During the year 2000, so far 25 cases with exposure greater than 20 mSv have been reported. The number has come down but NAPS again showed a comparatively high number. From the investigation reports reviewed it was observed that generally internal dose was quite high (>50% in most cases) and respiratory protective equipment was not being used. During the two year period 1999-2000 of the current five year block, 24 cases with exposure greater than 40 mSv have so far been reported from the power plants only.

The review of the cases in non-DAE institutions revealed that out of a total of 95 cases of 1999 reviewed by the Committee only 48 cases with exposures greater than 20 mSv were found to be genuine. In terms of percentage of incidence, it is 48 cases out of about 23,000 radiation workers monitored from non-DAE industrial, medical and research institutions (0.2%). Most of the non-genuine cases were due to carelessness on the part of the personnel leaving the dosimeters in the radiation areas through oversight or deliberately. There were a quite few cases of overexposures due to unsafe work practices or too much workload also or wearing the dosimeters above lead apron in case of X-ray workers. All these problems exist chronically and the concerned managements are being warned and asked to take preventive steps. Frequent periodic and unannounced radiological protection surveys should be carried out at non-DAE institutions by RPAD/BARC and AERB.

Thirty-two cases of exposures greater than 20 mSv for the year 2000 were also reviewed out of which only 13 were genuine. In the case of three persons for the first time doses were assigned on the basis of CA Test as they had not worn the TLD badges while handling the industrial radiography source. The institution has been warned by AERB for gross non-adherence to stipulated safety procedures and lack of safety culture. Their source authorisation has been withdrawn for one year and the three persons involved have been laid off from radiation work for periods ranging from four to ten years.

The number of workers in NPPs exposed to more than 20 mSv (Investigation limit) and more than 30 mSv (annual limit) is given in **Table 7(a)**. The percentage of the total number of workers in NPPs exposed to greater than the above limits is given in **Table 7(b)**.

