Government of India

NATIONAL REPORT

to

THE CONVENTION ON NUCLEAR SAFETY

Sixth Review Meeting of Contracting Parties, March 2014

August 2013

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Foreword

The Government of India ratified the Convention on Nuclear Safety on March 31, 2005. This is the third National Report being submitted by India for review by the Contracting Parties, pursuant to Article 5 of the Convention on Nuclear Safety, which entered into force on 24 October 1996. The Report demonstrates how Government of India has fulfilled its obligations under Articles 6 through 19 of the Convention.

This National Report was prepared in accordance with the "Guidelines Regarding National Reports under the Convention on Nuclear Safety" issued as information circular INFCIRC/572/Rev.4. Accordingly, all land-based nuclear power plants including storage, handling and treatment facilities for radioactive materials attached to the NPP and directly related to the operation of nuclear power plants are covered in the national report.

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List of Acronyms

ACCGD	Advisory Committee on Code, Guides & Associated Manuals for Safety in Design of NPPs
ACCGASO	Advisory Committee for Codes, Guides & Associated Manuals for Safety in Operation of NPPs
ACCGORN	Advisory Committee for preparation of Code & Guides on Governmental Organization for the Regulation of Nuclear & Radiation facilities
ACCGQA	Advisory Committee for Codes & Guides for Quality Assurance for Nuclear Power Plants Safety
ACIFS	Advisory Committee for Industrial and Fire Safety
ACOH	Advisory Committee on Occupational Health
ACPSR	Advisory Committee for Project Safety Review
ACRDCSE	Advisory Committee for Regulatory Documents on Civil and Structural Engineering
ACNS	Advisory Committee on Nuclear Safety
ACRDS	Advisory Committee for Regulatory Documents on Nuclear Power Plant Siting
ACROSS	Apex Committee for Review of Operating Station Safety
AC-RSR	Advisory Committee for Review of Safety Research
ACRS	Advisory Committee on Radiological Safety
ACSDFCF	Advisory Committee on Safety Documents relating to Fuel Cycle Facilities other than Nuclear Reactors
AEC	Atomic Energy Commission
AERB	Atomic Energy Regulatory Board
AERBSC-EE	AERB Safety Committee for External Events
AHWR	Advanced Heavy Water Reactor
ALARA	As Low As Reasonably Achievable
AMD	Atomic Minerals Directorate for Exploration and Research
AOO	Anticipated Operational Occurrence
BARC	Bhabha Atomic Research Centre
BHAVINI	Bharatiya Nabhikiya Vidyut Nigam Limited
BRIT	Board of Radiation & Isotope Technology
BRNS	Board of Research in Nuclear Sciences
BSD	Biennial Shutdown
BWR	Boiling Water Reactor
CCC	Construction Completion Certificate
CESC	Civil Engineering Safety Committee
CMG	Crisis Management Group
COG	CANDU Owners Group
CPR	Corporate Peer Review
CSIR	Council for Scientific & Industrial Research
CSNI	Committee on Safety of Nuclear Installations
CSRP	Committee for Safety Research Projects
DAE	Department of Atomic Energy
DEC	Design Extension Conditions
DDMA	District Disaster Management Authority
DIL	Derived Intervention Levels
DRD	Direct Reading Dosimeter
DSS	Decision Support System
EAC	Expert Appraisal Committee
EMCCR	En-Masse Coolant Channel Replacement
ECC	Emergency Control Centre
ECR	Emergency Communication Rooms
ECCS	Emergency Core Cooling System
EOP	Emergency Operating Procedure
EPR	European Pressurised Reactor

EPZ	Emergency Planning Zone
EZ	Exclusion Zone
ESL	Environmental Survey Laboratory
FAC	Flow Assisted Corrosion
FBTR	Fast Breeder Test Reactor
FPC	First Pour of Concrete
FSAR	Final Safety Analysis Report
GSR	General Statutory Rules
HBNI	Homi Bhabha National Institute
HPU	Health Physics Unit
HQI	Head Quarter Instruction
HRTF	Hydrogen Recombiner Test Facility
HWB	Heavy Water Board
IAEA	International Atomic Energy Agency
IERMON	Indian Environmental Radiation Monitoring Network
ICRP	International Commission on Radiation Protection
IGCAR	Indira Gandhi Centre for Atomic Research
IL	Intervention Level
INES	International Nuclear and Radiological Event Scale
IPSD	Industrial Plants Safety Division
IRE	Indian Rare Earths Limited
IRRS	Integrated Regulatory Review Services
ISI	In-service Inspection
ITSD	Information and Technical Services Division
KAPS	Kakrapar Atomic Power Station
KGS	Kaiga Generating Station
KKNPP	Kudankulam Nulclear Power Plant
LCO	Limiting Conditions for Operation
LOCA	Loss of Coolant Accident
LSSS	Limiting Safety System Settings
MAPS	Madras Atomic Power Station
MDEP	Multinational Design Evaluation Programme
MoEF	Ministry of Environment and Forests
NCMC	National Crisis Management Committee
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
NEA	Nuclear Energy Agency
NEC	National Executive Committee
NFC	Nuclear Fuel Complex
NPCIL	Nuclear Power Corporation of India Limited
NPP	Nuclear Power Plant
NPSD	Nuclear Projects Safety Division
NREMC	Nuclear and Radiological Emergency Monitoring Cell
NSAD	Nuclear Safety Analysis Division
NSRA	Nuclear Safety Regulatory Authority
NTC	Nuclear Training Centre
OED	Off-site Emergency Director
OERC	Operating Experience Review Committee
OPRD	Over Pressure Relief Devices
OPSD	Operating Plants Safety Division
OSART	Operational Safety Review Team
PAZ	Precautionary Action Zone
PCB	Pollution Control Board
PDHRS	Passive Decay Heat Removal System
PDSC	Project Design Safety Committee
PFBR	Prototype Fast Breeder Reactor
PHT	Primary Heat Transport
PHWR	Pressurised Heavy Water Reactor
PIE	Postulated Initiating Events

PSA	Probabilistic Safety Assessment
PSAR	Preliminary Safety Analysis Report
PSR	Periodic Safety Review
QMS	Quality Management System
RAPS	Rajasthan Atomic Power Station
RPR	Radiation Protection Rules
RSD	Radiological Safety Division
RSO	Radiological Safety Officer
RTI	Right To Information
SAMG	Severe Accident Management Guidelines
SARCAR	Safety Review Committee for Application of Radiation
SARCOP	Safety Review Committee for Operating Plants
SBO	Station Black Out
SDDP	Safety Document Development Proposal
SDMA	State Disaster Management Authority
SDS	Shutdown System
SEC	Site Evaluation Committee
SED	Site Emergency Director
SER	Significant Event Report
SFTD	Spent Fuel Transfer Duct
SNRIU	State Nuclear Regulatory Inspectorate of Ukraine
SORC	Station Operation Review Committee
SRI	Safety Research Institute
SSC	Structures, Systems and Components
SSED	Siting and Structural Engineering Division
STAR	Stop Think Act Review
STC	Station Training Centre
STD	System Transfer Document
TAPS	Tarapur Atomic Power Station
TIFR	Tata Institute of Fundamental Research
TSO	Technical Support Organisations
UCIL	Uranium Corporation of India Limited
UPZ	Urgent Protective Action Planning Zone
USC	Unit Safety Committee
USNRC	United States Nuclear Regulatory Commission
WANO	World Association of Nuclear Operators

1. INTRODUCTION

1.0 GENERAL

Integrated energy policy of India considers the role of nuclear power as vital for long term energy security and sustainable development of the country. To increase the nuclear power capacity in the country, India pursues development and deployment of nuclear power plants through indigenous technologies as well as import of reactors from abroad. In other applications of nuclear energy, India is pursuing comprehensive programmes in radiation and isotope technologies for societal benefit in the areas of food preservation, development of superior mutant varieties of seed/crops, nuclear medicine for diagnostics and radiation therapy, industrial radiography, sewage and waste management etc. These programmes have been making significant contributions to India's development.

Nuclear facilities in India are sited, designed, constructed, commissioned and operated in accordance with strict quality and safety standards. The primary responsibility for the safety of the facility lies with the utility and as required, they have a system of independent review and scrutiny of safety as an integral part of the management control. Atomic Energy Regulatory Board (AERB), the national regulatory body, oversees the safety and has been bestowed with powers to frame safety policies, lay down safety standards & requirements and has powers to monitor & enforce safety provisions in nuclear and radiation installations and practices.

1.1 NATIONAL NUCLEAR POWER PROGRAMME

Atomic Energy Programme in India is governed by Atomic Energy Act of 1962 and the rules framed there under. Atomic Energy Commission (AEC) is the apex body which lays down the policies for the national nuclear programme. The Department of Atomic Energy (DAE) is responsible for execution of policies laid down by the AEC. DAE is engaged in research, technology development and commercial operations in the areas of nuclear energy, related high technologies and also supports basic research in nuclear science and technology. Nuclear Power Corporation of India Limited (NPCIL) is a Government owned company for design, construction and operation of the nuclear power plants in the country and is currently operating all NPPs. Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) is another government company established for construction, commissioning and operation of the first 500 MWe Prototype Fast Breeder Reactor (PFBR) and future Fast Breeder Reactors. Bhabha Atomic Research Centre (BARC) is the premier multi disciplinary nuclear research centre of India having excellent infrastructure for advanced research and development, with expertise covering entire spectrum of nuclear science and engineering and related areas. Indira Gandhi Centre for Atomic Research (IGCAR) is another national institution engaged in broad based multidisciplinary programme of scientific research and advanced engineering directed towards the Fast Breeder Reactor technology.

The organizational structure for Atomic Energy in India is shown in Annex 1-1.

Presently, there are 20 NPP units in operation in India, with an installed capacity of 4780 MWe as indicated in Table 1. Seven more units with a capacity of 5300 MWe are under construction / commissioning as indicated in Table 2. In addition, a number of new NPPs are planned to significantly increase the nuclear power base from the current levels.

The first NPP in the country, TAPS -1&2, based on boiling water reactors (BWR), supplied by General Electric, USA, became operational in the year 1969. After completion of 30 years of operation, during the years 2000 to 2006, these plants underwent safety assessments for continued long term operation. Based on the review, a number of safety upgrades were implemented during the refuelling outages of individual units and in a simultaneous long shutdown of both the units during November 2005 to January 2006. These safety upgrades were described in the Indian National Reports submitted to the 4th and 5th Review Meetings of CNS.

The mainstay of India's nuclear power programme has been the PHWR. Two 200 MWe units (RAPS 1&2) were established in the 1970s, at Rawatbhata in Rajasthan, with the technical cooperation of AECL (Canada). Subsequently, in 1980s, two 220 MWe PHWRs (MAPS-1&2) were constructed at Kalpakkam in Tamilnadu, with indigenous efforts. Among these, presently RAPS -2 and MAPS -1&2 have undergone extensive safety upgrades.

Subsequently, India developed a standardised design of 220 MWe PHWRs. This design incorporated state of the art features viz. integral calandria & end shields, two independent fast acting shut down systems, high pressure Emergency Core Cooling System (ECCS), water filled calandria vault and provision of double containment with passive vapour suppression pool. Four units of this standardised design were built, two each at Narora in Uttar Pradesh (NAPS-1&2) and Kakrapar in Gujarat (KAPS-1&2). These plants became operational through the 1990s. Subsequently eight more units of standardised 220 MWe PHWRs were built, four each at Kaiga in Karnataka (KGS-1 to 4) and Rawatbhata in Rajasthan (RAPS-3 to 6). Over and above the basic standardised 220 MWe PHWR, the later designs have more compact site layout and incorporated further improvements in safety features and containment.

In 1990s, India undertook the design and development of 540 MWe PHWR. Two units based on this design became operational in 2005-2006 at Tarapur (TAPS- 3&4).Evolving on the 540 MWe PHWR design, India has now developed a 700 MWe PHWR design with limited boiling in the coolant channels. The construction of four such units is under progress, at the Kakrapar and Rawatbhata sites.

In addition, India has setup two units of 1000 MWe LWRs (VVER based design), at Kudankulam (KKNPP-1&2) in Tamilnadu, with the co-operation of Russian Federation. KKNPP-1 achieved first criticality on 13th July, 2013 and subsequently, low power physics experiments have been completed. In KKNPP-2, Commissioning activities have begun and final preparations towards Hot Run of primary coolant systems are in progress. These reactors incorporate many advanced safety features both passive and active.

Post-Fukushima, extensive safety review of all Indian NPPs, especially with respect to external events was undertaken and the findings were presented in the Second Extraordinary Review Meeting of CNS.

BHAVINI is presently engaged in construction of PFBR and will take on design responsibilities in due course after competency is developed in house. Major equipments such as main vessel and safety vessel, primary-secondary sodium heat exchangers, steam generators, other reactor auxiliaries are erected. The construction is expected to be completed by 2013.

India has taken a number of steps towards development of necessary technology for utilization of thorium in the nuclear power programme. Use of U-233 as nuclear fuel derived from irradiated thorium has been demonstrated successfully in a neutron source research reactor KAMINI. India has developed Advanced Heavy Water Reactor (AHWR) of 300 MWe capacity for direct utilization of thorium. The design incorporates state of the art advanced passive safety features. Pre-licensing safety review of the design of AHWR has been completed by AERB. A number of R&D activities have been taken up in BARC in connection with the development of AHWR. BARC has commissioned a critical facility to validate the physics design of AHWR.

1.2 EMERGING SCENARIO

The installed electricity generating capacity in India as of March 2013 is 225 GW. With this capacity India is globally fifth largest producer of the electricity. The annual per capita electricity consumption, as on March 2012 is 879 kWh. The contribution from nuclear energy to the overall electricity generation is about 3%. The Indian Integrated Energy Policy - 2006 emphasizes the need to increase the electricity generating capacity at an accelerated pace to meet the demand of the rapidly growing economy. The contribution of nuclear energy is also proposed to be enhanced to about 63 GW by 2032. To enhance the power generation capacity, India is in the process to set up Light Water Reactors with foreign collaboration.

The Government has accorded 'in-principle approval' of the sites for setting up 20 new NPP units (10 PHWRs of 700 MWe and 10 LWRs of 1000 MWe or higher) in the first instance. This will be followed up by setting-up of more reactors of the same design and at the same sites. Four units of 700 MWe are under construction at KAPP-3&4 and RAPP-7&8. Recognizing the necessity for developing indigenous capability to support this growth, setting up / augmentation of facilities to manufacture major components by the leading industry partners has been initiated. The opening up of nuclear trade with India has also encouraged many global equipment suppliers to tie up with Indian industry for establishing manufacturing hub in India for global nuclear requirements.

1.3 NUCLEAR FUEL CYCLE

India's nuclear power programme is based on a closed fuel cycle. India has adopted this approach considering the objectives of maximum utilisation of the energy potential of available resources and minimisation of high level waste.

Comprehensive fuel cycle technologies and facilities addressing the needs of both front end and back end have been developed and are in operation. Front end facilities including mining, milling & processing of ore and for fuel fabrication are operated by Uranium Corporation of India Limited (UCIL) and Nuclear Fuel Complex (NFC) respectively. The back end technologies & facilities for reprocessing of spent fuel for extraction of plutonium & uranium and the associated fuel fabrication facilities have been developed by DAE and are in operation.

India has developed necessary technologies for safe management of the radioactive wastes arising out of the nuclear fuel cycle. This includes the vitrification technology for conditioning and fixation of the high level waste produced during spent fuel reprocessing in a glass matrix. The vitrified high level nuclear waste is stored in exclusive storage and surveillance facilities, prior to its final disposal in a geological repository. The vitrification plants and storage & surveillance facilities for the vitrified waste packages are in operation.

1.4 REGULATION OF NUCLEAR FACILITIES

Atomic Energy Regulatory Board (AERB) was established in 1983 under the provisions of the Atomic Energy Act 1962, and was provided with the necessary powers and mandate to frame safety policies, lay down safety standards & requirements for monitoring & enforcing the safety provisions. AERB follows multi-tier system for its review and assessment, safety monitoring, surveillance and enforcement

AERB issues authorization in stages viz. Siting, Construction, Commissioning and operation during the life cycle of NPPs. It issues authorization for a specified stage after conducting safety review and assessment. The compliance to the regulatory requirements is ensured through regulatory inspection and enforcement actions. Periodic Safety Review (PSR) of NPP is carried out in ten years interval for renewal of authorization for operation.

AERB gets its technical support mainly from BARC and IGCAR. AERB has access to the outcome of the safety research performed by these organisations. Further as and when required AERB commissions their services to perform research, analysis and studies in specialised areas of its interest. AERB also utilises their expertise to conduct its safety review and assessment function. Safety Research Institute (SRI) of AERB conducts independent safety studies in certain specific areas to supplement regulatory review and assessment activities.

1.5 INDUSTRIAL INFRASTRUCTURE FOR NUCLEAR POWER

Towards developing various technologies for the envisaged nuclear power programme in the country, a number of facilities were established by DAE in the early years. These included uranium and thorium extraction plants, fuel fabrication plant, heavy water production facilities, research reactors, a fuel reprocessing plant, waste treatment facilities and a number of radiological laboratories for radioisotope production, radiochemistry research and radio-metallurgy studies. Significant up-gradation and developmental efforts were undertaken in initial days for manufacturing and precision machining jobs to meet the quality standards of nuclear industry.

Today almost all ferrous and non ferrous materials, components and equipment required for nuclear power plants are manufactured indigenously.

India has heavy engineering and manufacturing facilities in both public and private sectors. It is capable of manufacturing equipment / components like coolant tubes, calandria tubes, calandria and end shields for PHWRs, steam generators, turbines, electrical equipment, heat exchangers, pumps, pressure vessels, fuelling machines etc. The developments in manufacture of electrical machines, electrical and electronic accessories, and Control & Instrumentation items such as large size motors, high quality conductors, sophisticated control panels and computer based control systems progressed in line with requirements of nuclear power projects. The maturity of the industry and its capability to take up mega package contracts has contributed significantly in the reduction of gestation time of nuclear power projects in India. Concurrently with the development of manufacturing technologies, non-destructive examination techniques and related equipment such as optical instruments, laser technology etc. have been developed.

1.6 HUMAN RESOURCE DEVELOPMENT

In order to create a competent pool of well trained scientists and engineers, a specialized training school at BARC was established in 1957. The training school has since been adding competent human resource to the pool. With the growth of nuclear power, NPCIL set up its own Nuclear Training Centres (NTCs) to meet its demand. Training schools have also been set up at the Raja Ramanna Centre for Advanced Technology, Indore (2000), Nuclear Fuel Complex, Hyderabad (2001) and IGCAR, Kalpakkam (2006) to meet the expanding needs. The core of the human resource for the nuclear power programme comes through these training centres. In addition, experienced manpower from conventional power and industry are also inducted to meet the demand.

The country's universities, engineering and diploma institutes, and industrial training institutes form the basic educational infrastructure from which engineers/scientists, technicians and skilled tradesmen are recruited and subsequently trained to suit the job needs.

Networking with the Indian Institutes of Technology (IITs) has been strengthened and post-graduate courses in nuclear engineering have been started at several institutes. Sponsored post-graduate program called 'DAE Graduate Fellowship Scheme' were started at all the IITs. Board of Research in Nuclear Sciences (BRNS) under DAE provides another avenue for networking by sponsoring research projects in the field of Nuclear Science and Engineering at various educational institutes. Homi Bhabha National Institute (HBNI) established under DAE conducts post-graduation and doctoral programmes in areas of nuclear science and technology.

NPCIL's technical manpower includes freshly recruited engineers who go through one year of training in DAE/BARC Training School or in Nuclear Training Centres of NPCIL. It also hires experienced manpower from open market. NPCIL provides challenging work environment, attractive remunerations and promotional avenues to its employees for motivating them to continue their carrier with NPCIL. It also provides excellent quality of life at its residential colonies by adequately taking care of their health, education and transportation and recreational needs.

The initial manpower for construction, commissioning and operation of the Fast Breeder Reactor has been inducted from NPCIL and IGCAR. BHAVINI has also undertaken recruitment of graduate engineers and personnel at various grades. IGCAR training centre will cater to training needs for Fast Reactors. The operation staff is currently in training at FBTR and NPCIL plants and also engaged in the commissioning tests at PFBR. The qualification and licensing of the staff will be in line with the norms established by AERB for operation of PFBR.

AERB is continuously augmenting its human resource to meet the demand arising from the expanding nuclear power programme and increasing number of radiation facilities in the country. AERB inducts fresh technical and scientific staff from DAE's training schools and nuclear training centres. It also hires graduate engineers and sponsors them for Masters programmes in the Indian Institutes of Technology through the AERB Graduate Fellowship Scheme (AGFS) who later serve as AERB staff. Experienced professionals are also recruited from open advertisements. AERB imparts intensive in-house orientation training programs to the newly recruited staff. In addition,

refresher courses are regularly conducted on various topics of regulatory and safety importance to maintain the competence of the staff. AERB colloquia are organised on topics of current interests and on new developments in various fields.

1.7 COMMITMENT TO THE CONVENTION ON NUCLEAR SAFETY

India is committed to implement the provision of the Convention. The report demonstrates how these provisions are implemented in chapter wise description.

After the ratification of the Convention in 2005, India submitted the National Reports as well as answers to the questions raised on the reports in a comprehensive and timely manner in all the Review Meetings as well as Extraordinary Meeting of the Convention. India has actively participated in the Review Process of the Convention and engaged a large number of experts to undertake the review of the National Reports of the Contracting Parties. India provided services of the experts as officers in all the Review Meetings of CNS since its ratification of the Convention. India remains actively engaged in the review process that began post Fukushima nuclear accident in Japan to enhance the effectiveness of the Convention.

1.8 NATIONAL REPORT TO THE 6th REVIEW MEETING OF CNS

The national report of India to the 6th review meeting of the Convention is prepared in line with the guidelines contained in information circular INFCIRC/572/Rev.4 on “Guidelines regarding National Reports under the Convention on Nuclear Safety”.

In the 5th Review Meeting of CNS, India had identified certain challenges and the planned measures to further improve safety. Detailed account on the approach adopted to address them is given in the relevant chapters of the report. The recommendations adopted at the Plenary Sessions of the 5th Review Meeting have been addressed and future activities for further enhancement of safety are brought out. The summary of the action taken in response to the recommendations of the 2nd Extraordinary Meeting subsequent to Fukushima nuclear accident has also been included.

Table – 1

NPPs in Operation as of August 2013

Unit	Type	Gross Capacity (MWe)	Licensee / Owner	Reactor Supplier	Commencement of Operation
KGS-1	PHWR	220	NPCIL	NPCIL	Nov-2000
KGS-2	PHWR	220			Mar-2000
KGS-3	PHWR	220			May-2007
KGS-4	PHWR	220			Jan- 2011
KAPS-1	PHWR	220			May-1993
KAPS-2	PHWR	220			Sep-1995
MAPS-1	PHWR	220			Jan-1984
MAPS-2	PHWR	220			Mar-1986
NAPS-1	PHWR	220			Jan-1991
NAPS-2	PHWR	220			Jul-1992
RAPS-1#	PHWR	100	NPCIL / DAE	AECL, CANADA	Dec-1973
RAPS-2	PHWR	200	NPCIL	AECL/ DAE	Apr-1981
RAPS-3	PHWR	220		NPCIL	Jun-2000
RAPS-4	PHWR	220			Dec-2000
RAPS-5	PHWR	220			Feb-2010
RAPS-6	PHWR	220			Mar- 2010
TAPS-1	BWR	160		GE, USA	Oct-1969
TAPS-2	BWR	160			Oct-1969
TAPS-3	PHWR	540		NPCIL	Aug-2006
TAPS-4	PHWR	540			Sep-2005

 # Unit under shutdown since 2004.

Table – 2

NPPs under Construction and Commissioning as of August 2013

Project	Type	Gross Capacity (MWe)	Licensee/ Owner	Reactor Supplier	Start of Construction
KKNPP-1*	PWR	1000	NPCIL	ASE, RUSSIA	Mar-2002
KKNPP-2	PWR	1000	NPCIL		Mar-2002
PFBR	PFBR	500	BHAVINI	BHAVINI	Oct-2004
KAPP 3&4	PHWR	700 each	NPCIL	NPCIL	Nov-2010
RAPP 7&8	PHWR	700 each	NPCIL	NPCIL	Jul-2011

* **KKNPP-1 achieved first criticality on 13th July, 2013.**

Annex 1-1 Organisational Structure for Atomic Energy in India

Atomic Energy Commission

Atomic Energy Commission (AEC) is the apex body of the Central Government for atomic energy that provides direction on policies related to atomic energy. The members of AEC include, among others, eminent scientists & technocrats, secretaries of different ministries and senior most officials from the office of the Prime Minister. The AEC reports to the Prime Minister.

Atomic Energy Regulatory Board

Atomic Energy Regulatory Board (AERB) is the national regulatory body having powers to frame safety policies, lay down safety standards & requirements and powers to monitor & enforce safety provisions in nuclear and radiation installations and practices. AERB reports to AEC.

Department of Atomic Energy

Development and implementation of nuclear power and related nuclear fuel cycle activities and research & development activities are carried out in various units under the DAE. The DAE organisation is divided into four major sectors, viz. Research & Development sector, Industrial sector, Public Sector Undertakings and Services & Support sector. The DAE also provides for the interaction needed between the production and R&D units. The organisations engaged in the area of Atomic Energy in different sectors are as given below and the organisation structure is shown in Figure 1.1.

i. Research and Development sector includes Bhabha Atomic Research Centre (BARC), Indira Gandhi Centre for Atomic Research (IGCAR), Atomic Minerals Directorate for Exploration and Research (AMD), Raja Ramanna Centre for Advanced Technology (RRCAT) and Variable Energy Cyclotron Centre (VECC). Board of Research in Nuclear Sciences (BRNS) and National Board for Higher Mathematics (NBHM) provide funding to universities and other national laboratories. Homi Bhabha National Institute (HBNI) is an institute having academic programmes which are run by the R&D centres and grant-in-aid institutions.

ii. There are several grant-in-aid institutes like Tata Institute of Fundamental Research (TIFR), Institute for Plasma Research (IPR) and Saha Institute of Nuclear Physics (SINP) under DAE.

iii. Industrial sector includes Government owned units of Heavy Water Board (HWB) for the production of heavy water, Nuclear Fuel Complex (NFC) for the fabrication of nuclear fuel, zircaloy components and stainless steel tubes, and Board of Radiation & Isotope Technology (BRIT) for processing and supply of radioisotopes and developing technologies for radiation and isotope applications.

iv. Public Sector Enterprises along with their activities under the control of DAE are as follows:
- Nuclear Power Corporation of India Limited (NPCIL) engaged in the design, construction, commissioning and operation of the nuclear power plants;
- Uranium Corporation of India Limited (UCIL) engaged in mining, milling and processing of uranium ore;
- Indian Rare Earths Limited (IREL) engaged in mining and separation of beach sand minerals to produce ilmenite, rutile, monazite, leucoxene, zircon, silimanite and garnet and chemical processing of monazite to obtain thorium and rare earths;
- Electronics Corporation of India Limited (ECIL) engaged in design and manufacture of control and instrumentation equipment related to atomic energy and also to other sectors;
- Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) for setting up fast reactor based nuclear power plants.

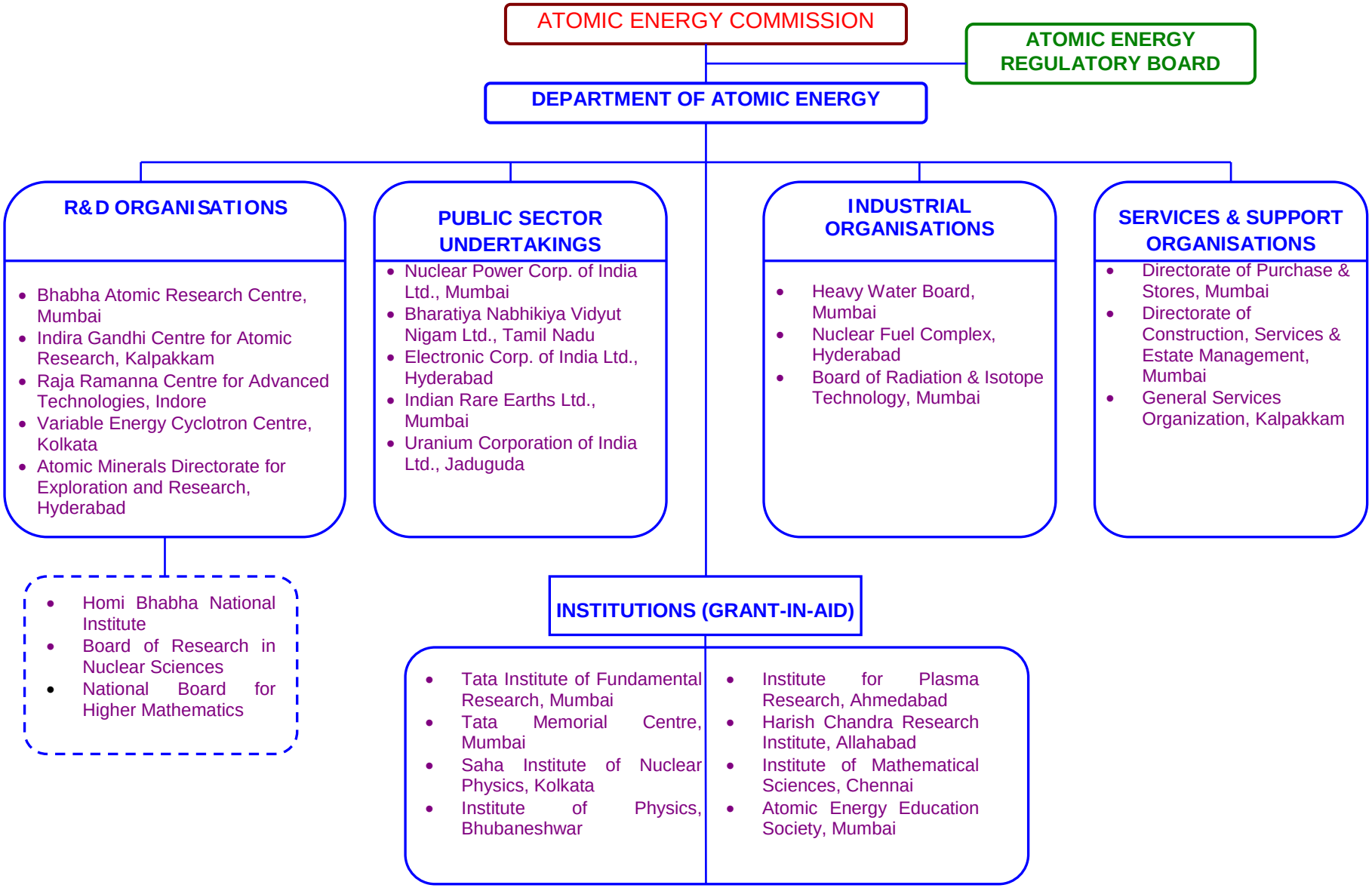


Figure-1.1 Organisational Structure for Atomic Energy in India

2. SUMMARY

Nuclear energy remains an important element in India's energy mix for sustaining rapid economic growth. India remains firmly committed to its indigenous nuclear power programme and is planning a major expansion of nuclear installed capacity. This is being pursued with full regard to safety and environment, and livelihood of the people living around the plants.