Figure 2a. LIQUID DISCHARGES FROM NPPs

Tritium

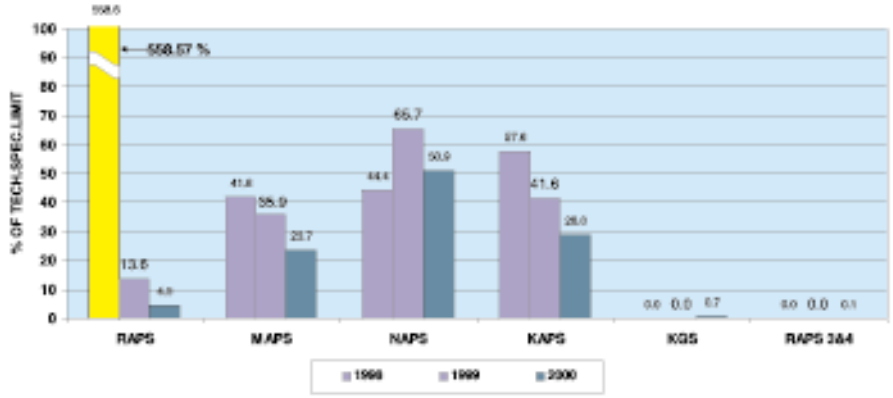


Figure 2b. LIQUID DISCHARGES FROM NPPs

Gross Beta

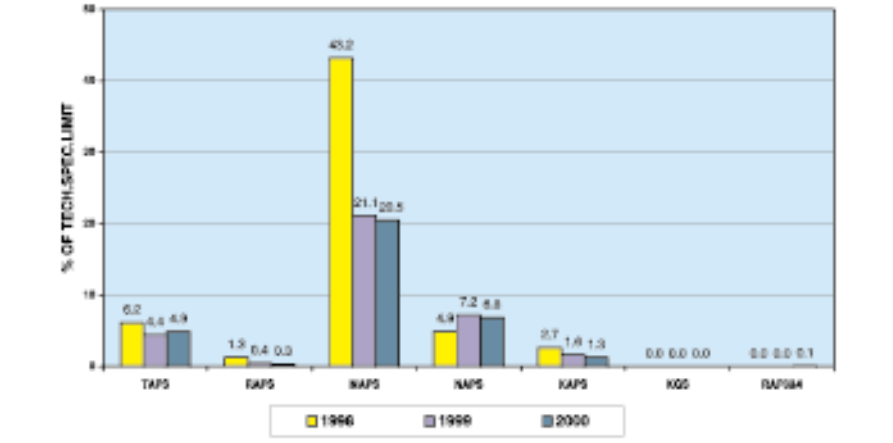


Figure 2c. GASEOUS DISCHARGES FROM NPPs

Tritium

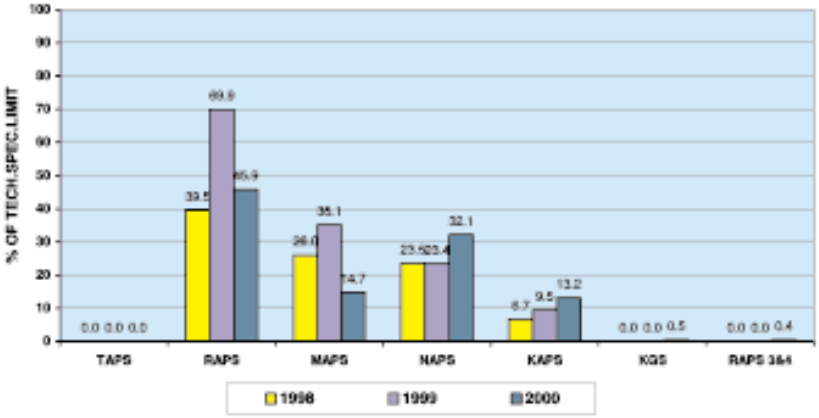


Figure 2d. GASEOUS DISCHARGES FROM NPPs

Argon-41

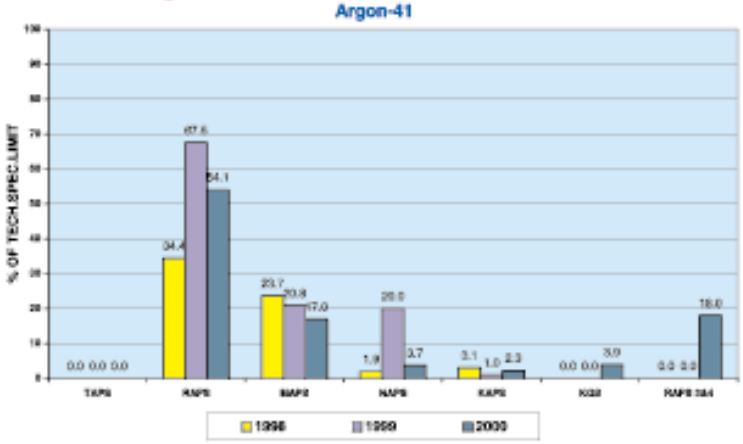


Figure 2e. GASEOUS DISCHARGES FROM NPPs

Fission Product Noble Gases

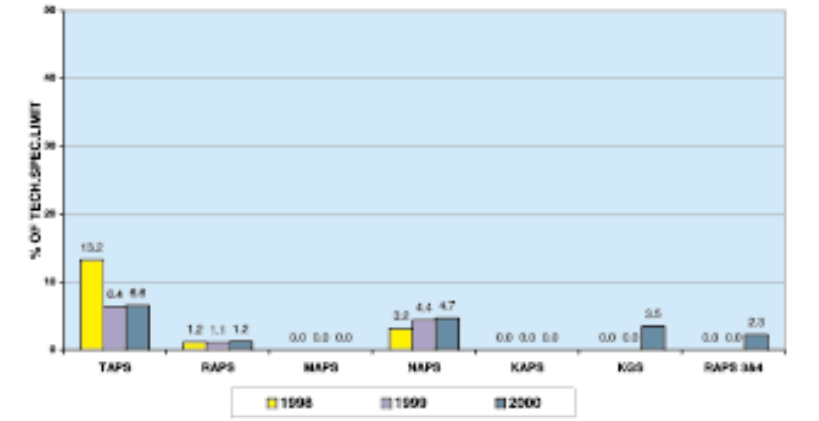


Figure 3a TOTAL EFFECTIVE DOSE AT 1.6Km DISTANCE

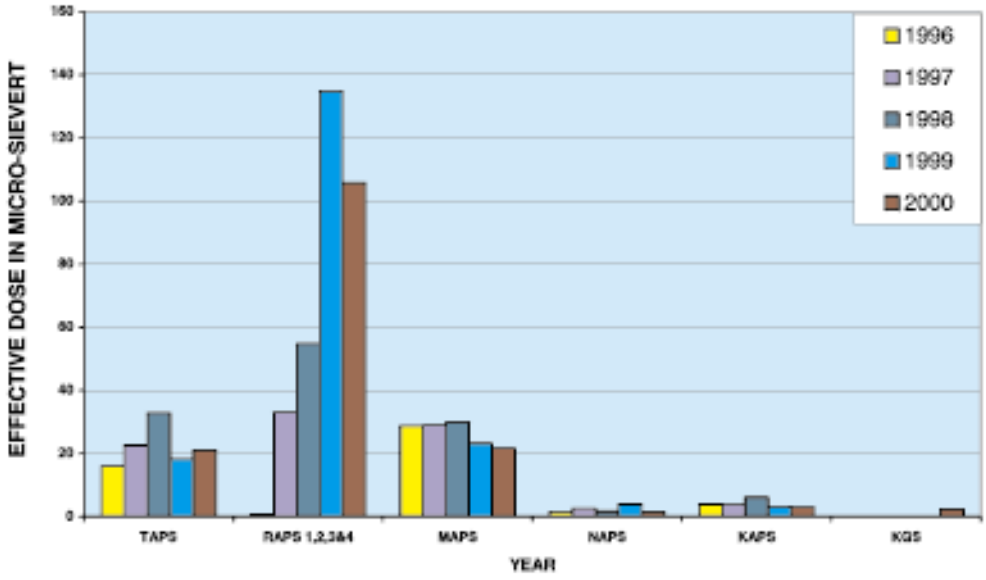


Figure 3b: TOTAL EFFECTIVE DOSE AT DIFFERENT ZONES DURING YEAR 2000

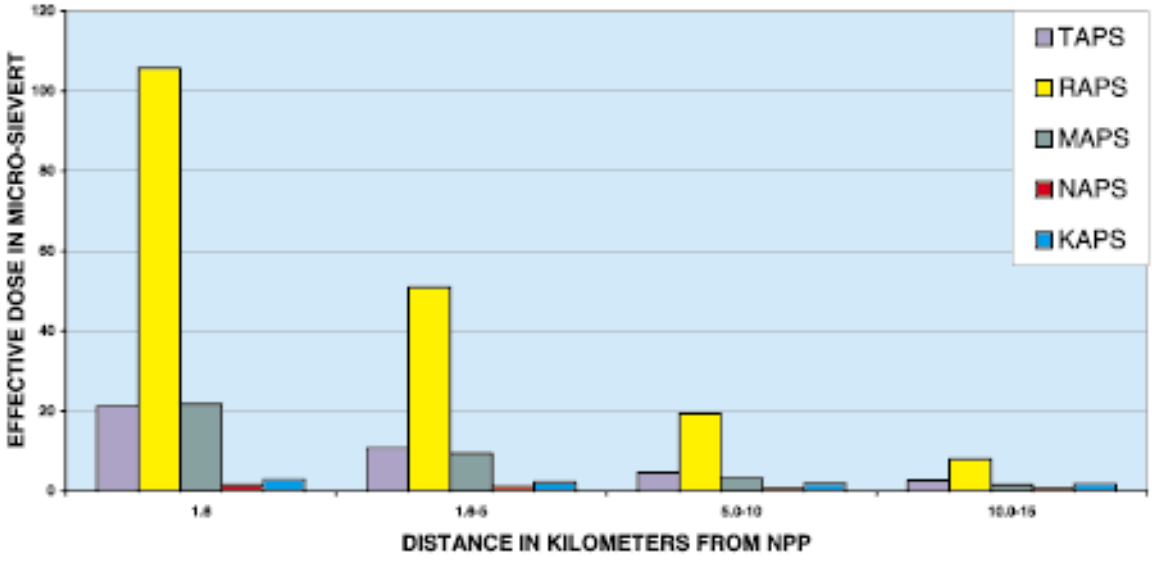


Table 7(a) : Number of Workers in NPPs Exposed to > 20 mSv and > 30 mSv

Year	1996		1997		1998		1999		2000	
	>20	>30	>20	>30	>20	>30	>20	>30	>20	>30
TAPS	9	0	4	1	0	0	0	0	0	0
RAPS	11	0	20	2	0	0	29	1	1	0
MAPS	3	0	4	0	3	1	10	4	1	0
NAPS	72	2	2	0	6	2	41	0	10	1
KAPS	3	1	0	0	0	0	0	0	0	0
KGS									0	0
RAPS 3&4									0	0

Table-7(b) Percentage of Total Number of Nuclear Power Plant Workers Exposed to > 20 mSv and 30 mSv

Year	Total number of workers	Those with annual dose exceeding			
		20 mSv		30 mSv	
		Number	%	Number	%
1996	11090	98*	0.88	3	0.03
1997	10008	30	0.30	3	0.03
1998	10145	9	0.09	3	0.03
1999	10233	80*	0.80	5	0.05
2000	14276	12	0.08	1	0.01

*** These large number of cases are due to significant number of cases of planned exposures at NAPS.**

For the 5 year block from January 01, 1999 to December 31, 2003, one person at RAPPCOF has exceeded the annual (30 mSv) as well as individual cumulative exposure limit. (100 mSv). This incident was already reported in the AERB Annual report of 1999.

As seen from Table 7a and 7b, there was only one case of exposure greater than 30 mSv during the year. This was at NAPS. On April 15, 2000, heavy water leaked at NAPS-2 moderator room due to failure of a gasket in a flange joint. The unit was shut down to attend to the task. One worker who was engaged in arresting the leak received an internal dose of 47.12 mSv. The station exposure investigation committee investigated the case which was reviewed by AERB. The worker is since laid off from all work in controlled areas for an appropriate duration.

Data on occupational exposure in Medical, Industrial and Research Institutions in India, during 2000 – 2001 are given in **Table 8**.

Table-8 Occupational Exposure in Medical, Industrial and Research Institutions

Category	No. of Insti-tutions	No. of Persons	Average Annual Dose mSv	No. of persons receiving Annual Dose (mSv)	
				>20	>30
Industry	555	5359	0.75	17	6
Medicine	2076	17259	0.55	37	18
Research	198	2490	0.14	-	-

The instances of exposures higher than the dose limits prescribed by AERB is primarily because of poor work practices. An instance in point is carrying out X-ray special procedures involving fluoroscopy. Similarly radiation workers who carry out industrial gamma radiography without making judicious use of time, distance and shielding, receive relatively higher radiation doses. ■

SECTION 5
EMERGENCY PREPAREDNESS

Different emergency preparedness exercises conducted at the plants in the year 2000 are indicated in **Table 9.**

Table-9 Emergency Exercises Conducted by Site and Off-Site Authorities

Plant	FEE	PEE	SEE	OSEE
TAPS	5	3	1	0
RAPS	7	4	3	0
MAPS	5	6	2	0
NAPS	5	4	1	0
KAPS	7	4	1	1
KGS	9	4	1	0
HWP (Kota)	12	3	1	0
HWP(Manuguru)	17	3	1	1

FEE : Fire emergency exercise

PEE : Plant emergency exercise

SEE : Site emergency exercise

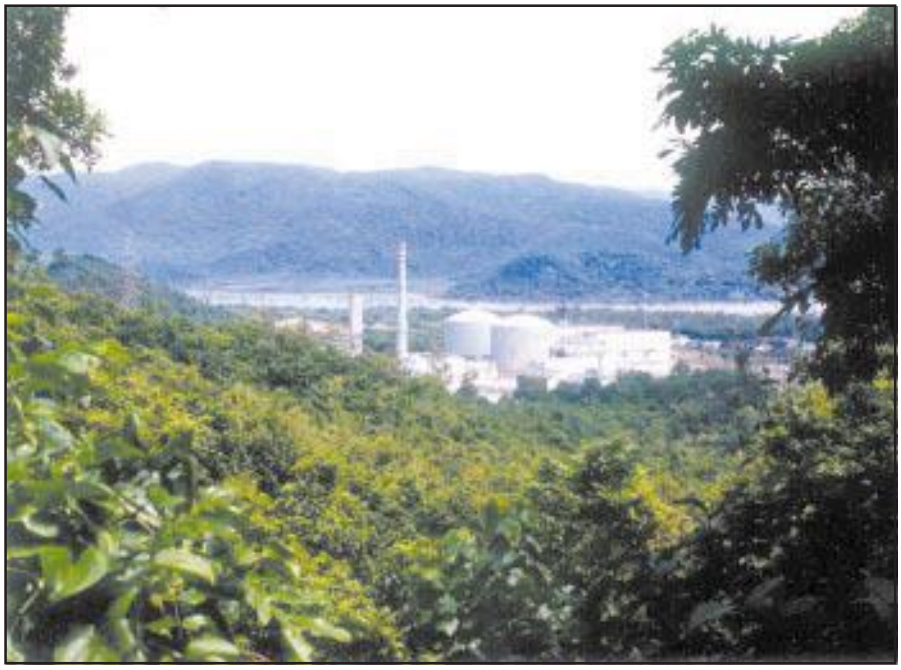
OSEE : Off-Site emergency exercise

Off-site Emergency Exercise

The off-site emergency preparedness plans are site-specific and involve joint participation of station authorities, district administration staff and members of public in selected villages around the facility. Off-site emergency exercises are conducted by the concerned district officials. The exercises are conducted once in two years. Officers from AERB participated as observers in these exercises. Emergency preparedness plan for off-site emergency was tested at the following facilities.

Heavy Water Plant (Manuguru) : 4th April 2000
Kakrapara Atomic Power Station : 24th November 2000

In the exercise at Kakrapara, three busloads of villagers from the mock-affected village were transported to the shelter village where the district administration accommodated them in the local school and provided lunch to the evacuees. In general, it was found that, the personnel are well prepared for emergency actions. During regulatory inspections the AERB team checked the availability of the emergency preparedness equipment. General level of emergency procedure awareness amongst the members of the public residing in the surrounding villages was good and the villagers readily co-operated with the management during the exercise. ■



Kaiga Atomic Power Station

SECTION 6
DEVELOPMENT OF STANDARDS, CODES, GUIDES AND MANUALS

The following safety documents were published during the year. The content of each document is briefly given below.

1. Hydrogeological Aspects of Siting of Nuclear Power Plants AERB/SG/S-4)

This safety guide deals in detail with various hydrogeological scenarios existing in Indian geological regimes and conditions and the requirement of database for assuring the characteristics of sub-surface media. The direction and rate of flow of ground water depend on such hydrogeological attributes as the amount of rainfall, run off, surface storage, recharge, porosity and permeability of soil and rock formations. Water being the leachant as well as the medium for migration of radionuclides, the hydrogeology of a site is evaluated thoroughly.

2. Renewal of Authorisation for Operation of Nuclear Power Plants (AERB/SG/O-12)

The consent for operation of a NPP is issued for its design life, which typically is in the range of 30 to 40 years. Within this consent, AERB grants initial authorisation for a specified period and issues subsequently renewals to assure that the NPP as a whole, continues to operate safely and that all structures, systems and components important to safety of the NPP have not shown any undue signs of deterioration and are capable of performing their intended safety function. This guide provides the methodology and guidelines for assessment of safety for such renewal of authorisations.

3. Preparation of Site Emergency Preparedness Plans (SEPP) for Non-Nuclear Installations (AERB/SG/EP-3)

This document is intended for non-nuclear facilities of the Department of Atomic Energy, other than the nuclear power plants/projects/research reactors which require to have SEPP as per statutory requirement under the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 and amendments thereafter and the Chemical Accident (Emergency Planning, Preparedness and Response) Rules, 1996. The guidelines enable the concerned organisation to draw up the necessary site emergency plan. The guidelines are intended to specifically describe the scope, description of the facility and site, organisation and responsibilities, accident scenarios considered, communications, resources, declaration and termination of site emergency, action plan for responding to site emergency, maintenance of the plan etc. in the SEPP. Typical accident scenarios which may lead to site emergency and the response groups involved in handling the emergency have been described in this document.

4. Preparation of Off-site Emergency Preparedness Plans (OSEPP) for Non-Nuclear Installations (AERB/SG/EP-4)

This document is intended for non-nuclear facilities of the Department of Atomic Energy units other than the nuclear power plants/projects/research reactors which require to have OSEPP as per the statutory requirement under the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 and amendment thereafter and the Chemical Accident (Emergency Planning, Preparedness and Response) Rules, 1996 and aims to provide guidelines to draw OSEPP. The document outlines the manner in which information in the OSEPP regarding scope, description of site facility, organisation and responsibilities, accident scenarios, communications, resources, declaration and termination of emergency, action plan for responding to Off-site emergency, maintenance of the plan and the public awareness program etc. are to be provided. Evacuation of public in case of requirement and probable nature of accidents, which lead to an off-site emergency and responsibilities of the persons concerned for handling the emergency has been described in this document.

5. Ultimate Heat Sink and Associated Systems in Pressurised Heavy Water Reactor (AERB/SG/D-15)

To ensure adequate safety of NPP, one of the general safety requirements is to provide means for transferring residual heat from the reactor at a rate, such that the specified acceptable fuel design limits and design conditions of primary heat transport pressure boundary are not exceeded under normal operation and operational transients and the radioactivity release to the environment is maintained within prescribed limits. This guide provides guidelines on these systems.

6. Vapour Suppression System (Pool Type) for Pressurised Heavy Water Reactor (AERB/SG/D-22)

The primary containment building is designed for confinement of radioactivity during normal operation as well as during accident conditions, including postulated loss of coolant accident; rapid rise of pressure and temperature within the containment imposes maximum thermal and mechanical loadings on its structure. The guide provides guidelines for designing an energy management system for limiting these loadings within acceptable limits by way of hydrodynamic behaviour of vapour suppression water pool in order to ensure containment integrity all the time.

7. Role of the Regulatory Body with respect to Emergency Response and Preparedness at Nuclear and Radiation Facilities (AERB/SG/G-5)

The guide aims at giving guidance for the regulatory body and its role during emergencies and elaborates the activities of the interfacing of associated agencies.

8. Regulation of Nuclear and Radiation Facilities (AERB/SC/G)

This Safety Code spells out the minimum safety related requirements/obligations to be met by a nuclear or radiation facility to qualify for the issue of regulatory consent, at every stage of development of the facility, leading to its eventual operation. The Code also addresses the inspection and enforcement aspects involved in the regulation of these facilities.

9. Design Basis Events for Pressurised Heavy Water Reactor (AERB/SG/D-5)

This guide deals with the list of various design basis events (DBEs) and their categorisation in four categories, based on their consequences and frequencies of occurrences, to serve as part of the basis for the establishment of design requirements for structures, systems and components within a Pressurised Heavy Water Reactor based nuclear power plant (NPP). Design Basis Events include those occurring under normal operations, operational transients and certain accident conditions, e.g., postulated initiating events (PIEs) considered in the design of the NPP.

10. Preparedness of the Operating Organisation for Handling Emergencies at Nuclear Power Plants (AERB/SG/O-6)

The guide provides guidelines for development and implementation of emergency procedures for protection of the plant, plant personnel and members of the public during on-site and off-site radiological emergencies at a nuclear power plant. Essential requirements for preparedness and facilities to be maintained for response to an emergency situation are also addressed.

11. Fire Protection for Pressurised Heavy Water Reactor Based Nuclear Power Plant (AERB/SG/D-4)

The guide gives guidelines for various fire protection requirements while designing a nuclear power plant considering appropriate methods such as suitable layout, physical separation, independence and segregation of safety-related systems, use of fire-resistant components/materials, means of protection of various buildings, structures, components and fire suppression systems. ■

SECTION 7

SAFETY RESEARCH & DEVELOPMENT; WORKSHOPS; CONFERENCES; SCIENTIFIC PUBLICATIONS

7.1 SAFETY ANALYSIS

Safety assessment of nuclear power plants by probabilistic methodology was initiated. The probabilistic safety assessment (PSA) complements the deterministic analysis and provides further insights in case of accident situations for design basis events. It is performed in three levels. Level-1 analysis provides information on possible reactor core damage states and frequency of such occurrence from postulated initiating events with probabilistic considerations. Level-2 analysis with input from Level-1 analysis quantifies radioactivity release from the plant site and its occurrence probability following core damage situation. Level-3 analysis taking input from Level-2 analysis quantifies radiological risk on population beyond plant exclusion zone, under such accident situation. PSA study for Kaiga Atomic Power Plant is being carried out by NPCIL as per the requirements of Ministry of Environment and Forests. Level-1 PSA as part of this study was submitted to AERB, review of which is in progress.

A draft paper on 'AERB policy on PSA' was prepared giving, in brief, regulatory approach to PSA, requirements of PSA studies for different stages/activities for new as well as operating nuclear plants, priority areas for PSA applications, probabilistic safety goals/criteria utility should try to achieve/ comply with, quality assurance in PSA studies and review processes, documentation, etc. This paper will be finalized after reviewing comments and after deliberations with utilities and experts.

7.2 SAFETY RESEARCH & DEVELOPMENT

AERB has given grants for the following new research projects during the year.

1. Study of crack initiation and propagation in nuclear components under low cycle fatigue, IIT-Madras, Chennai.

2. Implementation of QA programme in mammography and breast cancer control, BYL Nair Hospital, Mumbai.

3. Evaluation and generation of data for accelerator safety research, Visva-Bharati, Shantiniketan.

4. Analysis of PHWRs during off-normal transients, IIT-Bombay, Mumbai.

5. Single phase and two-phase thermo-syphon analysis, IIT-Bombay, Mumbai.

6. Somatic cell mutational immunoassay of gycophorin-A (GPA) using monoclonal antibodies for biological dosimetry, Ramachandra Medical College, Chennai.

7. Development of plastic materials for nuclear track detection, Goa University, Goa.

8. Development of gel dosimeter for 3-D dosimetry in radiation therapy, CMC, Vellore.

9. Project on High Performance Concrete, Jadavpur University, Kolkata.

10. Collaborative Project on High Performance Concrete with Associated Cement Companies, Thane.

In addition to the above, AERB has recommended extension of grants for fifteen on-going research projects. AERB has also extended grants to around thirty organisations for conducting various seminars/symposia/conferences during the year.

7.3 AERB - SAFETY RESEARCH INSTITUTE, KALPAKKAM

Since its formal inauguration on February 20,1999, Safety Research Institute has been making a steady progress towards establishing the basic infrastructure required for organising the research activities in the following areas

- Nuclear Plant Safety Studies
- Environmental Safety Studies
- Fire Safety and Industrial Safety Studies

Besides research, other components of SRI activities as planned include

- Periodic Training workshops and Discussion meetings
- Archiving of technical and research reports, course materials and management of data bases

The progress made in the above activities during the year 2000-2001 is described below.

7.3.1 Nuclear Plant Safety Studies

Probabilistic Safety Assessment (PSA)

Studies on the reliability of certain components of nuclear power plant were carried out. Studies on options to

distribute the Safety Signals to Control Safety Rods (CSR) and Diverse Safety Rods (DSR) of the Shut Down System (SDS) of Prototype Fast Breeder Reactor (PFBR) were continued. The objective of the study is to find using the fault tree technique the scheme that gives the highest reliability while meeting the design constraints. The off-site power failure statistics at Kalpakkam were analysed with the updated data from MAPS and the station blackout frequency was derived using the Markov modeling technique by combining the loss of offsite power (LOP) duration with the rate of emergency power system (DG system) failures of duration over the time period of interest. The Decay heat removal system (DHRS) of PFBR was studied as part of the reliability study.

7.3.2 Reactor Safety Studies

Thermal hydraulic studies

SRI participated in studies related to experimental and computational simulation of decay heat removal (DHR) systems in fast breeder reactors. SRI is also associated with studies on the thermal striping problem which relate to the damage on structural surfaces due to temperature fluctuations resulting from improper mixing of sodium coolant streams at different temperatures.

Life Assessment of High Temperature Components

Another area of work undertaken by SRI was the life extension of nuclear power plant components. In order to gain experience in the Life Assessment Techniques, work has commenced on building an Online Creep Fatigue Monitoring System for FBTR.

7.3.3 Radiation Safety Studies

Radiation Shielding Codes

Two codes QAD-CGPIC and GUI2QAD developed at SRI were contributed to Reactor Shielding Information Centre, ORNL, USA. RSIC has accepted these codes after their evaluation and has made them available for international distribution through their web site at http://www-rsicc.ornl.gov/rsic.html. QAD-CGPIC code is used for shielding calculation of gamma ray and fast neutron penetration through complex geometrical arrangement of structures and viewing the geometry modeled in 2D. GUI2QAD is a program developed in visual basic 6.0 to help in preparing input to QAD-CGPIC code even to a novice user.

Radiation Shielding Computations

Gamma Dose Rate Computations outside RCB during Core Disruptive Accident at PFBR

Computations of external gamma dose rates outside Reactor Containment Building (RCB) of Prototype Fast Breeder Reactor (PFBR) due to radioactive fission products released into RCB during a hypothetical Core Disruptive Accident (CDA) were performed as required by AERB-PDSC (PFBR).

PFBR Bulk Shielding Experiments

A report on the MCNP calculations for the PHASE-I PFBR bulk shielding experiments at APSARA reactor has been prepared. A detailed 3D Monte Carlo simulation of Depleted Uranium Converter Assembly and Shield Models of PFBR bulk shielding experiments at APSARA reactor has been carried out to compute the neutron flux spectrum and foil reaction rates at designated locations using MCNP code.

PFBR Transfer Arm Shielding Calculations

The dose rates due to neutrons and photons streaming through the gaps between guide tube and gripper assemblies of transfer arm from the reactor core to the accessible areas above roof slab were computed using MCNP code.

KAMINI West Beam Shielding Calculations

The experimental beam port at west side of the KAMINI reactor is presently shielded with temporary shield using paraffin, lead and high density concrete. To increase the experimental cavity dimensions from 20 liters to 1000 liters, shield design calculations were performed for both neutrons and photons using MCNP code and appropriate modifications in the shield design have been proposed.

Shielding Computations for Medical Cyclotron

Radiation Shielding Evaluation for Medical Cyclotron (GE PET trace) Project at RMC (BARC), Mumbai was reviewed. The aspects studied include

- Source term assessment for neutrons and photons
- Design estimate of shield thickness in terms of concrete equivalent thickness
- Activation analysis of constituents in soil and concrete

7.3.4 Fire Safety And Industrial Safety Studies

Fire Hazard Analysis

AGNI, a fire modelling tool, has been developed for assessment of fire hazard in plant environment. An experimental setup is being planned in IGCAR for the purpose of validating the Fire Hazard Analysis codes. An SRI officer was associated with the planning of this experimental facility.