The nuclear accident at Fukushima Daiichi nuclear power plants in Japan in March 2011 had brought the safety of NPPs under scanner. During the Fifth Review Meeting of CNS which happened to be immediately after the accident in April 2011, the Contracting Parties decided to hold an Extraordinary Meeting (EOM) in August 2012, to review the lessons learnt from the accident thus far and to consider measures to improve the effectiveness of the Convention in achieving the highest level of safety at NPPs.

Several actions were undertaken both at global and national level. India has been participating in several of the International initiatives to learn lessons from the accident. India submitted the report for peer review in the EOM covering actions taken on all the six topics identified during the Fifth Review Meeting. Indian experts are actively engaged in the working group constituted to enhance the effectiveness and transparency of the review process of CNS. India is committed to implement the IAEA Action Plan on Nuclear Safety. India's own initiatives are generally in line with the Action Plan. Indian experts are participating in IAEA's International Experts Meetings, workshops and expert groups.

NPCIL is engaged in the activities undertaken on other fora for operators like WANO and COG. Apart from regular peer reviews of the NPPs by the WANO, India invited IAEA OSART mission for the peer review of Rajasthan Atomic Power Station 3&4. The Agency performed its first OSART mission to India in November 2012. The mission was performed using the revised scope and modules updated form the lessons learnt from the Fukushima accident. The mission found presence of strong safety culture at the nuclear power plant and has recorded many good practices. The mission has made certain recommendations and suggestions to further improve operation of the NPP which India is committed to implement. India has declassified the OSART mission report. The follow up mission has also been invited which will take place in February 2014.

The preparation and planning for inviting IAEA's Integrated Regulatory Review Service (IRRS) mission for peer review of the regulatory system is in progress and India will approach the Agency with a request to undertake this mission.

POST FUKUSHIMA ACTIONS

India continued the construction of seven reactors and pursuing its expansion programme with additional emphasis on safety. While the safety performance of 20 operating Nuclear Power Plants in India remained satisfactory over the years, immediately following the Fukushima accident, India undertook comprehensive technical review of all safety systems of the nuclear power plants with a view to ensuring that they would be able to withstand the impact of extreme events and resulting prolonged Station Black Out (SBO) and loss of ultimate heat sink.

Transparency and public awareness

Considering the gravity of the accident and the consequent public concerns, it was imperative that the response to the accident would be robust and transparent. Therefore it was decided that India would make public the reports of the special committees constituted for the review of the safety of NPPs. Further, the Department of Atomic Energy and NPCIL individually stepped up drive to address public concerns. DAE and NPCIL have also enhanced their public

awareness programmes. NPCIL has so far engaged 21 professional organizations for its outreach program. AERB increased its public engagement and provided vetted information independently to the public through print and electronic media on various topics of immediate public concerns.

Strengthening of Emergency Preparedness

Indian regulation requires that the emergency preparedness programme is established and the essential infrastructure and resources are created prior to issuance of operating licence. Specific requirements with respect to emergency preparedness in NPPs are prescribed in AERB safety codes and guides. In 2005, the central government enacted a separate legislation (the Disaster Management Act), to institute the National Disaster Management Authority (NDMA) that also has the responsibility to strengthen the existing nuclear/radiological emergency management framework at district, state and national level. A National Disaster Response Force (NDRF) was developed under NDMA with clear command and control to respond to disasters. NDRF personnel are trained for handling nuclear and radiological emergencies.

Emergency preparedness and response got specific attention subsequent to Fukushima accident. AERB reviewed all the requirements which included onsite management capability during accidents at multi-unit site along with serious damage to the infrastructure and surroundings and installation of adequate monitoring system for deciding on intervention for early remedial actions in public domain. Simultaneously, NDMA had taken up special exercises at each NPP site ensuring participation of all the stakeholders and governmental agencies including training of personnel involved at various levels. These exercises were in addition to the one conducted at plant, site and off-site domain in every three months, one year and two years, respectively.

Safety Enhancement at Operating NPPs

All Nuclear Power Plants (NPPs) in India undergo Periodic Safety Reviews (PSR) following the procedure prescribed in AERB regulations. Review during PSR involves comparison with the current safety requirements and practices. Ageing management of structures, systems and components important to safety form an essential part of this review. Such periodic reviews and the results of special safety reviews conducted following accidents at TMI and Chernobyl and the incident of fire at Narora in India had led to substantial safety up-gradations in Indian NPPs. Following the incident of flooding at Kakrapar in 1994 and tsunami at Kalpakkam in 2004, safety of NPPs were assessed against external hazards. Based on these review, significant safety enhancements were implemented in older NPPs and subsequently they were included as the safety criteria for siting, design and construction of later NPPs. The post Fukushima review has established that these safety upgrades have substantially enhanced the safety of Indian NPPs including their capability to withstand natural events. However in the light of Fukushima experience it is considered prudent to further enhance this capability. In view of this, action plan has been prepared to implement the identified short term, midterm and long term measures. Short term measures have been implemented in all the NPPs whereas other measures are in different stages of implementation.

UPDATES ON TOPICS FROM PREVIOUS REVIEW MEETINGS

Strengthening Legislative framework

Atomic Energy Act, 1962 and rules framed there under provide the main legislative and regulatory framework pertaining to atomic energy in the county. For quite some time, the Central Government has been in the process of creating a separate primary legislation for regulating nuclear and radiological safety in the country. Nuclear Safety Regulatory Authority (NSRA) Bill 2011 has been introduced in the Parliament to fulfill this objective. Once this

legislation comes into effect, the promotional and regulatory function will have separation at the level of primary legislation.

Periodic Safety Review

In the last three years, NPCIL performed PSRs of KGS-1&2, RAPS-3&4, NAPS-1&2 and TAPS-3&4 as required by the Indian regulation for renewal of license for operation. Based on the satisfactory review of the report of PSR, AERB renewed the license for operation of these NPPs.

Probabilistic Safety Assessment

The updating of level 1 PSA with internal events with plant specific data and current configuration is required as part of the Periodic Safety Review for renewal of operating license. NPCIL has taken initiative to prepare a comprehensive level-1 PSA by incorporating external events (seismic and flood), internal fire and shutdown states. This has been completed for a typical 220 MWe PHWR unit.

Equipment Qualification

As reported in the Fifth Review Meeting of CNS, maintenance of Equipment Qualification for the SSCs of older NPPs was identified as one of the important outcomes of PSR. A comprehensive equipment qualification programme was prepared and approved for older PHWRs to address this issue. Qualification of equipment is being performed in a phased manner. The tests include subjecting the components to radiation ageing, accelerated thermal ageing and LOCA environment.

Equipment performance database during seismic event

A study to collect information on performance of equipment in industries during earthquake event was performed. The data from nine industries and 18 electrical substations were analyzed as many of the equipment used in these industries are similar to the ones used in NPPs. It was observed that the majority of failures were due to inadequate anchorage and falling off of brick walls. These aspects were strengthened in older NPPs in a systematic manner.

Severe Accident Management

India had identified the implementation of a systematic programme for severe accident management for the operating NPPs in the earlier meetings of the CNS. Considerable progress has been made in the development of additional guidelines and measures required for strengthening these aspects. Following the Fukushima accident, efforts have been put in with respect to (i) incorporating the lessons learned from Fukushima, particularly to identify the weak links in the existing provisions, (ii) emphasising the analytical and R&D efforts to address such weakness, (iii) translating the identified solutions to plant specific measures and (iv) incorporating the plant specific enhancement measures. The enhancement measures e.g. hook up points for enhancing cooling capability, provision of air cooled portable power packs, etc that were specific to prevent the escalation of accident to core melt scenario have been implemented. Interim guidelines on these measures have been issued and operators have been trained on these aspects. Significant progress has been made in implementation of comprehensive severe accident management programme that include provision of Passive Autocatalytic Recombiner (PAR) to strengthen the hydrogen management system, containment filtered venting to enhance containment performance and On-site Emergency Support Centre.

Construction reviews

First of the two units of 2x1000 MWe, VVER of Russian design being established at Kudankulam achieved its first criticality on 13th July, 2013. After satisfactory review of the results of the commissioning tests by AERB, the unit will be granted permission for regular operation. The commissioning activities in the other unit are in progress. The construction of 500 MWe pool type, sodium cooled, mixed oxide (MOX) fuelled, Prototype Fast Breeder Reactor (PFBR) is nearing completion. Safety review for the next consenting stage i.e. commissioning is in progress. The review of Preliminary Safety Analysis Report (PSAR) for indigenously designed 700 MWe PHWRs, two each at existing sites of Rawatbhata in Rajasthan (RAPP-7&8) and Kakrapar in Gujarat (KAPP-3&4), is continuing. Regulatory clearance for 'First Pour of Concrete' (FPC), a sub-stage of construction has been granted based on review of relevant chapters of PSAR. Presently, safety review for grant of regulatory clearance for 'major equipment erection', another sub stage of construction, is in progress.

Design support to Operating NPPs

The Central Government had created Nuclear Power Corporation of India Limited (NPCIL) with the responsibility for design, construction, commissioning and operation of nuclear power plants. The benefit of this "one house approach" is that the operators continue to get design support during the life cycle of nuclear power plants. NPCIL also creates specific design support groups for continued support to the operators of new or imported reactor designs. NPCIL has its own research and development facilities where experiments related to safety, design and ageing are performed. The facilities are also engaged in development & testing of innovative features being incorporated in 700 MWe PHWRs and systems for enhancing containment performance during severe accidents.

Development and revision of safety documents

AERB has so far issued more than 140 regulatory documents in various areas of safety regulation. These documents are reviewed and updated periodically based on experience and scientific developments and as appropriate to take into account the recommendations of IAEA safety documents. Recently, AERB has undertaken a comprehensive review of the prevailing safety requirements to ascertain whether they would require further revision in the light of lessons learnt from the Fukushima accident. In this context it is worthwhile to mention that the revision of the AERB Siting Code which was already in progress has taken into account the experience from the accident at Fukushima.

Human Resource augmentation in Regulatory Body

AERB is progressively inducting technical staff in different areas of expertise. In the last three years, the staff strength of AERB has increased from 215 to 310. AERB also takes the services of consultants from the vast pool of retired experts from government organizations.

Human and organizational factors

Human and organizational factors are adequately considered in all the activities of NPCIL and AERB. They continue to remain the key focus area. Feedback of experience from operation, construction, design and safety reviews remain the main inputs for continual improvement on these fronts. Safety culture assessment of NPPs is part of the integrated management system of NPCIL. It has instituted a system of periodic audit by a corporate mechanism for safety culture assessment.

PLANNED MEASURES

India as a country with serious interest in nuclear power to meet its developmental aspirations, remains committed to implement the highest level of safety at its nuclear facilities. India is fully engaged in learning complete lessons from the Fukushima accident to enhance safety of operating NPPs as well as incorporate these lessons in siting, design and construction of new NPPs. Therefore, the planned measures are directed to meet these aspects. These include implementation of planned safety measures identified during post Fukushima reviews, revision of safety documents, enhancement of offsite emergency preparedness and severe accident management measures including firming up of criteria for additional safety features and complimentary provisions to limit the consequences of severe accidents . As mentioned above, in addition to periodic WANO peer reviews at all the NPPs, India has invited follow-up IAEA OSART mission for RAPS-3&4 in February 2014. India has a challenge to prepare itself for the planned rapid expansion of nuclear power in the coming years.

ARTICLE 6: EXISTING NUCLEAR INSTALLATIONS

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shutdown may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

6.0 GENERAL

At present twenty nuclear power reactors in India are being operated by NPCIL. The first NPP in the country, TAPS-1&2, boiling water reactors (BWR), supplied by General Electric, USA, became operational in the year 1969. Thereafter, the mainstay of India's nuclear power programme has been the Pressurised Heavy Water Reactor (PHWR) technology. The first two 200 MWe units (RAPS-1&2) were established in the 1970s, at Rawatbhata in Rajasthan, with the technical cooperation of AECL (Canada). In 1980s, two 220 MWe PHWRs (MAPS-1&2) were constructed at Kalpakkam in Tamil Nadu, with indigenous efforts. Subsequently, indigenous design for standardised 220 MWe PHWRs was developed and two units at Narora were commissioned in early 1990s. The design incorporated the state of art features viz. integral calandria & end shields, two independent fast acting shut down systems, high pressure ECCS, water filled calandria vault and provision of double containment with passive vapour suppression pool. Additional ten units of 220 MWe PHWRs based on this standard design with compact layout and further improved safety features and containment were constructed in the next two decades and are in operation.

In 1990, India undertook the design and development of 540 MWe PHWR. Two units based on this design became operational in 2005-2006 at Tarapur (TAPS-3&4). This design is now further modified to incorporate limited boiling of the coolant in the channels at the outlet and the capacity has been increased to 700 MWe. The construction of four such units is under progress at the Kakrapar (KAPP-3&4) and Rawatbhata sites (RAPP-7&8).

Currently two light water reactors (1000 MWe each), four pressurised heavy water units (700 MWe) and one fast breeder reactor (500 MWe) are under different stages of construction/commissioning.

High safety standards are maintained in all spheres of nuclear power generation right from the inception of the programme in the country. A comprehensive, independent and effective safety review mechanism has been evolved over a period of time. The practice of independent safety review within the utility followed by a formal regulatory review has always been associated with siting, design, construction, commissioning and operation of NPPs. These mechanisms have resulted in progressive improvements in the safety and reliability of units over the years through backfits and upgrades being incorporated as necessary. Every event in an operating NPP is reviewed and corrective actions are taken based on lessons learnt. Such corrective actions are taken not only in the concerned NPP, but also in all NPPs in operation as well as under construction, as applicable. Lessons are also learnt from internationally reported events and their applicability to Indian NPPs is checked. Systems, procedures and aspects related to training & safety culture are further improved accordingly. For implementing any safety significant changes in the design and procedures during operation, an elaborate review and approval system is in place. The inputs from operational experience are also utilised for design improvements in the new reactors for enhancing performance and safety.