7.3.5 Environmental Safety Studies

Environmental Impact Assessment for NPPs

A project proposal submitted by Space Applications Centre (SAC), Ahmedabad for Environmental Impact

DISCUSSION MEETING ON FIRE HAZARD ANALYSIS AND MODELING (FIREHAM) AUGUST 28-29, 2000 AT SRI, KALPAKKAM

Welcome Address by Shri A. R. Sundararajan, Jt. Director SRI

Introductory Remarks By Shri P. K. Ghosh, Head, IRSD, AERB

Release of Fireham Proceedings by Shri S. B. Bhoje, Director RG IGCAR

Assessment for NPPs using Remote Sensing- Geographic Information System (RS-GIS) data has been approved. The proposal covers setting up a RS-GIS Facility at SRI, Kalpakkam for generating and maintaining a digital data base on all the existing nuclear facilities using past RS data and other collateral information on population, ground water, land use/land cover, radiation level etc. The data base will be useful in the long term environmental assessment around nuclear power installations. The detailed specifications for both hardware and software were obtained from SAC, Ahmedabad and procurement actions have been initiated.

7.3.6 Periodic Training and Discussion Meetings

One of the primary objectives of Safety Research Institute is to provide a forum for designers, operators, research groups and regulators to come together for exchange of information and expertise. As part of these efforts, a discussion meeting on " Fire Hazard Analysis and Modeling " was organized at SRI on the 28th and 29th of August 2000. About 50 participants from BARC, AERB, HWB, NPCIL, SRI and IGCAR were registered. Eleven papers were presented on various topics related to fire safety. A User Friendly Windows based application program AGNI developed at SRI was presented. It has been well received and participants have started evaluating the software.

7.3.7 ESL Professionals Meet – 2001

SRI organised a meeting of the scientists from Environmental Survey Laboratories (ESL) during January 23-24, 2001. About 35 delegates from the various ESLs in the country participated. The above meet was jointly organized by AWARE and IGCAR and sponsored by AERB. Detailed proceedings of the ESL Professionals Meet – 2001 were documented and distributed to the delegates.

ENVIRONMENTAL SURVEY LABORATORY PROFESSIONALS MEET-2001 JANUARY 23-24, 2001 AT SRI KALPAKKAM

Inaugural Address by Prof. S. P. Sukhatme, Chairman, AERB

Presidential Address by Dr. Baldev Raj, Director MMG IGCAR

7.3.8 Establishment of Code Depository at SRI

As part of the efforts to establish and maintain a safety related computer code depository, following codes installed at SRI are available with all the manuals for any user.

1. **MCNP** — General purpose Monte Carlo program for radiation transport
2. **KENO** — Monte Carlo program for estimation of neutron multiplication factor (K_{eff}) of system containing fissile materials
3. **ASFIT** — Gamma ray transport code for 1-D systems
4. **ORIGIN** — Fission product inventory calculation code
5. **QADCG-GP** — A point kernel code for shielding calculations
6. **GUIMCNP** — A graphical user interface program for MCNP code
7. **SAND -II** — A code for spectrum analysis for neutron detectors

The following codes were put up for public access on the web server

1. GUI2QAD — A GUI to Point kernel shielding code QAD-CGPIC
2. QAD-CGPIC — For DOS users
3. VIEW-NG-CXS — Neutron and Gamma Cross sections plotting program

7.3.9 Projects awarded by Safety Research Institute

In view of the fact that it would take some more time for SRI to have its own infrastructure and manpower to conduct research studies, some of the studies in the chosen area of work were awarded to academic institutions and national laboratories after appropriate review process. The following is the list of such Collaborative Research Projects with other institutions together with the report on the progress made during the year.

1. Characterisation of Thermal Internal Boundary Layer (TIBL) structure along the eastern coast of India

   Principal Investigator: Prof. D.V. Baskara Rao, Head, Dept. of Meteorology and Oceanography, Andhra University

A workstation has been installed to carry out the modeling experiments with codes FITNAH and MM5. A tethered balloon system has been acquired as per the original proposal. The terrain data over Visakhatpatnam region covering 25km x 25km grid has been digitized. The FITNAH model has been run to obtain the flow pattern for 1 case in the month of June. NCAR MM5 has been installed and the preliminary runs have been made with different domains at 60 km, 30 km, 20 km and 10 km resolution

2. Investigation of wind characteristics and other site specific parameters by intensive meteorological measurements at Kalpakkam

   Principal Investigator: Dr. R. Narayanan, Dy. Director, SERC, CSIR, Chennai

COMMISSIONING OF SRI METEOROLOGICAL TOWER FACILITY AT ANUPURAM TOWNSHIP, KALPAKKAM ON OCTOBER 16, 2000

Prof. S.P. Sukhatme, Chairman AERB Welcoming
Prof. P. Rama Rao, Former Chairman, AERB

Prof. P. Rama Rao, Former Chairman,
AERB Inaugrating the Facility

SRI Metorlogical Tower at Anupuram
Township, Kalpakkam

Data Logger for the SRI Meteorological Tower at Anupuram
Township, Kalpakkam

For carrying out the measurements proposed, three meteorological towers have been located at IGCAR site, 0.5km from the sea shore; Amaipakkam, 5km from the seashore and Thirukalukundram, 15 km from the seashore. These towers are guyed lattice towers, 50 meters in height and are designed as per IS 800. The instrumentation put on these towers include 3 cup anemometers and wind vanes at 4 levels and triaxial accelerometers at two levels. Data collection is done on a continuous basis using a computer based data acquisition system. The analysis of wind characteristics of a cyclone which crossed the eastern coast in November 2000 was carried out. The aspects studied include stationarity, mean wind profile, turbulence intensity and spectrum of wind.

3. Development of tracer release, sampling and analysis technique

Principal Investigator : Dr.(Smt.) Ganga Radhakrishnan, Dy. Director, EXCEL Lab, CLRI, Chennai.

Gas chromatograph model Auto XL system with electron capture detector with special gas sampling accessories has been commissioned. The system has been tested with Hexachlorobenzene and shown to detect 8 ppt. Samples of technical grade SF_6 and subsequent dilution with technical grade nitrogen gas have been injected into the system and tested for detection and chromatographic separation.

4. Formal methods for development of safety critical software

Principal Investigator : Dr. K.M. Mehta, Director School of Computer Science, Anna University, Chennai.

Hardware and software needed for the execution of the projects have been procured.

7.4 ANNUAL MEET OF DAE SAFETY PROFESSIONALS

As an on-going programme, the 17th DAE Safety Professionals Meet was held from 16th to 18th October 2000 at Indira Gandhi Centre for Atomic Research, (IGCAR), Kalpakkam for exchange of safety related information. It was organised jointly by AERB, IGCAR and BARC facilities at Kalpakkam for Safety Professionals and Occupational Health Specialists from various units of DAE. The programme included a seminar on the first day on 'Role of Training, Awareness and Promotional Campaigns in Improving Safety Performance' followed by a two-day workshop. Occupational Health Professionals from inside the DAE units as well as from outside held a parallel session in the afternoon on the second day on topics like incidence of occupational backache, hypertension etc. among the staff.

7.5 WORKSHOP ON SAFETY LEGISLATION FOR HEADS OF DAE UNITS

AERB organised a one-day Workshop on Safety Legislation for Heads of DAE Units on 13th October 2000 at Niyamak Bhavan. Officers of AERB gave talks on Acts and Rules pertaining to safety. This was followed by discussions on some issues connected with their implementation. More than 60 participants from various DAE units attended the workshop.

7.6 WORKSHOP ON DUTIES AND RESPONSIBILITIES OF CERTIFYING SURGEON

AERB organised a two-day Workshop on Duties and Responsibilities of Certifying Surgeons for DAE Units on 28th & 29th March 2001 at Niyamak Bhavan.

7.7 INVITED LECTURES DELIVERED AND PAPERS PRESENTED/PUBLISHED BY AERB OFFICERS

Officers from AERB gave invited lectures and presented technical papers at the following programmes:

1. Seminar on Fire Safety organised at Tarapur by Tarapur Atomic Power Project (TAPP) 3-4 on 'AERB Standard for Fire Protection Systems of Nuclear Facilities' on 18th & 19th April 2000.

2. Workshop on Safety Legislation organised at Indore by Centre for Advanced Technology (CAT), Indore on 'Static and Mobile Pressure Vessels (Unfired) Rules, 1981' on 30th June 2000.

3. Appreciation Programme for Factory Inspectors organised at AERB jointly by AERB and BARC at the request of Central Labour Institute, Mumbai on 'Regulatory Aspects in Industrial Applications of Ionising Radiation' on 19th July 2000.

4. Lectures for Senior Officers at Chavara organised by Indian Rare Earths Ltd., Chavara on the 'Atomic Energy Act, 1962' and the 'Factories Act, 1948 (as amended up to 1987) on 4th August 2000.

5. Discussion Meet on Fire Hazard Analysis and Modelling at Indore organised by Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam on 'AERB Standard/Guide on Fire Protection for Nuclear Facilities', 'Fire Risk Assessment in Heavy Water Plants' and 'Fire Hazard Analysis in Nuclear Power Plants' on 28th & 29th August 2000.

6. Lectures for Senior Officers of Indira Gandhi Centre for Atomic Research (IGCAR) and Madras Atomic Power Station (MAPS) at Kalpakkam on 'Role of Competent Persons' and 'Pressure Vessel Inspection and Testing' on 30th August 2000.

7. Lectures for Senior Officers of Nuclear Fuel Complex (NFC) and Electronics Corporation of India Ltd. (ECIL) at Hyderabad on 'Environment (Protection) Act and Rules' on 4th & 21st September 2000 respectively.

8. One-day Workshop on Safety Legislation for Heads of DAE Units organised by AERB at Mumbai on 'Overview of Relevant Acts and Rules applicable in DAE Units', 'Atomic Energy (Factories) Rules, 1996', 'Rules under Environment (Protection) Act, 1986', 'Gas Cylinder Rules, 1981' and 'Static and Mobile Pressure Vessels (Unfired) Rules, 1981 (as amended up to February 2000)' on 13th October 2000.

9. Workshop organised by National Safety Council at Mumbai on 'Concept and Preparation of Safety Report'.

10. Training Programme on Law and Administrator organised by DAE at Mumbai on 'The Factories Act, 1948 (as amended up to 1987)' and 'Workmen's Compensation Act, 1923 (as amended up to 2000) on 14th March 2001.

11. Lectures for Senior Officers of Indian Rare Earths Ltd., OSCOM Plant, at Chhatrapur on the 'Atomic Energy Act, 1962' and the 'Factories Act, 1948 (as amended up to 1987).

12. Lecture on the Regulatory Activities of AERB at the National Seminar on Environmental Awareness, Education and Management of Sustainable Rural Development at Sri Venkateswara University, Tirupathy during August 24 – 26, 2000.

13. Lecture on Radiological Safety of Medical X-ray Workers at the Symposium on Radiation Technology & Technocrats in Health Care at the All India Institute of Medical Sciences, New Delhi on February 10, 2001.