6.1 PERFORMANCE AND SAFETY STATUS OF OPERATING NPPs

6.1.1 Collective dose to occupational workers

There exists a practice for preparation of annual budget for collective exposure of occupational workers for each station based on previous year's exposures and also taking account of the jobs to be taken up during the year. This budget is reviewed and approved by AERB at the beginning of each calendar year. Finally at the end of the calendar year, the actual collective dose consumed is also reviewed to get the feedback on the operating practices. Figures 6.1 & 6.2 give collective doses consumed for older and new plants respectively in last three years.

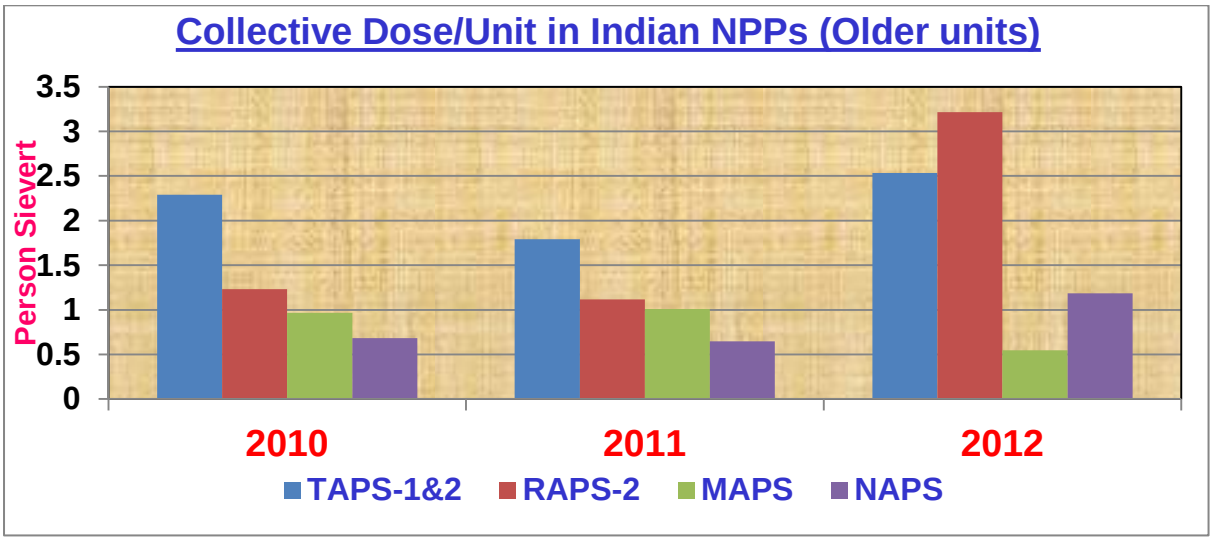


Figure 6.1

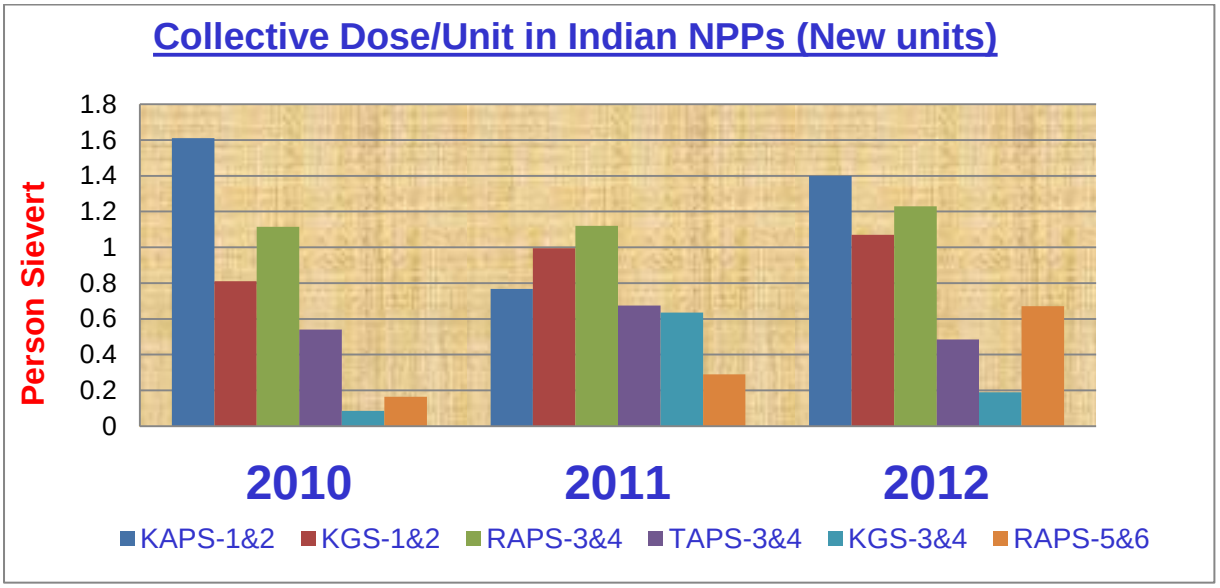


Figure 6.2

6.1.2 Radiological impact due to operation of NPPs

The radiological impact due to operation of NPPs on the environment is monitored by the Environmental Survey Laboratory (ESL), which is established at each NPP by BARC (a TSO for AERB) well before the commencement of operation of NPP. The ESL, which is independent of the utility, carries out periodic surveillance of the areas around NPPs, based on which the radiological impact of NPP operation on the environment & public around the NPP is assessed annually.

The aspects related to the impact of plant operation on the environment and public are also re-assessed during PSR of the NPPs. The area up to a distance of about 30 km is covered under the environmental survey programme.

Figure 6.3 gives the estimated dose at the plant boundary due to operation of NPPs for last three years. As can be seen, the dose to the public at the exclusion boundary at any site (having a minimum of two operating units to a maximum of six operating units), as estimated by the surveillance program is negligible as compared to limits prescribed by AERB.

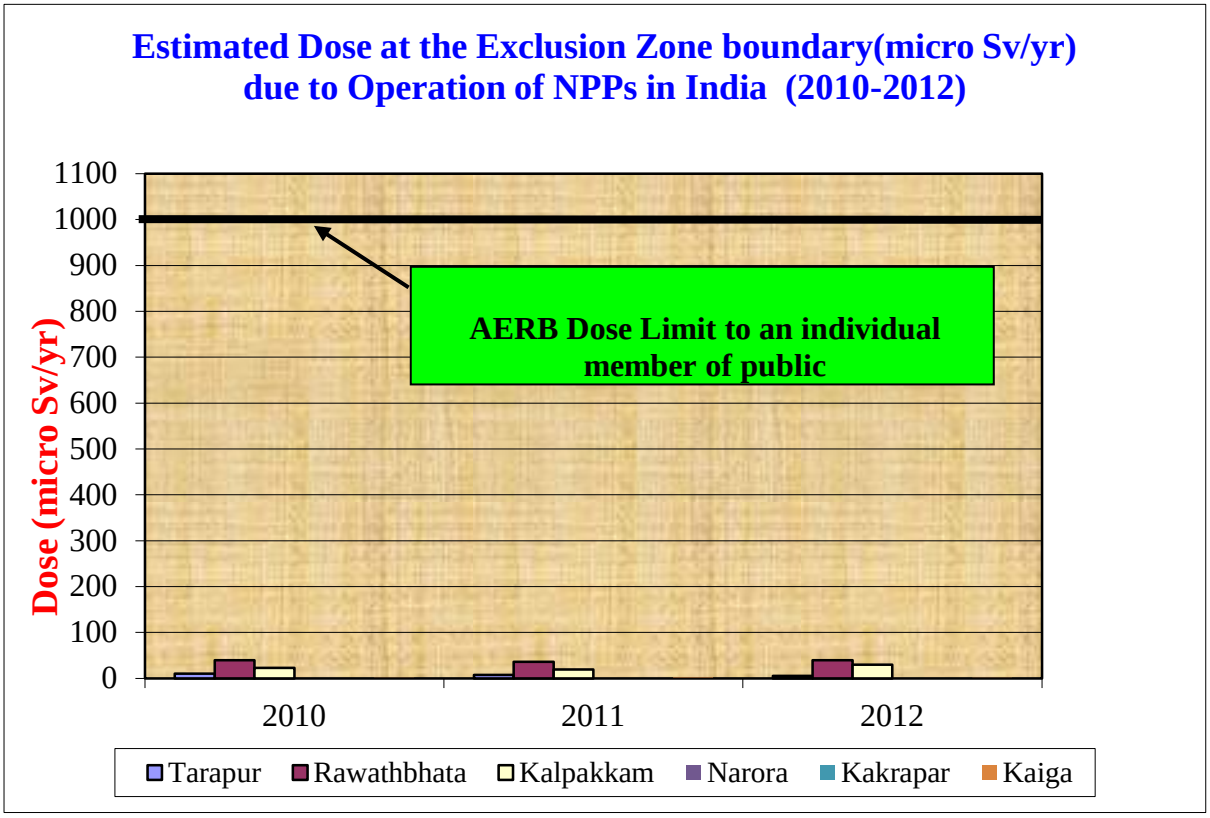


Figure 6.3

6.1.3 Operational performance of NPPs

Operating nuclear installations in India are subjected to continuous appraisal of safety by NPCIL and AERB as per the established requirements. The operational performance and significant events are reviewed and the required modifications are implemented.

The operational performance of all the NPPs operated by NPCIL has remained satisfactory over the years. The improvement in the performance of NPP is reflected as increased availability factor, reduced number of outages and outage duration and increased duration of continuous stable operation.

The overall weighted average Availability Factor and Continuous Operation run for NPPs during last three financial years (April –March) are brought out in the charts below:

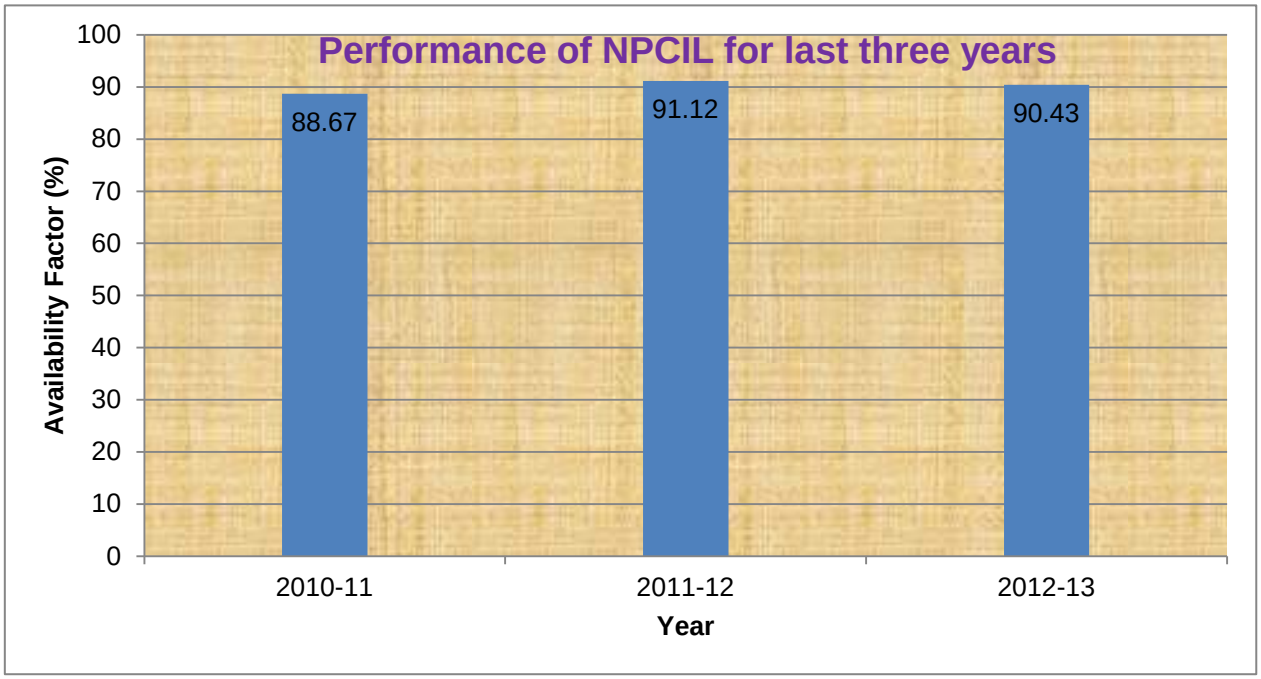


Figure 6.4

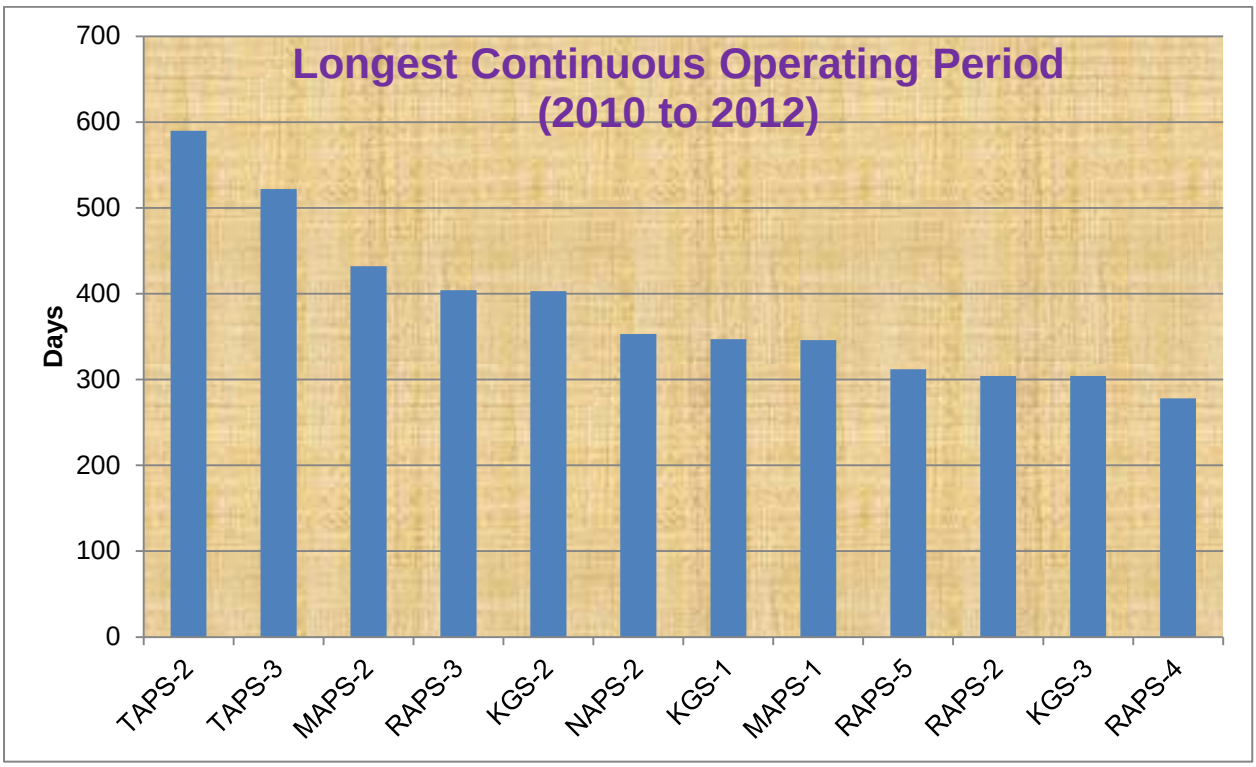


Figure 6.5

6.1.4 Periodic Safety Review (PSR)

Periodic Safety Reviews (PSR) of the nuclear power plants are being carried out as a regulatory requirement for renewal of license for operation of NPP. As per the regulatory requirements, PSR is carried out every ten years. The first round of PSR for all the NPPs has been completed. For an NPP of new design the first PSR is required to be carried out after five years of initial operation and accordingly, the PSR of TAPS-3&4 (540 MWe) is completed after five years of commercial operation.