Technical Papers presented in Conferences / Published in Journals

1. Parthasarathy K.S., Implementation of ICRP-60 Recommendations on the Dose Limits to Radiation Workers in India, Proceedings of Tenth International Conference of the International Radiation Protection Association at Hiroshima during May 14 – 19, 2000.

2. Murali Mohan K., Chakraborti Sekhar K., Basu Prabir C., Ghosh Siddharta, Study of Linear Behaviour of a PSC Containment Dome with Large Openings, Nuclear Engineering and Design, 196 (2000), 123-137.

3. Basu Prabir C., Observations on design provisions, Special Issue on IS456: 2000, The Indian Concrete Journal, Vol. 75, February 2001, No.2.

4. Basu Prabir C., High Performance Concrete: Mechanism and Application, ICI Journal, Vol.2, No.1, April-June 2001, Indian Concrete Institute.

5. Basu Prabir C., Shreeti Mavinkurve, Bhattachajee K.N., Deshpande Yogini, Basu Sumana, High reactivity metakaolin: a supplementary cementitious material; Proceedings of ICI – ASIAN conference on Ecstasy in Concrete ACECON 2000), 20-22 November 2000, Bangalore, India.

6. Gupchup V.N., Basu Prabir C., Structural Safety against Dynamic Loads in Design of Nuclear Power Plant Structures, Proceedings of the National Symposium on Advances in Structural Dynamics on Design (ASDD), January 9-11, 2001, Structural Engineering Research Centre, Chennai, India.

7. Jain S.K, Roshan A.D., Arlekar J.N. and Basu P.C., Empirical Attenuation Relationships for the Himalayan Earthquakes Based on Indian Strong Motion Data Proceedings of 6th International Conference on Seismic Zonation (6th ICSZ), November 12-15, 2000, Palm Springs, California, USA

8. Ghosh P.K. and Bhattacharya, S. Environmental Issues in Oil Sector – Indian Scenario, Technical Committee Meeting of IAEA on Comparative Studies of Health and Environmental Risks associated with Electricity generation Systems held from March 20 - 22, 2000.

9. Sivaraman G., Kannan R.,RaghavendranC.P., Arunkumar, Vishwakarma, R.R.,Yadav R.K., Iyer V.S., Rane D.M. and Sonawane A.U., Effectiveness of Unannounced Inspections of Industrial Radiography Sites from Radiological Safety Standpoint: An Analysis. International Conference organised by the Indian Association for Radiation Protection on "Radiation Protection Measurements and Dosimetry" held during February 20-23, 2001 in Mumbai.

10. Senthil Kumar C,John Arul A. and Om Pal Singh, Application of Markov Model for the Estimation of Nuclear Power Station Blackout Frequency, National Conference on Quality, Reliability and Management, Vaniyambadi September 7-8, 2000.

11. Ravi Kumar Kodwani and Chellpandi P., Life Assessment of Critical Components of FBTR, International Symposium of Materials Ageing and Life Management, ISOMALM – 2000, October 2000, Kalpakkam.

12. Sunil Sunny C. and Subbaiah K.V., Radiation Shield Design Evaluation for GE PET-trace Proton Cyclotron Seminar on Accelerator Safety conducted at VECC, Calcutta during November 16-17, 2000.

13. Sunil Sunny C. and Subbaiah K.V., Optimisation of Shield Structure of South Beam Port of KAMINI Reactor, Accepted for publication in American Journal of Nuclear Technology.

14. Subbaiah K.V., Sarangapani R. and Baskar S., A Graphical User Interface for QAD-CGPIC Program, IARP International Conference on Radiation Protection Measurements and Dosimetry: Current Practices and Future Trends, February 20-23, 2001, Mumbai.

15. Gopalakrishnan C.R., and Sunil Sunny C., A new look at Dosimetry System-86, IARP International Conference on Radiation Protection Measurements and Dosimetry: Current Practices and Future Trends, February 20-23, 2001 Mumbai.

16. Inamdar, M.V., Vadiwala, R.N. and Masood Ahmad, Incineration – an option for disposal of biomedical radwaste, AMPI National Conference on Medical Physics November 9-11, 2000 Bangalore

17. Anuradha V, S.A. Sukheswalla - A study of the radiation exposure cases exceeding Regulatory Constraints in Indian PHWRs, IARP International Conference on Radiation Protection Measurements and Dosimetry: Current Practices and Future Trends, February 20-23, 2001 Mumbai.

7.8 PARTICIPATION IN WORKSHOPS, SEMINARS AND TRAINING COURSES

1. Dr.Prabir C. Basu, L.R. Bishnoi and Shri A.D Roshan attended the National Symposium on Advances in Structural Dynamics on Design (ASDD), January 9-11, 2001, Structural Engineering Research Centre, Chennai, India.

2. Shri Ajai. S. Pisharady, attended the three day workshop on "Repair and rehabilitation of Reinforced Cement Concrete Structures" conducted by NCCBM, in Mumbai.

3. Mrs.S. Bhattacharya attended the National Workshop on Industrial Ergonomics and Its Application for Augmenting Safety, Health and Productivity at Work organised by Central Labour Institute, Mumbai during 18th to 22nd December 2000.

7.9 AERB COLLOQUIA

AERB conducted seven colloquia during 2000-2001. These covered various issues related to regulatory/scientific aspects in nuclear engineering. The details are as follows:

1. *Management of Regulatory Activities*
Shri G.R.Srinivasan, Vice-Chairman, AERB

2. *Cement-based Composites*
Dr. A.K.Chatterjee, Director, ACC

3. *Interaction Between Regulatory Authority and Utility : A Historical Perspective*
Shri Ch.Surendar, Chairman & MD, NPCIL

4. *Towards an Intrinsically Safe and Economic Thorium Breeder Reactor*
Dr V.Jagannathan,
Theoretical Physics Division, BARC

5. *Biology Physics Interface*
Dr.R.Chidambaram, Chairman, Atomic Energy Commission

6. *Russian Reprocessing Activities - Legacy and Lessons*
Shri A.R.Sundararajan
Head, Radiological Safety Division, AERB

7. *Aseismic Design of Building Structures*
Dr. P.C.Basu, Head, Civil & Structural Engineering Division, AERB. ■

Rajasthan Atomic Power Project

SECTION 8
PUBLIC INFORMATION/AWARENESS PROGRAMMES

8.1 AERB NEWSLETTER

AERB published four issues of the AERB Newsletter during the year. The topics covered were radiological safety surveillance for industrial gamma radiography, summary of the reports of the United Nations Scientific Committee on the effects of Atomic Radiation (UNSCEAR-2000), summary of the radio biologic work being carried out in the areas of high background radiation, research and development in radiation protection and dosimetry, implementation of ICRP-60 recommendations on dose limits to radiation workers, and radiation safety of medical X-ray workers.

8.2 INTERVIEWS ON TELEVISION

Prof. S.P.Sukhatme, Chairman, AERB was interviewed on Doordarshan, Mumbai on January 30, 2001. The topic covered was the impact of the Bhuj earthquake on Indian Nuclear Power Plants.

Dr.K.S.Parthasarathy, Secretary, AERB was interviewed on television channels as detailed below:

(a) Entertainment Television Channel on Hazards of Depleted Uranium, April 28, 2000.

(b) Entertainment Television Channel on Separation of Regulatory Responsibilities of AERB and BARC, May 26, 2000

(c) Star World Channel, in "Focus Asia" on Safety Status of Uranium Mining in India in a programme titled "Toxic Tool", May 30, 2000

(d) Entertainment Television Channel on The Loss of Radioactive. Sources in a Medical Institution, August 18, 2000.

(e) Zee News Channel on Radiation Safety in Medical X-ray Installations, December 5, 2000.

8.3 RADIO PROGRAMMES

Dr. K.S.Parthasarathy delivered a lecture on The Regulatory Activity of AERB: An Update on August 18, 2000, on Akashwani and on December 10, 2000 In the Science Spectrum programme.

Mr. Julian Marshall, interviewed Dr.K.S. Parthasarathy on BBC on the topic of Safety Status of X-ray Installations in India.

8.4 PRESS RELEASES

The following press releases were issued:

1. Safety Status of Operations carried out by UCIL in Bihar (April 13, 2000).
2. AERB and Food Irradiation (April 28, 2000).
3. AERB Authorises Full Power Operation of Unit-3 of Rajasthan Atomic Power Project (June 1, 2000).
4. Director, UDCT Appointed Member of AERB (June 2, 2000).
5. Loss of Radioactive Source from Hospital (August 16, 2000).
6. AERB Clears Kaiga Nuclear Power Plant (September 25, 2000).
7. AERB Authorises Criticality of Unit–4 of Rajasthan Atomic Power Project (November 1, 2000).
8. AERB Warning on Radioactive Wrist Watches (December 8, 2000).
9. Nuclear Power Reactors in India Safe (January 29, 2001).
10. AERB Industrial Safety Awards (March 8, 2001).

8.4.1 Radioactive Sources in Hospitals

A premier medical hospital lost a radioactive source (Caesium 137) of strength 73 mCi due to serious procedural lapses. Scientists from BARC and AERB and medical physicists from the hospital thoroughly searched all possible locations in which the source may have fallen with the help of very sensitive radiation detecting instruments. Although these searches did not help in locating the lost source, they have assured that the source is unlikely to be present in any occupiable area. In that context, the source poses an insignificant risk.

The missing source capsule has a length of 18 mm containing two radioactive "seeds" of length 5 mm each, a ceramic spacer of 4.5 mm and a closing part of 3 mm. The diameter of the capsule is 3 mm. The radioactive material is in the form of special glass in to which caesium-137 is incorporated. One of the special advantages of this form of source material is that the radioactive material is virtually non-leachable. The radioactive "seed" has a special heavy metal cover of 0.1 mm. Two such seeds are further covered on all

sides with a stainless sheath of 0.5 mm. The source is unattractive and looks like a dull, blunt nail. The possibility of any one taking the source and keeping it in close contact with the body is very remote.

AERB issued revised guidelines on the issue and receipt of brachytherapy sources to 68 hospitals handling such sources. The regulatory agency prohibited use of brachytherapy sources in the concerned hospital till the revised guidelines which ensure safety and security of the sources were put in place.

8.4.2 Radioactive Wrist Watches

During December 2000, AERB received a warning message from the International Atomic Energy Agency about Cobalt-60 contaminated wrist watches discovered in France. The watches under the brand name Tropy (Series number T65007-3) sold by CARREFOUR chain of shops were found to be contaminated with Cobalt 60 in the link pins of their metal bracelets. AERB issued a warning message through a press release giving details of the watches.