Safety assessments performed during PSR take into account current regulatory requirements, safety standards and operating practices. It also considers factors such as cumulative effects of plant ageing, modifications, feedback of operating experience, safety analysis and development in science and technology. Through this process of PSR, the strengths and shortcomings of the NPP against the requirements of current standards are identified. The report on the PSR prepared by NPP is subjected to regulatory review for satisfactory resolution of the identified issues.

In the last three years PSRs were carried out for four NPPs (NAPS 1&2, KGS-1&2, RAPS-3&4 and TAPS-3&4). During PSR for these stations the upgrades necessary for safety enhancement taking into considerations Fukushima accident were also reviewed and the long term actions for safety enhancements are drawn and being followed up.

6.1.5 In-Service Inspections (ISI)

In the last three years In-Service Inspections of coolant channels were carried out in six units of PHWRs as per schedule. The ISI activities for PHWRs were carried out using a specially developed tool called BARCIS. The tool has provisions to measure wall thickness, pressure tube sag, and internal diameter of pressure tubes. Results of these inspections were analysed and found to be normal.

In RAPS-4, 2nd In-Service Inspection for all identified channels was carried out in 2011 and no abnormality was observed. The analysis results of sliver sampling of the coolant tube revealed that hydrogen pick up is very low and sufficient margin exists with respect to permissible limit.

In TAPS-4, Coolant channel inspection was undertaken for the first time at 3.48 FPY in November 2011. 16 representative channels were selected for inspections and pressure tube ID, wall thickness & garter spring positions were measured. The maximum diametrical creep in the channels was well within the permissible limit. The sag profile of the pressure tubes has also been evaluated using the creep-sag program and the estimated values were seen to be conservative. All other parameters were also well within the acceptable range.

In TAPS-3, Coolant channel inspection was undertaken for the first time at 4.63 FPYs in March 2013. 15 representative channels were selected for inspections and pressure tube ID, wall thickness & garter spring positions were measured. Out of these, sag measurements were carried out for four channels. The measured sag profiles were compared with calculated profiles. It was observed that the measured sag compared well with the theoretically estimated values for ISI condition. All other parameters were also well within the acceptable range.

In RAPS-2, Coolant channel inspection was carried out in May 2012 after 9.2 FPYs. 10 representative channels were selected for inspections. Pressure tube ID, wall thickness & garter spring positions were measured. There was no relevant indications found during ultra-sonic thickness measurement and no significant movement of garter springs is observed in any of the channels.

In MAPS-2, Coolant Channel inspections were carried out in January 2011 after 6.17 FPYs. 15 representative coolant channels were selected for inspections. ISI, Garter Spring Positions, Ultrasonic Examination for flaw, Wall thickness measurements, Pressure tube ID, sag were measured. There was no significant indications found during ultra-sonic thickness measurement and no significant movement of garter springs is observed in any of the channels.

In KAPS-2, 2nd ISI was carried out on total 21 coolant channels in 2012 after 12.88 FPYs. The measured wall thickness of all channels was higher than the minimum design wall thickness. The measured garter spring positions were compared with the PSI positions and observed to be within the allowable limit. The maximum diametrical creep in the channels was well within the permissible limit.

In TAPS-1, extensive In-service Inspections were carried out during the refuelling outage in July 2012. Inspections of some of the previously uninspected RPV welds of TAPS-1 were undertaken this time after development of special manipulators and probes. The inspections revealed a few recordable indications in the vicinity of the welds. Growth assessments were carried out conservatively assuming these indications as flaws and it was concluded through analysis that further operation of the unit would not have any impact on safety of the RPV. Similar inspections were carried out in TAPS-2 in 2013 and unit was made operational.

6.1.6 Calandria vault leak repair at KAPS-1

En-masse Coolant Channel Replacement (EMCCR) and En-masse Feeder Replacement (EMFR) activities were taken up in KAPS-1 in July 2008. Apart from the safety upgrades, one of the major jobs undertaken during KAPS-1 EMCCR outage was the repair of light water leaks from calandria vault. The light water seepage from calandria vault of KAPS-1 had been existing for some years at certain locations in reactor building. Although the leaks were minor in nature, it was decided to utilise the opportunity of long outage to identify exact location of leaks and remedial measures. Specially developed remote tools were used to identify and repair the leaky points. In all six leaky points were identified and these were repaired. KAPS-1 was restarted in January 2011 after completion of all upgrades/repairs and has been operating satisfactorily.

6.1.7 Away from Reactor (AFR) Fuel Storage Facility, Tarapur

With necessary clearance form AERB, NPCIL has expanded the spent fuel storage capacity at AFR to cater to the continuous operation of TAPS-1&2 reactors.

6.1.8 Maintenance of equipment qualification in older NPPs

Equipment Qualification for the SSCs of older NPPs was identified as one of the important activities in Fifth Review Meeting of CNS. A comprehensive equipment qualification programme was taken up for older PHWRs. The facilities available at BARC & Tarapur were utilised for qualifying the components. Highlights of the major steps taken in this direction are as follows:

a. Identification of safety systems required during design basis accident conditions.
b. Preparation of the master list of components belonging to these safety systems. All the SSCs were assigned one of following four categories:
    - components to be qualified by testing on sample basis
    - components to be modified and then tested
    - components to be replaced with those meeting requirements.
    - components for which justification for their continued use was provided based on their location, design specification etc

c. Qualification tests include subjecting the components to radiation ageing, accelerated thermal ageing and LOCA environment in phased manner. In the radiation ageing test, the components are exposed to an integrated gamma dose equivalent to life time plus accident dose and then functional performance is checked. In accelerated thermal ageing, the component is subjected to elevated temperatures and the performance of equipment is monitored at regular intervals by computing the service life (based on Arrhenius methodology). If the component successfully qualifies both these tests it is further subjected to LOCA environment corresponding to LOCA conditions (temperature, pressure and humidity profiles).

Following this process it was found that most of the components (for e.g. pressure switches, cables, solenoid valves, fan belts, etc) qualified all the tests. However, a few components could not pass all the stages of the qualification tests. Such components are planned to be replaced with qualified make/model in a phased manner. Additionally, detailed consequence analysis has been carried out to assess the impact of failure of components, while these are in service.

Based on the above, equipment qualification aspects are being suitably addressed and will be periodically assessed.

6.2 SIGNIFICANT EVENTS

As part of the established Operating Experience Feedback (OEF) programme, events occurring within the country and abroad were reviewed regularly. Comprehensive safety reviews are carried out both by NPCIL and AERB in response to major events. Through these reviews important lessons are learnt and wherever applicable improvements in design, procedures, training, safety culture, etc are made.

6.2.1 Exposure of Workers beyond Annual Regulatory Limit at KAPS

On May 30, 2011, three workers who were involved in housekeeping and painting jobs in the area around the Spent Fuel Transfer Duct (SFTD) received doses above annual regulatory dose limit (30 mSv). The incident occurred when spent fuel from the reactor was transferred to spent fuel storage bay through SFTD, when the workers were still present in the nearby area. The event occurred due to inadequate review of the work procedure, inadequate appreciation of the potential hazard and non-adherence to the standard work practices like isolation of system prior to taking up of job in SFTD. The workers received 90.72 mSv, 66.81 mSv & 58.70 mSv radiation dose during the incident. The INES rating of the event was level-2.

Various corrective actions like strengthening of pre-job briefing procedure, administrative controls for opening of SFTD blocks, ensuring the closure of SFTD blocks before taking up refueling were taken to prevent the recurrence of such event in future.

6.2.2 Simultaneous rupture of Over Pressure Relief Devices at TAPS-4

On June 09, 2011, when TAPS-4 was under Guaranteed Shutdown State (GSS), deuterium and oxygen concentration increased in the cover gas space resulting in sudden release of energy leading to rupture of calandria OPRDs.

Under GSS conditions the conductivity of moderator system is high due to presence of poison (Gadolinium Nitrate). High conductivity accelerates radiolysis of heavy water. Also cover gas recombiners were in OFF state for some maintenance work. Under such conditions sampling of deuterium concentration should have been done to assess the chemistry of the cover gas. As this was not done, the increase in deuterium concentration could not be detected. The event did not cause any damage to calandria internals.

Corrective measures such as requirement for sampling of cover gas during shutdown state, modification of cover gas circuits to prevent dead/stagnant pockets in cover gas circuit, revision of procedures, etc were taken to prevent recurrence of the event in future. To prevent occurrence of such event at other NPPs, the event was reviewed by individual plants and suitable corrective actions were incorporated.

6.2.3 Ingress of gas from Emergency Core Cooling System into PHT system at NAPS-2

On May 21, 2012, when the reactor was in shutdown state and Emergency Core Cooling System (ECCS) surveillance tests were being carried out, the operator unblocked the ECCS. This resulted in injection of heavy water from ECCS accumulator. However, the injection did not terminate as per the built in logic. This led to ingress of nitrogen gas, used for keeping accumulator pressurised, into the reactor coolant channels. The pressurised gas pushed a part of the PHT coolant to storage tank resulting in opening of storage tank relief valves. Gas in PHT system also caused minor disturbances in shutdown cooling system pump flow.

The logic for termination of heavy water injection from ECCS requires simultaneous signal of low level and low pressure of the ECCS accumulator. However, this did not work as control room operator had lowered the pressure set point while cooling down the reactor. Such event happened for the first time and as such procedure to handle the event was not available. The operator took mitigating actions based on the system knowledge. The entrapped gas was removed by opening various vent valves in the system. With this the shutdown cooling flow became normal.

Following the event a special investigation team was set up by the regulatory body to review for understanding the causes of the event, plant response to the event, status of core cooling during the event and the safety significance of the event. Various corrective actions like strengthening of administrative controls and use of error prevention tools were taken. Heavy water inventory in PHT storage tank was augmented to avoid the need for any change in pressure set point during routine operations and testing.

6.3 FUKUSHIMA RELATED MODIFICATIONS IN ALL NPPs

Safety enhancement in Indian NPPs has been a continuous process. The existing requirements call for Periodic Safety Review which brings out the need for safety upgrades, if any. In addition, extensive operational experience feedback programme and findings of the special safety assessments conducted subsequent to accidents at TMI (USA), Chernobyl (Ukraine) led to substantial safety upgrades in older NPPs and design of NPPs built later.

Immediately after the Fukushima (Japan) Accident safety re-assessment of all Indian NPPs was carried out by NPCIL and also by AERB. These assessments brought out the requirements for further enhancement in safety, especially against severe external events.

The approach adopted for these safety enhancements is outlined below:

- Re-confirmation of capability to withstand currently defined site specific design / review basis levels of external events for individual plants. This included revisiting the results of earlier PSRs and review of need for further strengthening, as necessary.

- Assessment of margins available for beyond the design / review bases levels of external events. The objective of this assessment was to find out if cliff edges were close to the design basis /review basis levels and to suggest modifications such that minimum safety functions can be performed in such situation.

- Enhancing the capability of the plants to perform the safety functions under extended SBO / extended loss of heat sink through the design provisions. Towards this, NPCIL

was asked to carry out safety assessment for extended SBO and augment the capability for continued heat removal for 7 days. The measures being incorporated based on the above assessments include:

- Alternate provisions for core cooling and cooling of reactor components including identification / creation of alternate water sources and providing hookup points to transfer water for long term core cooling,
- Provision of portable DGs / power packs
- Battery operated devices for plant status monitoring
- Additional hook up points for adding up water to spent fuel storage pools

– Review and strengthening of severe accident management provisions particularly with respect to:
  - Hydrogen Management
  - Containment venting

– Creation of an On-Site Emergency Support Centre at each NPP site which should remain functional under extreme events including radiological, with adequate provisions of communication, monitoring of plant status and having capacity for housing essential personnel for a minimum period of one week.

Significant progress has been made in all the areas identified for post Fukushima upgrades for each of the operating NPP in the country. Photographs of some of these modifications are given in Annex 6-1. The identified measures for enhancement of safety against external hazards are being implemented as brought out below:

6.3.1 Generic Safety Measures (applicable to all NPPs)

Short-term measures: (to be completed by 2013)

The implementation of the following identified short term upgrades are nearing completion:

i. Installation of external hook up points for addition of water to Steam Generator, PHT, ECCS, End-shield, Calandria, Calandria Vault and Spent Fuel Bay is in progress.
ii. Provision of additional emergency lighting backed up by solar cells has been provided in some stations and is in progress in the others.
iii. Emergency Operating Procedures have been reviewed and revised for all Indian nuclear power plants
iv. Training and mock-up exercises of operating personnel have been completed for all Indian NPPs.

Medium-term measures: (to be completed by 2014)

The following identified medium term upgrades are in the advanced stage of implementation:

i. Introduction of seismic trip in NPPs where it does not exist
ii. Provision of additional backup DGs (air cooled mobile/installed at higher elevation)
iii. Strengthening provision for monitoring of critical parameter under prolonged loss of power
iv. Provision of diesel driven pumps for transfer of water from deaerator storage tank to steam generators

v. Additional mobile pumps and fire tenders
vi. Augmentation of onsite water storage, wherever required

Long term measures (to be completed by 2015)

The following long term upgrades are in various stages of implementation:

i. Enhancing Severe Accident Management programme
ii. Strengthening hydrogen management provisions
iii. Provision for venting of containment
iv. Creation of an On-site Emergency Support Centre capable of withstanding severe flood, cyclone & earthquake etc.

6.3.2 Plant Specific Safety Measures

In addition to the above generic measure at all the plants, following specific actions have been implemented at the older NPPs at RAPS-2, MAPS-1&2 and TAPS-1&2. In these plants the flood level which was originally considered for design got revised in the subsequent PSR.

i. TAPS-1&2

Specific measures implemented at TAPS-1&2 are as follows:

a. Enhanced flood protection measures for SBO DG, and ECCS pumps & valves to ensure operability during beyond design flood by increasing their elevation.
b. Provision of seismic instrumentation and earthquake notification system.
c. Provision of hook-up points for alternate means for injecting water to RPV through multiple routes, shell side of emergency condenser and containment spray system from outside RB.
d. Provision for high point vent for the reactor pressure vessel to depressurize the vessel.
e. Alternate provisions for replenishment of water in spent fuel pool inside the Reactor Building and Away From Reactor (AFR) storage facility has been provided.

In addition to the above, steps are being taken for implementation of nitrogen inerting of primary containment at TAPS 1&2.

ii. RAPS-2

For RAPS-2, the flood level was revised from original design basis flood level of 354.2 m to the current review basis flood level of 359.6 m based on consideration of upstream dam failure. Based on this revision, two additional EDGs (air cooled) were provided at higher elevation for supplying essential loads. Following the present reviews, additional measures taken are:

a. Provision of seismically qualified hook-up arrangements for cooling water addition to calandria, end shield, steam generators, PHT system, ECCS and spent fuel pool. These are located outside the reactor building above the review basis flood level.
b. Additional air compressor at higher elevation for supplying instrument air to critical valves and dampers.
c. Seismic strengthening of additional water storage tanks.

iii. MAPS-1&2

Based on the current assessments, the flood level for MAPS-1&2 was revised from original design basis flow considered level of 8.96 m to 12.9 m. Following the reviews, further measures implemented are as follows:

a. Provision of 200 kVA EDGs (air cooled) at higher elevation.
b. Flood protection measures for existing EDG.
c. Additional UPS to supply power to vital instruments for monitoring important plant parameters under prolonged SBO.

Following upgrades are in progress:

a. Provision of seismically qualified hook-up arrangements for cooling water addition to calandria, end shield, steam generators, PHT system, ECCS and spent fuel pool has been provided in one of the units and is in progress in the other unit. These will be located outside reactor building above review basis flood level.
b. Construction of seismically qualified water storage tank along with diesel engine driven pumps at higher elevation to augment on-site water storage
c. Provision of additional EDG of higher capacity

6.4 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Since the inception of the atomic energy programme in the country, priority has been given to the adoption and maintenance of high safety standards. Safety status of the NPPs is continually monitored by an established system and also during renewal of license for operation every five years. Replacements or modifications of the structures, systems and components important to safety are carried out as necessary. Up-gradations are also carried out to resolve obsolescence issues. Every event is promptly reviewed and lessons are learnt. Analysis of international events and their applicability is checked and accordingly the systems, procedures, aspects related to training and safety culture are further improved. In line with these practices lessons learnt from the accident at Fukushima are also addressed and further enhancement in safety against external natural events are being incorporated at all NPPs. Therefore, India complies with the obligations of Article 6 of the Convention.

Annex 6-1: Photographs on safety up-gradations in NPPs

Hook-up points at RAPS-3&4

Hook-up points at RAPS-5&6

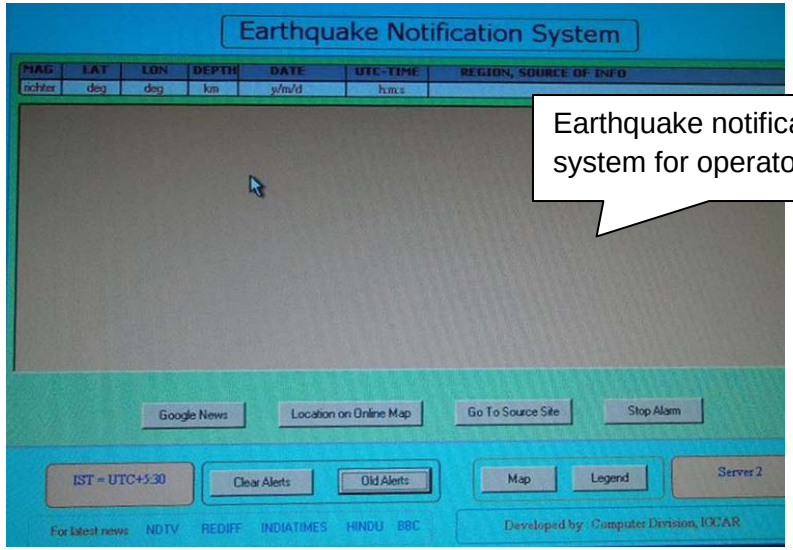
Hook-up points at KGS-1&2

External Hookup points for addition of water to Reactor systems

Mock exercise for checking adequacy of mobile pump with the hookup points at KGS-1&2

Foundation of SBO DG and starting batteries elevated

Foundation of Cooling Tower and pumps of SBO DG elevated



Earthquake notification system for operator action

Seismic system annunciator to alert operator

Safety Upgrades at TAPS-1&2

Diesel Generator Power Pack

Seismically qualified emergency water storage tank (8000m^3)

Provision of Alternate Power Supply and Water Source for BDBA at KKNPP

ARTICLE 7: LEGISLATIVE AND REGULATORY FRAMEWORK

1. **Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.**
2. **The legislative and regulatory framework shall provide for:**
    i. **the establishment of applicable national safety requirements and regulations;**
    ii. **a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence:**
    iii. **a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;**
    iv. **the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation.**

7.0 GENERAL

India is a Union of States. It is a Sovereign Socialist, Secular, and Democratic Republic with a parliamentary system of government. The Constitution provides for a Parliamentary form of government which is federal in structure. The Constitution distributes legislative powers between the Parliament and State Legislatures as per the lists of entries in the Seventh Schedule of the Constitution. The subject 'atomic energy and the mineral resources necessary for its production' are placed in the union list. The laws pertaining to atomic energy are enacted by the Parliament and enforced by the Central Government.

7.1 ESTABLISHING AND MAINTAINING LEGISLATIVE AND REGULATORY FRAMEWORK

Atomic Energy Act 1962 and rules framed there under provide the main legislative and regulatory framework pertaining to atomic energy in the country. The Act was enacted to provide for the development, control and use of atomic energy for the welfare of the people of India and for other peaceful purposes and for matters connected therewith. The Act also provides Central Government with the powers to frame rules and issue notifications to implement the provisions of the Act. The rules framed under the Act are laid on the floor of both the houses of the Parliament. In addition to the provisions of the Atomic Energy Act, the provisions of several other legislations related to environment, land use, etc have also to be met for locating and operating Nuclear Power Plants (NPPs). The provisions of these acts are enforced by Central or State Government, as the case may be. Some of the important legislations that have a bearing on the establishment of NPPs are summarised below:

7.1.1 Atomic Energy Act 1962

The following paragraphs briefly describe the salient provisions of this Act.

i. Powers of the Central Government in the domain of atomic energy

Section 3 of the Act describes the powers of Central Government in the domain of atomic energy including the powers (i) to produce, develop, use and dispose of atomic energy; (ii) to provide for the production and supply of electricity from atomic energy, (iii) to provide for control over radioactive substances or radiation generating plant in order to (a) prevent radiation hazards; (b) secure safety of public and plant personnel and (c) ensure safe disposal of radioactive wastes; etc. The Central Government is also empowered to fulfil the

responsibilities assigned by the Act either by itself or through any authority or Corporation established by it or a Government company.

ii. Control over Mining or Concentration of Prescribed Substances

Section 4 to section 13 of the Act gives wide-ranging authority to the Central Government for harnessing and securing the prescribed substances useful for atomic energy.

iii. Control over production and use of atomic energy

Section 14 of the Act gives the Central Government control over production and use of atomic energy and prohibits these activities except under a licence granted by it. Subsection 2 of this section gives the Central Government powers to refuse licence or put conditions as it deems fit or revoke the licence. Sub section 3 of this section of the Act also gives the Central Government powers to frame rules to specify the licensees the provisions in the areas of:

a. control on information and access,
b. measures necessary for protection against radiation and disposal of by-products or wastes
c. the extent of the licensee's liability and
d. the provisions by licensee to meet obligations of the liability either by insurance or by such other means as the Central Government may approve of.

iv. Control over radioactive substances

Section 16 of the Act gives the Central Government power to prohibit the manufacture, possession, use, transfer by sale or otherwise, export and import and in an emergency, transport and disposal, of any radioactive substances without its written consent.

v. Special Provisions as to safety

Section 17 of the Act empowers the Central Government to frame rules to be followed in places or premises in which radioactive substances are manufactured, produced, mined, treated, stored or used or any radiation generating plant, equipment or appliance is used. This section gives the Central Government authority to make rules to prevent injury being caused to the health of the persons engaged or other persons, caused by the transport of radioactive or prescribed substances and to impose requirements, prohibitions and restrictions on employers, employee and other persons. It also gives the Central Government authority to inspect any premises, or any vehicle, vessel or aircraft and take enforcement action for any contravention of the rules made under this section.

vi. Special provisions as to electricity

Section 22 of the Act gives the Central Government the authority to develop national policy for atomic power and coordinate with national & state authorities concerned with control and utilization of other power resources for electricity generation to implement the policy. It authorizes the Central Government to fulfil the mandate either by itself or through any authority or corporation established by it or a Government Company.

vii. Administering Factories Act, 1948

Section 23 gives the Central Government authority to administer the Factories Act, 1948 to enforce its provisions by framing rules and appointment of inspection staff in relations to any factory owned by the Central Government or any Government Company engaged in carrying out the purposes of the Act.

viii. Offences and Penalties

Section 24 of the Act gives provision for imposing penalties. Whoever contravenes any order or any provision of the Act shall be punishable prosecution with imprisonment, or with fine, or both.

ix. Delegation of powers

Section 27 of the Act gives the provision for the Central Government to delegate any power conferred or any duty imposed on it by this Act to any officer or authority subordinate to the Central Government, or state government, as specified in the direction.

x. Power to make rules

Section 30 of the Act gives the provisions for the Central Government to frame rules for carrying out the purposes of the Act.

7.1.2 Indian Electricity Act 2003

Indian Electricity Act, 2003, consolidates the laws relating to generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to development of electricity industry. The Act prohibits any person from transmission or distribution or trading in electricity unless he is authorised to do so by a licence issued under section 14, or is exempt under section 13 of the Act.

7.1.3 Environment (Protection) Act 1986

The Environment Protection Act, 1986 provides for the protection and improvement of environment and matter connected therewith. All projects or activities, including expansion and modernization of existing projects or activities, require prior environmental clearance from the Central Government in the Ministry of Environment and Forests (MoEF) on the recommendations of an Expert Appraisal Committee (EAC).

7.1.4 Factories Act 1948

The Factories Act is a social legislation which has been enacted for occupational safety, health and welfare of workers at work places. The administration of the provisions of the Factories Act 1948, in the units of Department of Atomic Energy (DAE) is done through Atomic Energy (Factories) Rules, 1996, as per the provisions in Section 23 of Atomic Energy Act.

7.1.5 The Disaster Management Act, 2005

The Disaster Management Act, 2005 provides for effective management of disasters including accidents involving NPPs. As per the provisions of the Act, the National Disaster Management Authority (NDMA) has been established. The NDMA has the responsibility for laying down policies, plans and guidelines for disaster management for ensuring timely and effective response to any disaster including radiological/nuclear disasters.

7.1.6 Other Applicable Legislations

The other applicable legislation for locating and operating NPPs in the country include:

i. The Water (Prevention & Control of Pollution) Act, 1974
ii. The Air (Prevention & Control of Pollution) Act, 1981

iii. The Water (Prevention & Control of Pollution) Cess Act, 1977
iv. Indian Explosive Act 1884, and Indian Explosive Rule, 1983
v. Indian Boilers Act, 1923

7.1.7 International Conventions related to Nuclear Safety

India has ratified the following international conventions:

i. Convention on Early Notification of a Nuclear Accident
ii. Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency
Convention on the Physical Protection of Nuclear Material
iii. International Convention for Suppression of Acts of Nuclear Terrorism
iv. Convention on Nuclear Safety

7.2 PROVISIONS OF LEGISLATIVE AND REGULATORY FRAMEWORK

7.2.1 National Safety Requirements and Regulations

7.2.1.1 Subordinate Legislation for Nuclear safety

The National Legislative requirement on nuclear and radiological safety for all activities related to atomic energy program and the use of ionising radiation in India is provided by Sections 3 (e) (i), (ii) and (iii), 16, 17 and 23 of the Atomic Energy Act, 1962. Also, exercising powers under section 30 of the Act, the Central Government has framed rules to implement the provisions of the Act which are subordinate legislation for regulation. These cover radiological safety, management of radioactive wastes, administration of Factories Act and prescription of qualifications of persons employed in installations dealing with radioactive substances or use of any radiation generating plant, equipment or appliance.

I. Rules Framed under the Atomic Energy Act, 1962

Under the Atomic Energy Act 1962, the Central Government promulgated the following rules:

i. Atomic Energy (Radiation Protection) Rules 2004, GSR 1691: These rules give requirement of consent for carrying out any activities for nuclear fuel cycle facilities and use of radiation for the purpose of industry, research, medicine, etc.
ii. Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987, GSR 125: establishes the requirements for the disposal of radioactive waste in the country.
iii. Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules, 1984, GSR 781. These rules regulate the activities pertaining to mining, milling, processing and/or handling of prescribed substance.
iv. Atomic Energy (Arbitration Procedure) Rules, 1983: These rules were framed to regulate arbitration procedure for determining compensation.

II. Atomic Energy (Factories) Rules, 1996

The Central Government exercising the powers conferred by sections 41, 49, 50, 76, 83, 112 and all other enabling sections of the Factories Act, 1948, read with sections 23 and 30 of the Atomic Energy Act, 1962, had framed the Atomic Energy (Factories) Rules, 1984 to administer the requirement of Factories Act in the nuclear establishments to ensure industrial

safety. These rules were revised in 1996 and superseded by Atomic Energy (Factories) Rules 1996 GSR 253. (The Gazette of India Part II Sec 3(i) June 22, 1996)

III. Rules arising from other Legislations

In addition to above, the safety requirements of other applicable legislations also need to be met for establishing and operating NPPs in India. The central or state agencies, as the case may be, have been identified to regulate the safety provisions of these acts and the applicants are required to obtain necessary clearances from these agencies. Some of the important applicable legislations are mentioned here.

i. Environment Protection Act,1986, and Environment (Protection) Rules,1986, which provides safety requirement and regulation for the protection of environment, requires prior environmental clearance from Central Ministry of Environment and Forests (MoEF) for establishing nuclear power stations. Public hearing is conducted as per the 'procedure for conduct of public hearing' given in the gazette notification from MoEF. The hearing is conducted on the environmental and social impact of the nuclear power station. The hearing allows public to express its views and receive answers to its questions.

ii. The Pollution Control Boards (PCB), ensure implementation of the following legislations related to the protection of the environment in the country.

    a. The Water (Prevention & Control of Pollution) Act, 1974
    b. The Air (Prevention & Control of Pollution) Act, 1981
    c. The Water (Prevention & Control of Pollution) Cess Act, 1977
    d. The Hazardous Waste (Management, Handling and Transboundary Movement), Rules 2008.

iii. The Indian Electricity Act, 2003 and Indian Electricity Rules, 2005 covering various aspects of electrical safety also apply to NPPs. The Electricity Inspector of Electricity Board of the concerned state is designated as the authority to implement the provisions of these acts & rules.

iv. The Indian Boilers Act, 1923 also applies to the boilers used at NPPs and the authority to implement the provision of this act vests with the Boiler Inspector of the state under which the plant is located.

v. Indian Explosives Act 1884 and Indian Explosives Rules 1983 provide the Central Government power to prohibit manufacture, possess, use, sell, transport of explosives except under a licence granted by it. The Directorate of Explosives regulates the provision of this Act and the rules for use and storage of materials such as Diesel, Chlorine, compressed air, fuel oil etc.