The press release stated that there is no immediate danger from the watches. Those who have purchased this brand of watches were directed to contact the Radiological Physics and Advisory Division, BARC, Mumbai-400 094 or Health Physics Unit of the Variable Energy Cyclotron Centre at Kolkata or the Environmental Survey Laboratory, Kalpakkam to assist the Board in identifying the contaminated watches. So far no contaminated watch has been brought to the laboratories. Besides India and France, the other countries which issued the warning were Finland, Sweden and United Kingdom.

8.4.3 Regulatory Control on Depleted Uranium

During the year, there were three instances of recovery of depleted uranium from the public domain. In all these instances the material came from old teletherapy units where it was used as a shielding material. The user institutions are expected to return all depleted uranium to Bhabha Atomic Research Centre. In these instances where the police recovered sources from public domain, the user institutions have not complied with the mandatory procedure.

In the light of these experiences, the Radiological Physics and Advisory Division which assists AERB in enforcing safety provisions, directed all institutions owning depleted uranium to take a separate licence from DAE under the Atomic Energy (Working of Mines, Minerals and Handling of Prescribed Substances) Rules, 1984.

Depleted uranium has relatively less radioactivity compared to uranium. It predominantly emits alpha particles and hence does not pose any serious external radiation hazard. Beta and gamma radiation associated with depleted uranium are low and external exposure may occur only if one is very close to it. Normally, chemical toxicity is more of concern than radiological toxicity. Toxicity of depleted uranium and uranium is comparable to that of stable lead.

Because of the low level of radiation, the workers handling depleted uranium are exposed to only a small fraction of the doses permitted by regulatory agencies. The radiation dose to public will be insignificant. Personnel employed in recovery operations in which hundreds of kilograms of depleted uranium were involved in fire incidents were estimated to be exposed to only a small fraction of the dose limits prescribed by the regulatory levels.

8.4.4 Food Irradiation

During June 2000, reports appearing in a section of the press implied that irradiated food is radioactive and therefore, perhaps, harmful to the public. In order to dispel the doubts raised regarding the safety of irradiated food and inform the public about the factual position, AERB issued a press release.

There is ample scientific evidence to substantiate the fact that irradiation of food does not make it radioactive. The book titled "Safety and Nutritional Adequacy of Irradiated Food" (1994) from the World Health Organisation, covers aspects such as toxicology, microbiology, nutritional quality, etc., with regard to the irradiated food and concludes that such food produced in accordance with good manufacturing practice is safe and nutritionally adequate.

The role of the Atomic Energy Regulatory Board is to ensure that facilities where food is irradiated are operated in a safe manner so that neither the workers not the public are exposed to undue amounts of radiation exceeding safe limits. AERB assesses the site, examines the design of the facility, enforces the qualification and training of the staff and ensures that there are adequate radiation monitoring instruments at the facility before issuing the certificate of approval. AERB enforces the provisions of the Atomic Energy (Control of Irradiation of Food Rules) 1996. AERB has approved three food irradiation facilities and these are being run in a completely safe manner.

8.4.5 Radiation Safety in X-ray Installations

A section of the print media alleged that a few X-ray workers in Delhi are suffering or have suffered cancer because of unsafe conditions in X-ray installations. Such reports give the wrong impression which causes alarm totally disproportionate with any harm.

Actually, X-ray workers nationwide are among those exposed to relatively less amount of radiation compared with other radiation workers. For instance, the average annual dose to X-ray workers is less than three percent of the dose limit prescribed by the Atomic Energy Regulatory Board. Also the average doses have been steadily decreasing over the years. The trend is similar for the past twenty years.

In 1999, only nine out of about 8000 workers monitored got doses above the AERB limit of 30 mSv. The exposure conditions of unmonitored workers are likely to be the same as the data available with the Board is representative.

Some X-ray workers appear to believe that AERB stipulated that that they should not carry out more than a certain number of X-ray examinations per month. AERB did not specify any limit in terms of "the number of X-ray shots per month" as alleged in the press reports. The AERB prescription of a maximum annual dose limit of 30 mSv and a dose constraint of 100 mSv over a period of 5 years to all radiation workers including X-ray workers is similar to those accepted internationally. Every institution has been informed about these limits.

Workers can receive, unless adequate precautions are observed, high radiation doses, if they carry out procedures such as X-ray screening with conventional X-ray units or participate in special X-ray procedures. They should not carry out such procedures, if they are neither qualified nor competent to attend to such tasks.

In some instances the workers had used, by mistake, the personal monitoring badges allotted to their colleagues. This is because there was no foolproof method in the receipt and issue of personnel dosimeters. Careless behaviour on the part of a few workers causes avoidable confusion and defeats the very objective of maintaining accurate personnel dose records.

In several hospitals where the dosimeters are provided to the staff they do not care to use them. Once an AERB official carried out an unannounced inspection in a busy hospital in Delhi. A few senior radiographers were operating the X-ray units. They were not wearing dosimeters. On being questioned, they were found searching the dosimeters in the X-ray room itself. Leaving the dosimeters inside will lead to inadvertent exposures to them. These doses will be mistakenly added to the personnel dose of the workers. The behaviour of such personnel indicate total lack of appreciation of the principles of radiation protection.

Those who own and operate X-ray units must provide all protective accessories. One out of five installations do not have required protective accessories such as lead aprons. Improper lay out, inadequate floor area and X-ray rooms designed without taking into out aspects of radiation safety are the other deficiencies. There is wide scope for improvement in all these aspects. In spite of all deficiencies, X-ray workers are exposed to relatively small amounts of doses and X-ray equipment continues to be a very beneficial tool.

8.4.6 Safety Status of Operations carried out by UCIL in Bihar

Some reports have appeared recently regarding the uranium ore mining and processing operations being carried out by the Uranium Corporation of India Limited (UCIL) in their mines at Jaduguda in Bihar. These reports indicate that the operations are being conducted in an unsafe manner causing excessive radiation exposure and that as a result, the health of the workers and people in the area has been adversely affected.

AERB enforces relevant regulatory and safety functions in the uranium mines and the mill and has been constantly monitoring the safety status of these facilities through its Unit Safety Committee. The Committee meets periodically. These facilities are inspected by the staff of AERB to enforce industrial, radiological and environmental safety.

The radiation dose to workers in the mines and mill are well within the limits prescribed by AERB. The releases of radioactivity into the environment have also been within the limits.

The Safety Committee has recommended augmentation of the ventilation system in the Jaduguda mines to bring down further the airborne radioactivity levels, though the radiation doses to workers are within limits. The Committee also recommended provision of individual radon dosimeters to improve assessment of dose to mine workers. All stipulations of AERB are being complied with.

An Environmental Survey Laboratory (ESL) regularly monitors areas around Jaduguda to ensure that radiation exposure to members of public are well within the limits set by AERB. ESL takes samples of air, water and soil in and around UCIL complex. Results of these surveys indicate that the public are exposed to negligible amount of radiation. This is highly unlikely to cause any radiation induced health effects.

8.4.7 Indian Nuclear Power Reactors Unaffected by Earthquake

The nuclear power stations at Kakrapar, Rawat Bhata, Tarapur, Narora, Kalpakkam and Kaiga recorded the Bhuj earthquake on January 26, 2001. No damage took place at any of the nuclear power plants. Kakrapar Atomic Power Station is the nearest to the epicentre. Both units of Kakrapar Atomic Power Station which were working at a power level of 220 MWe on January 26, 2001 continued to work at the same power level. No damage was observed in any of the civil structures, pipes, pipe supports, cable trays and physical barriers provided for safety related equipment. All the three channels of the seismic trip which are designed to trip the reactors automatically in case of a major earthquake were tested and confirmed to be operating satisfactorily.

8.5 AERB WEBSITE

AERB WEBSITE (http://www.aerb.gov.in) contains useful information about AERB and its activities. Full texts of Annual Reports from 1999-2000 and the AERB NEWSLETTERS from 1999, press releases are published in the home page. The composition of the Board and its important committees, the list of publications, text of the Atomic Energy Act 1962, the format for various applications are also available.

SECTION 9
INTERACTIONS WITH OTHER INSTITUTIONS

9.1 BUREAU OF INDIAN STANDARDS (BIS)

Work on 'Code of Practice for Hazard Identification and Risk Assessment' under an ad-hoc panel of Industrial Safety Sectional Committee of the Bureau of Indian Standards is in progress. Officers from AERB act as members/Convener for preparation of various documents of BIS.

A revised Draft Indian Standard on 'Industrial Plant Layout' incorporating the comments received from the members of the ad-hoc panel was prepared.

9.2 INDUSTRIAL PLANTS

a) Hydrogen Cynamide Plant

Assessment of safety evaluation of a Hydrogen Cyanamide plant in Maharashtra was carried out on behalf of Ministry of Agriculture, Government of India and recommendations sent to them.

b) Liquefied Natural Gas (LNG) Terminal, Trombay

Assessment of safety evaluation and evaluation of the risk assessment study of proposed LNG Terminal, Trombay to be constructed by M/s. India Natural Gas Pvt. Ltd. was carried out on behalf of Pollution Control Board and report submitted to them.

c) Ethylene Oxide Storage Tanks

Consequence Analysis for Ethylene Oxide tanks of M/s. ICI India Ltd., Navi Mumbai was done for the following three conditions:

i) Catastrophic Failure of the Storage Tank,

ii) Guillotine Rupture of Level Indicator (150-mm. diameter),

iii) Leakage from Drain Pipe (80-mm. diameter). ■

Kaiga Atomic Power Project

Rajasthan Atomic Power Project

SECTION 10
INTERNATIONAL ACTIVITIES

10.1 IAEA-AERB RESEARCH PROJECTS

10.1.1 Risk from Disposal of Waste

As a part of risk comparison from wastes generated from electricity generation, IAEA awarded a contract to AERB with Shri P.K.Ghosh as the Chief Scientific Investigator for a project. The contract is for 'Collection and Evaluation of Data Sets for Waste Quantities and Characteristics associated with different Electricity Generation Units in India – Characteristics associated with Oil and Gas Exploration and Production of Oil Refineries'.

Data from Hindustan Petroleum (Mumbai and Visakhapatnam), Bharat Petroleum and seven units of Indian Oil Corporation (Guwahati, Barauni, Haldia, Gujarat, Assam, Digboi and Panipat) have been received and tabulated as waste quantities and their components and calculated for quantification of 'Waste per Unit of Fuel Oil produced'.

As a part of a test case study under this contract, risk calculations have been made, based on the report prepared for expressing risk from disposal of various wastes generated by different fuel cycles (like nuclear, coal, oil) for power generation in conformity with WHO/BIS Standards/Guidelines.