Annex 7-1 gives a list of the important legislations and the agencies identified to regulate them.

7.2.1.2 AERB Safety Codes and Guides

One of the mandates of AERB is to formulate safety requirements for nuclear and radiation facilities. For NPPs, AERB has issued Safety Codes for Regulation, Siting, Design, Operation, Radiation Protection and Quality Assurance and also several safety guides and manuals under these Codes. Safety codes establish objectives and set minimum requirements that have to be fulfilled to provide adequate assurance for safety in nuclear and radiation facilities. Safety Guides provide guidelines and indicate methods for implementing specific

requirements prescribed in the Codes. Safety Manuals elaborate specific aspects and contain detailed technical information and procedures. During the preparation of these documents, the safety requirements recommended by IAEA and the regulatory agencies of other countries are also considered. The safety documents are reviewed and updated periodically based on experience and scientific developments and to harmonize these with the recommended current safety standards of IAEA. The existing good practices are also incorporated.

AERB also issues safety directives on dose limits for radiation workers and members of public which are in line with the recommendation of the International Commission on Radiological Protection (ICRP).

7.2.1.3 Process of Developing and Revising Safety Codes and Guides

As mentioned above, one of the mandates of AERB is to develop safety codes and guides for regulation of nuclear and radiation facilities. The need for a development / revision of a safety document is identified by the various Divisions of AERB. Having identified the document to be prepared / revised, a Safety Document Development Proposal (SDDP) is prepared and circulated within AERB for comments. The SDDP is reviewed by advisory committees for development of safety documents as applicable (please refer section 8.1.2.2 and 8.1.2.4 in Article 8). The SDDP of the document for NPPs is further reviewed by Advisory Committee on Nuclear Safety (ACNS) and is finally approved by Chairman, AERB. The SDDP for safety codes is approved by the Board of AERB. Based on the SDDP, the draft of the document is prepared by a working group constituted for the purpose. The document is reviewed and approved following the same procedure as for the SDDP.

AERB follows a system of "multi-tier committees" to prepare safety documents. The system ensures that the documents are based on expert opinion and are unbiased. The specialists from AERB, user organisations, technical institutions like Indian Institutes of Technology, national research laboratories and universities are members in the various committees.

7.2.2 System of Licensing

7.2.2.1 Requirements and Legal Provisions of Licensing under the Atomic Energy Act

Section 14 of the Act specifies the requirement of obtaining licence from the Central government for production and use of atomic energy. Section 16 of Act prohibits the manufacture, possession, use, transfer by sale or otherwise, export and import and in an emergency, transport and disposal, of any radioactive substances without obtaining the consent of the Central government. Further, Section 17 of the Act gives the Central Government power to prescribe the requirement for safety and waste management.

The Competent Authority grants the Regulatory Consent / Licence in accordance with the provisions of the Section 16 and 17 of the Atomic Energy Act, 1962 and the Rule 3 of the Radiation Protection Rules, 2004. Rule 3 of the RPR 2004, prescribes that a licence from the Competent Authority is necessary for handling any radioactive substance. Rule 3 of the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules 1987, stipulates that an Authorisation from the Competent Authority is required for disposal or transfer of radioactive wastes. Rule 4 of Atomic Energy (Factories) Rules 1996 prescribes that 'Approval' of the Competent Authority shall be obtained for using any premises as a factory for purposes of the Atomic Energy Act 1962. Chairman, AERB is the competent authority designated by the Central Government for issuing consents/licenses as applicable under the above said rules.

AERB issues the licence to an NPP and carries out safety monitoring, inspection and enforcement activities under the provisions of above legislations. AERB code of practice ‘Regulation of Nuclear and Radiation facilities (AERB/SC/G: 2000)’ specifies the minimum

safety related requirements/obligations to be met by a nuclear or radiation facility to qualify for the issue of regulatory consent / licence at every stage leading to eventual operation.

These licenses are issued by AERB on the basis of its review and assessment. Compliance to the regulatory requirements is verified by conducting periodic regulatory inspections. In general AERB adopts a multi-tier review process for new projects and operating NPPs. The code also elaborates on regulatory inspection and enforcement to be carried out by the Regulatory body in such facilities. For NPPs, the consents are issued for the major stages like Siting, Construction, Commissioning and Decommissioning and licence is issued for Operation. After the issuance of licence for operation, AERB establishes the system of regulatory review and assessment by way of reporting obligations, periodic safety review and regulatory inspections & enforcements. Annex 7-2 typically indicates various requirements for locating and operating NPPs in India and Annex 7-3 shows the hierarchy of the regulatory framework.

The detailed licensing process in India is described in chapter on Article 14 (Assessment and Verification of Safety).

7.2.2.2 Consenting Process for Nuclear Power Plants

AERB safety code on 'Regulation of Nuclear and Radiation Facilities AERB/SC/G: 2000' gives the mandatory requirements/obligations to be met by a nuclear or radiation facility, to qualify for the issue of regulatory consent/ licence. The Safety Guide "Consenting Process for Nuclear Power Plants and Research Reactors" AERB/NPP&RR/SG/G-1:2007 defines the regulatory consenting process for all the major stages of a nuclear power plant/research reactor. It covers in detail the information required to be included in the submissions to AERB, mode of document submissions and their classification, and areas of review and assessment for granting the regulatory consent. The major stages of consenting process for NPPs/Research Reactors are Siting, Construction, Commissioning, Operation and Decommissioning. AERB may also consider pre-licensing safety review.

Safety in siting, design, construction, commissioning and operation of the facilities is ensured primarily through regulatory actions including grant of consent for activities and imposition of conditions on the applicant. AERB performs these actions on the basis of its review and assessment. In general, a three-tier review process is followed by AERB before any major activity concerning NPP, is granted consent. In certain cases AERB may opt for alternative review process as deemed necessary.

7.2.3 System of Regulatory Inspection and Assessment

Regulatory Inspection is one of the responsibilities and functions of AERB. The Regulatory inspection and assessment process ensures:

i. compliance with the safety provisions of the primary and subordinate legislations and other consenting conditions;
ii. that nuclear facilities are sited, constructed and operated in conformity with design intent duly approved by AERB;
iii. that safety-related structures, components and systems are of approved quality based on acceptable standards; and
iv. facilities operate within the approved Technical Specifications for Operation and the respective operating personnel are competent to operate the facility safely.

7.2.3.1 Legal Provision for Regulatory Inspection

Section 8 of the Atomic Energy Act gives the Central Government powers to enter and inspect any mine, premises and land for the purpose of the Act. For the purpose of safety,

subsections 4 and 5 of Section 17 of the Act gives the Central Government powers to inspect any premises, vehicle, vessel or aircraft and take enforcement actions to prevent any contravention of the rules framed under the provision of this section. The provisions of Atomic Energy (Radiation Protection) Rules 2004, Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 and Atomic Energy (Factories) Rules, 1996 are also enforced by AERB. A system of regulatory inspection is established to verify compliance with the rules. The powers to inspect and take enforcement actions for industrial safety are drawn from the provisions of section 8 & 9 of the Factories Act 1948. AERB Code of practice in Safety on Regulation of Nuclear and Radiation facilities AERB/SC/G: 2000 and safety guides and manuals issued there under provides the details regarding the system of regulatory inspection and enforcement.

Other governmental bodies like PCB, MoEF also carry out inspection from time to time for enforcement of the requirements relating to conventional pollutants, environmental aspects etc.

7.2.3.2 Inspection Strategies and Assessment Method

The regulatory inspection strategies are comprehensive and developed within the overall regulatory strategy to ensure that nuclear and radiation facilities comply with the regulatory requirements. Inspections are carried out as necessary during all stages of consenting process. The extent to which inspection is performed in the regulatory process depends upon the importance of the consenting stages with respect to safety and potential, magnitude or nature of the hazard associated with the type of activity.

AERB undertakes inspection activities as per its inspection schedule or as warranted by any event. For all routine/planned regulatory inspections the areas and frequencies of inspection are specified. AERB can also carry out surprise inspections.

Verification of overall safety performance also requires inspections that focus on a relatively broad range of subject areas, with adequate depth and frequency. Each planned inspection has specific objectives, which are identified in advance and informed to the plant management and the inspection personnel. On the other hand, during regulatory inspection following an event, specialists carry out an in-depth review of the areas relevant to the event.

The observations made during regulatory inspections are categorized according to their safety significance. Inspection findings and utility response are reviewed in AERB and enforcement actions as deemed necessary are taken.

7.2.3.3 Inspection Programme

Regulatory inspection programme of AERB is described in the safety guide “Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities” AERB/SG/G-4. The inspection programme includes the following:

i. developing required procedures for the effective conduct and administration of the inspection programme;
ii. conducting, as necessary, planned inspections during all stages of the consenting process and throughout the service life of the NPP as well as on decommissioning;
iii. verifying the Consentee's compliance with the regulatory requirements and otherwise assuring continuous adherence to safety objectives;
iv. carrying out reactive inspections in response to events
v. documenting its inspection activities and findings;

The regulatory inspection includes both planned and reactive inspections. Inspections are carried out throughout the life cycle of a NPP, and where necessary, includes inspections of vendor facilities and activities too. Planned inspections are conducted every quarter for NPP

projects and twice in a year for operating NPPs. Planned inspections include examinations of actual physical status of NPPs, various procedures, records and documents, surveillance tests, and interviews with the utility personnel.

7.2.4 Enforcement of Applicable Regulations and Terms of Licences

AERB has the necessary legislative power to frame safety regulations, establish licensing conditions. It has also established regulatory mechanism to enforce them.

7.2.4.1 Legal Provision and Power for Enforcement

Subsections 4 and 5 of Section 17 (Special provisions as to safety) of the Atomic Energy Act gives the Central Government powers to inspect and take enforcement actions to prevent any contravention of the rules. Atomic Energy (Radiation Protection) Rules 2004 and Atomic Energy (Safe Disposal of Radioactive Wastes) Rules 1987 identify AERB as the enforcement authority. AERB also enforces the provisions of Atomic Energy (Factories) Rules, 1996 for industrial safety of the plants under DAE. The powers to inspect and take enforcement actions for industrial safety are drawn from the provisions of section 8 & 9 of the Factories Act 1948. AERB Code of practice 'Regulation of Nuclear and Radiation facilities AERB/SC/G: 2000' and safety guides issued under it provide the details regarding the system of enforcement.

7.2.4.2 Elements for Enforcement Actions

Several graded enforcement options are available to AERB to ensure that the consentee takes timely corrective actions. The actions taken by the Regulatory Body are based on aspects such as safety significance of the deficiency, seriousness of violations, the repetitive nature and/or deliberate nature of the violations. Enforcement actions by the Regulatory Body arise from review of documents submitted by the consentee or findings during review or inspection. The enforcement actions include one or more of the following:

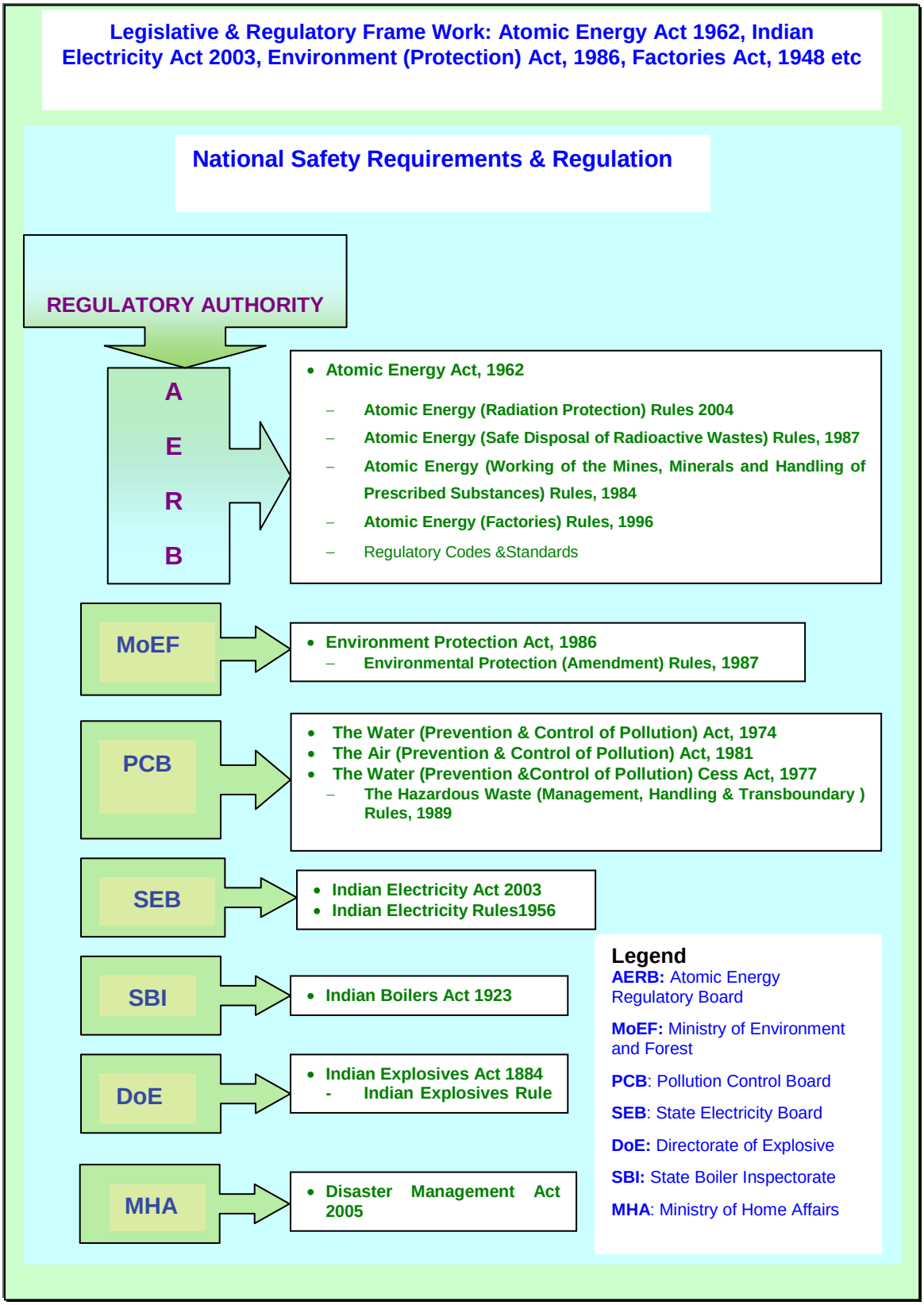
i. a written directive for satisfactory rectification of the deficiency or deviation detected during inspection;
ii. written directive for improvement within a reasonable time frame;
iii. orders to curtail or stop activity;
iv. modification, suspension or revocation of operating consents; and
v. penalties.