Health effects of liquid and solid wastes were assessed from the waste data on some Indian refineries.

10.1.2 Methodologies for Event Analysis

India participated in another IAEA Coordinated Research Programme with the following objectives:

1. Comparison & review of our Incident Reporting System and methods of incident analysis vis-à-vis other methods.

2. Improvement in our methodology based on feed back from the international experience.

Shri S.K. Chande, Shri R. Venkataraman and Shri Deepak Ojha of AERB participated in the CRP. The CRP concluded in March 2001. As part of the programme,

i) the CRP team with the help of some NPCIL personnel had taken up ASSET (Assessment of Safety Significant Events Team) review of the incident at KAPS on 'Actuation of Secondary Shut down System on failure of Two Primary Shut-off Rods'. The incident was also analysed using 'Human Performance Enhancement System' and 'Cause & Effect Method' of Root Cause Analysis (RCA). Based on these analyses using different techniques, strengths and limitations of different RCA techniques were identified.

ii) CRP team also analysed a large number of low level events (undesirable occurrences with minimal consequences) related to frequent failures in class-II electrical systems at MAPS. For analysis of these events a comprehensive and less time consuming method of identifying root causes of a group of low level events was developed.

iii) Based on the review of the reporting criteria in different Indian NPPs and also the event reporting systems operating in other countries, the CRP team developed new two tier event reporting system in which reportable events are classified into two categories as Event Reports and Significant Event Reports. The new event reporting system will make the reporting from all the NPPs uniform and provide more systematic information for event analysis. The new system will be adopted after discussions, which are taking place presently. ■

Dr.K.S. Parthasarathy, Secretary AERB and President, Indian Association for Radiation Protection addressing the meeting of the Associated Societies Forum at Hiroshima on May 16, 2000.

10.2 DEPUTATIONS ABROAD

Name of Officer	Period of deputation	Venue	Purpose
Prof. S.P.Sukhatme	17-9 – 2000 to 23-9-2000	Vienna	IAEA General Conference.
	27-11-2000 to 29-11-2000	Vienna	IAEA Meeting of the Commission on Safety Standards.
Shri G.R. Srinivasan	08.05.2000 to 12.05.2000	AECB, Ottawa, Canada	Consultants' Meet to identify Generic Safety Issues of PHWRs.
	15.05.2000 to 18.05.2000	KEPCO Nuclear Power Education Centre, Ulsan, South Korea	Management Workshop on Operation and Safety Issues of NPPs.
	22.05.2000 to 26.05.2000	OECD Headquarters, Paris.	IAEA/NEA Joint Meeting of Exchange Information on Recent Events in NPPs and TCM-Annual Meeting of IRS National Co-ordinators.
	11.09.2000 to 15.09.2000	IAEA, Vienna	Annual Meeting of Senior Regulators of Countries Operating CANDU Type Reactors.
	11.12.2000 to 15.12.2000	IAEA, Vienna.	IAEA Meeting for Generic Safety Issues of PHWRs.
	20.02.2001 to 21.02.2001 & 22.02.2001 to 23.02.2001	Bordeaux, France & NEA HQ at Issyles Moulineaux, France.	To visit Shipping Flask Test Facility & Consultancy Meeting of Joint IAEA-NEA Advisory Committee on IRS Operations.
	27.03.2001 to 29.03.2001	IAEA, Vienna.	Advisory Group Meeting on Education and Training in Nuclear Safety.
Dr. K.S Parthasarathy	14.05.2000 to 19.05.2000	Hiroshima	• 10th International Congress of the International Radiation Protection Association. • Represented Indian Association for Radiation Protection in the Associated Society as the President of IRPA. • General Assembly of 10th Congress of International Radiation Protection Association. • Visited Radiation Effects Research Foundation.
	11.12.2000 to 15.12.2000	Vienna	Advisory Group Meeting to finalise Safety Report titled "Communicating Nuclear, Radiation, Radioactive Waste and Transport Safety by the Regulatory Body".
Shri S.K. Chande	05.03.2001 to 9.03.2001	Capetown South Africa	IAEA Co-ordinated Research Programme (Final Meeting) on Investigation of Methodologies for Incident Analysis.

Name of Officer	Period of deputation	Venue	Purpose
Shri Deepak De	12.2.2001 to 16.2.2001	Vienna	Consultants Meeting on Loss of Corporate Knowledge and Memory in Nuclear Power Plants
	20.3.2001 to 30.3.2001	Moscow	Review work of design aspects of Kudankulam Project with the Principal designers
Shri P.K. Ghosh	13.11.2000 to 17.11.2000	Perth, Australia	IAEA Co-ordinated Research Programme on Formulation of Approaches to Compare the Potential Impacts of Wastes from Electricity Generation Technologies.
	11.12.2000 to 15.12.2000	Buenos Aires, Argentina	International Conference of National Regulatory Authorities with Conference on the Safety of Radiation Sources and the Security of Radioactive Materials.
Dr. Prabir C. Basu	17-12-2000 to 22-12-2000	Paris	Discussions with French Regulatory Authority, DSIN, on various aspects of safety review / analysis of nuclear power plants.
	13-10-2000 to 25-10-2000	Raleigh, USA	Participation in the Meeting of International Association for Structural Mechanics in Reactor Technology (IASMiRT). Served as Co-ordinator for the Session on, "Analysis and design for Dynamic and External Loads" in the 16th International Conference on Structural Mechanics in Reactor Technology (SMiRT -16).
Shri R Venkataraman	11.09.2000 to 15.09.2000	Madrid	IAEA TCM on 'Operational Cycle Extension of NPPs'
	19.03.2001 to 23.03.2001	Vienna	IAEA Consultants meeting on 'Human Factors Reporting Guidelines/ Safety Culture For Incident Reporting System'
Shri Deepak Ojha	26.06.2000 to 30.03.2000	Portoroz, Slovenia	IAEA TCM 'Assessing and Assuring Plant Modification Safety' (with Technical visit – Steam Generator Replacement).
Shri S.N.Rao	13.11.2000 to 01.12.2000	Ulsan, South Korea	Interregional Training Course on 'Qualification of NPP Personnel and the role of Management'
	19.03.2001 to 23.03.2001	Moscow	Regulatory Interface with Russian Federation on Kudankulam Project'
Dr. A.N. Nandakumar	5.2.2001 to 9.2-.2001	Vienna	IAEA Transport Safety Standards Committee (TRANSSC) Meeting.
Shri Jaharlal Koley	26.06.2000 to 30.06.2000	Vienna	IAEA TCM 'Regulatory Review of Level-2 Probabilistic Safety Assessment (PSA) and PSA Application'.
Shri A.U. Sonawane	27.11.2000 to 8.12.2000	Sydney	IAEA-RCA Regional Training Course on the Safe Transport of Radioactive Material
	18.12.2000 to 22.12.2000	Paris	Discussions on regulatory activities and French experience in the field of transport of radioactive material.

SECTION 11
HUMAN RESOURCE DEVELOPMENT

Staff members of AERB delivered lectures to the students of BARC Training School. They also delivered lectures to students studying for the Diploma in Radiological Physics of the University of Mumbai and for the M.Sc. (Medical Physics) course of Anna University. Radiological Physics and Advisory Division assists AERB by organising training programmes for different levels of Radiological Safety Officers.

Dr. B. C. Bhatt, Head, Radiological Physics and Advisory Division, BARC, Welcomes Dr. (Mrs.) A. M. Samuel, Director Biomedical Group, BARC

Ms. Mahua Basu, Trainee Graduated from the 39th Diploma Course in Radiological Physics.

SECTION 12

SAFETY PROMOTIONAL ACTIVITIES IN DAE

12.1 INDUSTRIAL SAFETY AWARDS

The AERB Industrial Safety Award winners for the performance year 2000 are as follows:

Group 1	Construction and Underground Mining Units	No award given
Group II	Production Units (HWP & NPCIL Units)	HWP, Kota
Group III	Production Units (Others)	IRE, Manavalakurichi
Group IV	Research Units (R&D)	No award given
Group V	Research Units (Industrial)	FBTR (IGCAR), Kalpakkam

These awards were presented on 8th March 2001 at Niyamak Bhavan, AERB, Mumbai. The awards were based on safety statistics and efforts put in by the units towards imparting Industrial Safety Training to Engineers, Supervisors, Workers and Contractors' Employees. In addition, only those units that were above the Minimum Acceptable Level of safety specified for their group were considered for the Industrial Safety Award. Units with a fatality are debarred from the competition.

12.2 FIRE SAFETY AWARD

The Fire Safety Award is decided by taking into account the safety records on fire incidents and the fire potential at the site. The award is given on the basis of best performance in fire safety amongst all DAE units. The award for the performance year 1999 was presented to Rajasthan Atomic Power Project 3-4 during 17th DAE Safety Professionals Meet held from 16th to 18th October 2000 at IGCAR, Kalpakkam.

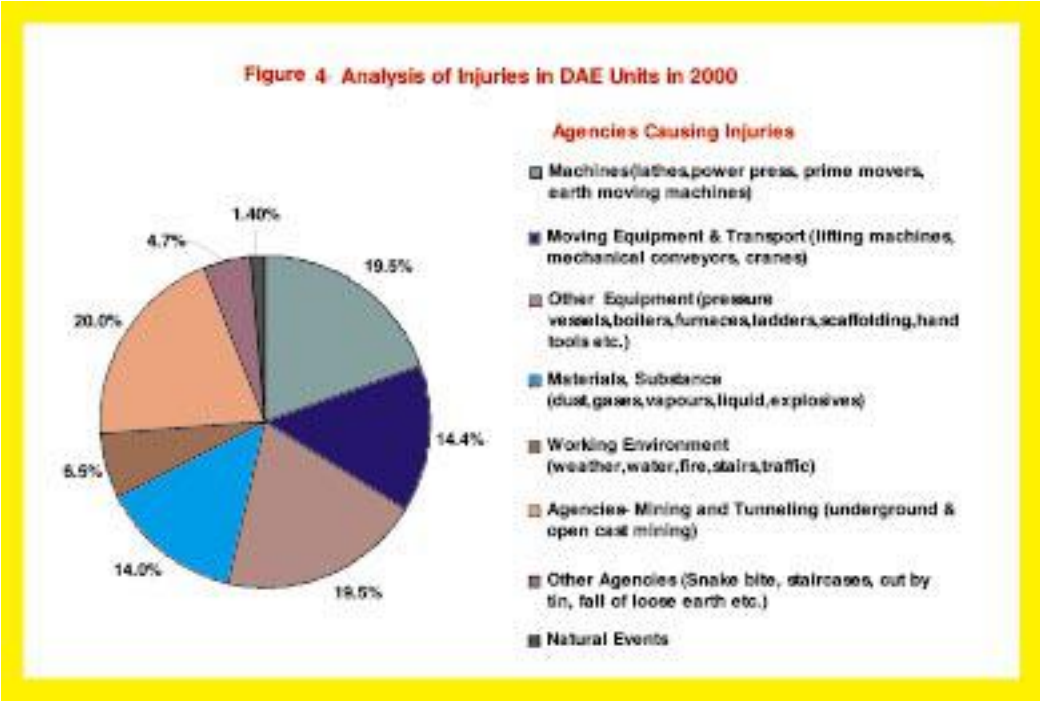
12.3 GREEN SITE AWARD

The Green Site Award for the performance year 1999 was won jointly by IRE, OSCOM and Heavy Water Plant, Thal. This award is based on greenery in and around the site and the efforts made to improve greenery in three consecutive years.

12.4 DATA BASE MANAGEMENT FOR INDUSTRIAL ACCIDENTS IN DAE UNITS FOR THE YEAR 2000

Accident data sent by various DAE units were compiled and analysed and a booklet entitled 'Data Base Management for Industrial Accidents in the DAE units for the year 2000' was published and released on March 8, 2001 during AERB Industrial Safety Awards presentation ceremony.

The compilation provides an opportunity to compare the accident statistics amongst the individual units of DAE as well as non-DAE units. The data is processed to have accident statistics in standard format as well as analysis in respect of each unit of DAE, groups of units viz. NPPs, HWPs, IREL plants and other DAE units, viz. UCIL, NFC, AMD, BRIT in tabular and graphical forms. The percentage of agency-wise injuries in DAE units for the year 2000 has been depicted in **figure 4.** ■



SECTION 13
AERB PERSONNEL PROFILE

Sl. No.	Name	Designation/Grade
1.	Prof. S.P. Sukhatme	Chairman
2.	Shri G.R. Srinivasan	Distinguished Scientist
3.	Dr. K.S. Parthasarathy	Scientific Officer(H)
4.	Shri S.K. Chande	"
5.	Shri S.K. Agarwal	"
6.	Shri A.R. Sundararajan	"
7.	Shri Deepak De	"
8.	Shri P.K. Ghosh	"
9.	Dr. P.C. Basu	"
10.	Shri D.K. Dave	"
11.	Shri S.K. Warrier	Scientific Officer(G)
12.	Shri P. Hajra	"
13.	Shri G. Venkataraman	"
14.	Dr. Masood Ahmad	"
15.	Shri K.K. Chandrakar	"
16.	Shri J. Lal	"
17.	Shri S.A. Sukheswala	"
18.	Shri R.K. Chugha	"
19.	Dr. A.N. Nandakumar	"
20.	Shri K.S. Kini	"
21.	Shri V.V. Pande	"
22.	Shri J. Prasad	"
23.	Shri A. Ramakrishna	"
24.	Shri S.N. Rao	"
25.	Shri P.R. Krishnamurthy	Scientific Officer (F)
26.	Shri S.P. Agarwal	"
27.	Shri R.R. Vishwakarma	"
28.	Shri R. Bhattacharya	"
29.	Shri Fredric Lall	"
30.	Shri R.P. Singh	"
31.	Shri K. Srivasista	"
32.	Shri B.S. Chauhan	"
33.	Shri Y.K. Shah	"
34.	Smt. S. Bhattacharya	"
35.	Smt. Kanta Chhokra	"
36.	Shri K.V. Subbiah	"
37.	Shri S.G. Sawant	"
38.	Shri S.A.H. Ashraf	"
39.	Shri V.K. Shirva	"
40.	Shri L.R. Bishnoi	"
41.	Shri S.A. Khan	"
42.	Shri S.T. Swamy	"
43.	Shri C.P. Raghavendran	Scientific Officer(E)
44.	Shri G. Janakiraman	"
45.	Shri George Thomas	"
46.	Shri Arun Kumar	"
47.	Smt. B. Nagalakshmi	"
48.	Shri U.K. Paul	"
49.	Shri S. Harikumar	"
50.	Dr. P. Sasidhar	"
51.	Shri A.U. Sonawane	"
52.	Shri Deepak Ojha	"
53.	Shri J. Koley	"
54.	Shri K.D. Pushpangadan	"
55.	Shri K.C. Upadhyay	Scientific Officer(D)
56.	Shri R.P. Gupta	"
57.	Shri G. Natarajan	"
58.	Shri Senthil Kumar	"
59.	Shri P.K. Dash Sharma	"
60.	Shri S.R. Bhave	"
61.	Shri E.R. Titto	"
62.	Smt. P. Shylamoni	"
63.	Shri V.S. Iyer	"
64.	Shri R.K. Singh	Scientific Officer(C)
65.	Shri P. Vijayan	"
66.	Shri R.K. Kodwani	"

Sl. No.	Name	Designation/Grade
67.	Shri L.N. Valivetti	"
68.	Shri D. Bhattacharya	"
69.	Shri Vivek	"
70.	Shri P.S. Virdhi	"
71.	Shri K. Suneet	"
72.	Shri J.P. Jena	"
73.	Shri A.D. Roshan	"
74.	Smt. V. Anuradha	"
75.	Shri R.B. Solanki	"
76.	Shri R.S. Rao	"
77.	Shri S.K. Pradhan	"
78.	Shri U.S. Chikkanagoudar	"
79.	Shri S.K. Dubey	"
80.	Shri Ajay S.Pisharady	"
81.	Shri S.K. Tripathi	"
82.	Shri Mahendra Prasad	"
83.	Shri J. Mishra	"
84.	Smt. M. Inamdar	"
85.	Shri Sunil Sunny	"
86.	Shri D.V. Pimpale	"
87.	Shri V.P. Gholap	Scientific Officer(SB)
88.	Shri Gurumoorthy	"
89.	Shri B.K. Singh	"
90.	Smt. B.H. Ingavale	"
91.	Shri M.S. Chaudhari	Draughtsman F
92.	Smt. R.N. Vadivala	Scientific Assistant(E)
93.	Shri G. Sivaraman	Scientific Assistant (D)
94.	Shri S.M. Kodolkar	"
95.	Shri D.M. Rane	"
96.	Shri N.M. Chodankar	"
97.	Shri V.R. Dhotre	"
98.	Shri Kavi Upreti	Scientific Assistant (B)

Sl. No.	Name	Designation/Grade
99.	Shri A.P. Bapat	Tradesman F
100.	Shri S.S. Bhoite	Chargehand
101.	Shri R.D. Salgaonkar	Tradesman D
102.	Shri Puran Singh	Tradesman A
103.	Shri B.D. Kajania	"
104.	Shri N.S. Nair	Administrative Officer-III
105.	Smt. Sarojini Lakshmanan	Principal Private Secretary
106.	Smt. T.M. Elsie	Deputy Controller of Accounts
107.	Smt. V. Kalyani	Senior Accounts Officer
108.	Shri C.K. Vijayan	Assistant Personnel Officer
109.	Shri V.P. Kuriakose	Assistant Personnel Officer
110.	Shri J.N. Soni	Assistant Director (Official Language)
111.	Smt. S.M. Nair	Assistant Accounts Officer
112.	Shri R.J. Palamattom	Senior Personal Assistant
113.	Smt. P. Chandrasekhar	Steno I
114.	Smt. Sheela K.Menon	"
115.	Smt. Mallika C. Nair	Steno II
116.	Shri P. Narayanan	"
117.	Smt. Radha Raghavan	"
118.	Smt. Latha Mohandas	"
119.	Smt. Suma Panicker	Assistant
120.	Shri Javed Jafri	Assistant Accountant
121.	Shri M.K. Shukla	Junior Hindi Translator
122.	Shri G.D. Gudekar	Cashier
123.	Smt. N. Jayashankar	Steno III
124.	Smt. P. Shelar	Upper Division Clerk
125.	Shri K.V. Prakash	"
126.	Smt. P. Harinarayanan	Lower Division Clerk
127.	Shri R.R. Koli	"
128.	Shri J.K. More	"
129.	Smt. S.M. Shettigar	"

ABBREVIATIONS USED

ACPSR	Advisory Committee for Project Safety Review
AERB	Atomic Energy Regulatory Board
AMD	Atomic Minerals Division
BARC	Bhabha Atomic Research Centre
BRIT	Board of Radiation and Isotope Technology
CESC	Civil Engineering Safety Committee
CSIR	Council for Scientific and Industrial Research
CT	Computed Tomography
DAE	Department of Atomic Energy
DRDO	Defence Research and Development Organisation
DSF	Dry Storage Facility
ECCS	Emergency Core Cooling System
ECIL	Electronics Corporation of India Ltd.
EFPY	Effective Full Power years
FBTR	Fast Breeder Test Reactor
HWB	Heavy Water Board
HWP	Heavy Water Plant
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IGCAR	Indira Gandhi Centre for Atomic Research
INES	International Nuclear Event Scale
IREL	Indian Rare Earths Ltd.
IRS	Incident Reporting System (of International Atomic Energy Agency)
ISI	In-Service Inspection
KAMINI	Kalpakkam Mini Reactor
KAPS	Kakrapar Atomic Power Station
KGS	Kaiga Generating Station
MAPS	Madras Atomic Power Station
MOU	Memorandum of Understanding
NAPS	Narora Atomic Power Station
NFC	Nuclear Fuel Complex
NOC	No-Objection Certificate
NPCIL	Nuclear Power Corporation of India Ltd.
NPP	Nuclear Power Plant
OPSD	Operating Plants Safety Division
OSCOM	Orissa Sand Complex
PDSC	Project Design Safety Committee
PFBR	Prototype Fast Breeder Reactor
PHT	Primary Heat Transport
PHWR	Pressurised Heavy Water Reactor
QA	Quality Assurance
RAPP	Rajasthan Atomic Power Project
RAPPCOF	Rajasthan Atomic Power Project Cobalt Facility
RAPS	Rajasthan Atomic Power Station
RPS	Rana Pratap Sagar
RSO	Radiological Safety Officer
SARCAR	Safety Review Committee for Applications of Radiation
SARCOP	Safety Review Committee for Operating Plants
SC	Safety Committee
SSSF	Soild Storage Surveillance Facility
TAPP	Tarapur Atomic Power Project
TAPS	Tarapur Atomic Power Station
Type B(U)	Type B (Unilateral)
UCIL	Uranium Corporation of India Ltd
WIP	Waste Immobilisation Plant

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