The enforcement measures taken by AERB during the past three years are brought out in chapter on Article 14 (Assessment and Verification of Safety).

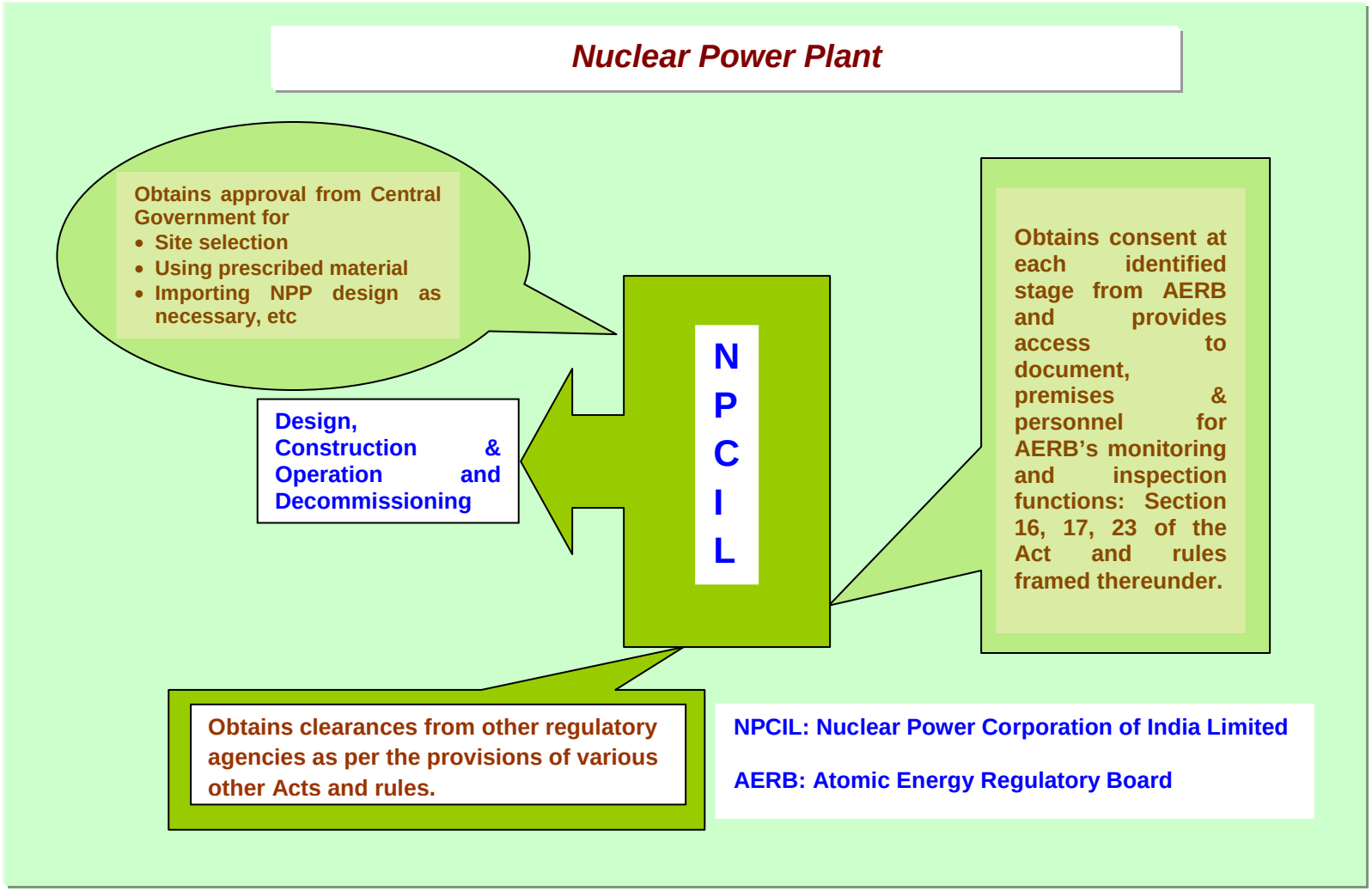
7.3 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Since the inception of the atomic energy programme in the country, an elaborate legislative and regulatory framework is in place. The national safety requirements pertaining to atomic energy emanate from the Atomic Energy Act 1962 & rules issued there under. Acts and rules explicitly bring out the requirement of licensing, inspection & enforcement. The system of licensing, inspection and enforcement has been established. AERB code of practice on regulation of Nuclear and Radiation Facilities and several guides issued under the Code gives the process of regulation of safety in the country. The Legislative and Regulatory framework in the country is comprehensive to harness the benefit of Atomic energy in a safe and secured manner. Hence, India complies with the obligations of Article 7 of the Convention.

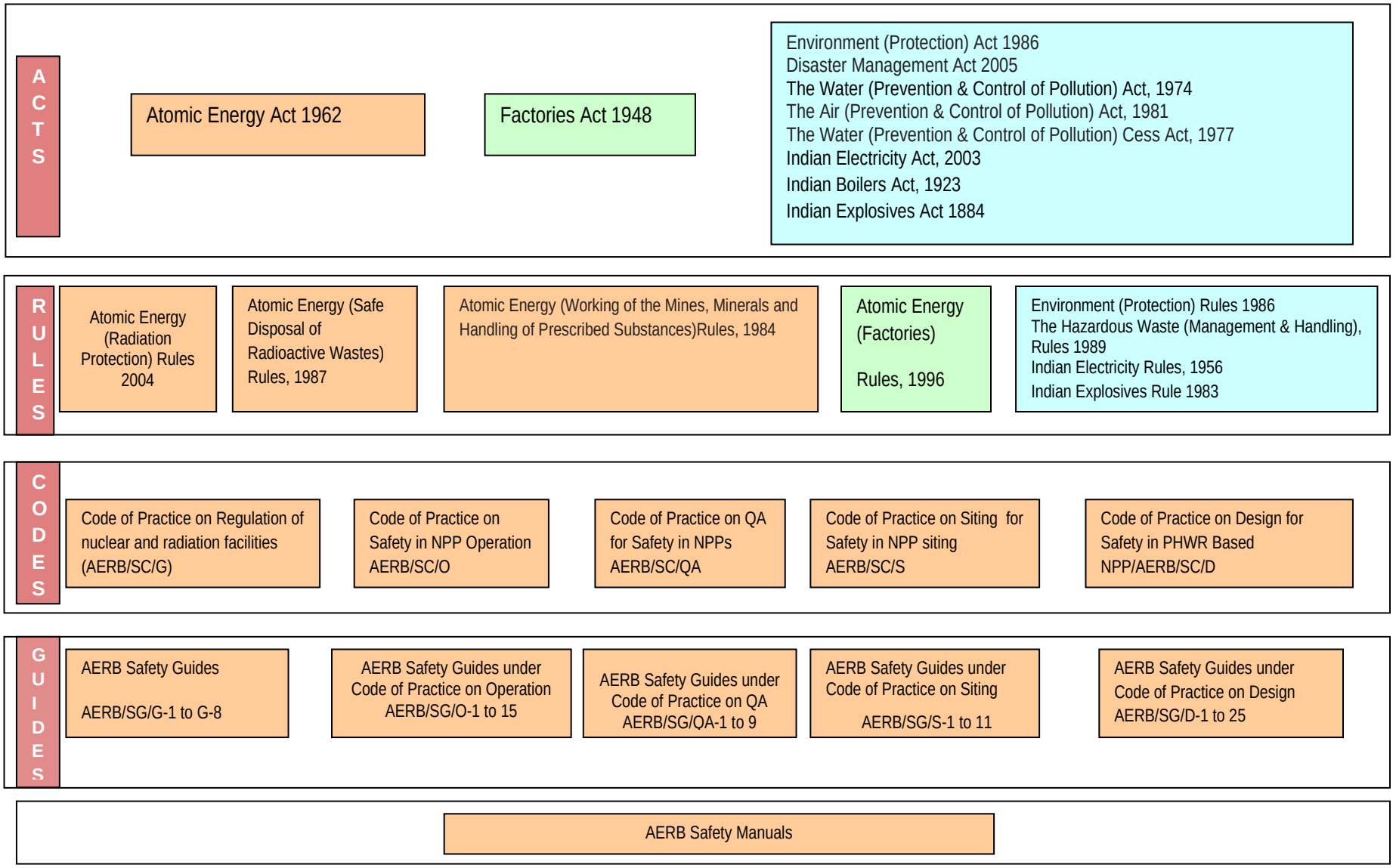
Annex 7-1: National Safety Requirements and Regulation



Annex 7-2: Requirement of Approvals for Locating NPPs



Annex 7-3: Regulatory Framework – Hierarchy



ARTICLE 8: REGULATORY BODY

1. **Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities.**

2. **Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy.**

8.0 GENERAL

The Government of India, exercising the powers conferred by Section 27 of the Atomic Energy Act 1962 established the Atomic Energy Regulatory Board (AERB) in 1983, to carry out regulatory and safety functions with regard to nuclear power generation and use of ionising radiations in the country. The authority of AERB is derived from the presidential notification (gazette notification) for establishment of AERB and rules promulgated under the Atomic Energy Act, 1962. The mission of AERB is to ensure that the presence of ionising radiation and the use of nuclear energy in India do not cause unacceptable impact on the health of workers, members of the public and the environment.

AERB is entrusted with the responsibility for regulating activities related to nuclear power generation, nuclear fuel cycle facilities, research and industrial and medical uses of radiation. AERB also regulates industrial safety as per the provision of Factories Act 1948 and the Atomic Energy (Factories) Rules 1996, for the plants and facilities managed by the constituents of DAE.

8.1 ESTABLISHMENT OF AERB

8.1.1 Mandate and Duties of AERB

The basic regulatory framework for safety for all activities related to atomic energy program and the use of ionising radiation in India is derived from Sections 16, 17 and 23 of the Atomic Energy Act, 1962. These provisions have been described in detail in Chapter on Article 7. AERB carries out certain regulatory and safety functions of these sections of the Act. The mandate for AERB brought out in the presidential (gazette) notification issued by the Central Government in the year 1983 inter-alia includes:

i. Powers to lay down safety standard and frame rules and regulations in regard to the regulatory and safety requirements envisaged under the Atomic Energy Act,1962.
ii. Powers of the Competent Authority to enforce rules and regulations framed under the Atomic Energy Act, 1962 for radiation safety in the country.
iii. Authority to administer the provisions of the Factories Act, 1948 for the industrial safety of the units of DAE as per Section 23 of the Atomic Energy Act, 1962.

The functions & responsibilities of AERB are summarized below:

i. Develop safety policies in nuclear, radiological and industrial safety areas.
ii. Develop Safety Codes, Guides and Standards for siting, design, construction, commissioning, operation and decommissioning of different types of nuclear and radiation facilities.

iii. Grant consents for siting, construction commissioning, operation and decommissioning, after an appropriate safety review and assessment, for establishment of nuclear and radiation facilities.
iv. Ensure compliance of the regulatory requirements prescribed by AERB during all stages of consenting through a system of review and assessment, regulatory inspection and enforcement.
v. Prescribe the acceptance limits of radiation exposure to occupational workers and members of the public and approve acceptable limits of environmental releases of radioactive substances.
vi. Review the emergency preparedness plans for nuclear and radiation facilities and during transport of large radioactive sources, irradiated fuel and fissile material.
vii. Review the training program, qualifications and licensing policies for personnel of nuclear and radiation facilities and prescribe the syllabi for training of personnel in safety aspects at all levels. Assessment of competence of key personnel for operation of NPP.
viii. Take such steps as necessary to keep the public informed on major issues of radiological safety significance.
ix. Promote research and development efforts in the areas of safety.
x. Maintain liaison with statutory bodies in the country as well as abroad regarding safety matters.
xi. Review of Nuclear Security at Nuclear installations
xii. Notify Nuclear incident under Civil Liability for Nuclear Damage Act, 2010

Deriving powers and functions specified in the gazette notification, AERB Safety Code, AERB/SC/G: 2000 on "Regulation of Nuclear and Radiation Facilities" establishes the regulatory practices in the country.

8.1.2 Structure of AERB

8.1.2.1 The Board

The governing Board of AERB consists of a Chairman, five members and a Secretary. Chairman, AERB is the Chairman of the Board. Chairman, Safety Review Committee for Operating Plants (SARCOP) is also an ex-officio member of the Board. Secretary of the Board is an employee of AERB. The other members of the Board are serving or retired eminent persons from the government, academic institutes, medical institutes or national laboratories.

The Board formulates the regulatory policies and decides on all important matters related to Consent, renewal of consents, enforcement actions, major incidents, etc. Chairman AERB, functions as the executive head of the AERB secretariat. The Board reports to Atomic Energy Commission (AEC). Atomic Energy Commission is the apex body of the Central Government for atomic energy that provides direction on policies related to atomic energy. The members of AEC among others include some eminent scientists & technocrats, secretaries of different ministries and senior most officials from the office of the Prime Minister. The AEC reports to the Prime Minister.

AERB sends periodic reports to AEC on safety & security status including observance of safety & security regulations, standards and implementation of the recommendations in all DAE units. In addition, the safety status for non- DAE units is covered in these periodic reports.

8.1.2.2 Advisory Committees

The Board is supported by several advisory committees in its regulatory functions. The advisory committees viz. Safety Review Committee for Operating Plants (SARCOP) and Safety Review Committee for Application of Radiation (SARCAR) are the two apex level committees for ensuring safety. SARCOP monitors and enforces safety regulations in NPPs & other Nuclear and Radiation Facilities identified by the Central Government. SARCAR is the safety monitoring and

advisory committee of AERB that reviews safety aspects related to the application of radiation sources and equipment in industry, medicine, agriculture and research for non-DAE units as well as during transportation of radioactive materials in public domain.

The Advisory Committee for Nuclear Safety (ACNS) advises AERB on generic safety issues affecting the safety of nuclear installations. It is also mandated to conduct the final review of draft safety documents like safety codes, guides and manuals pertaining to siting, design, construction, operation, quality assurance and decommissioning of Nuclear Facilities.

The Advisory Committee on Occupational Health (ACOH) advises AERB on the matters of occupational health in the DAE industrial units. The Committee also recommends requirements in each unit with respect to infrastructure for the occupational health activities including medical officers as well as appropriate facilities.

The Advisory Committee for Industrial and Fire Safety (ACIFS) advises AERB on generic industrial and fire safety issues and recommends measures on industrial safety aspects for prevention of accidents at all DAE installations including projects under construction.

The Advisory Committee on Radiological Safety (ACRS) advises on generic safety issues concerning radiological safety in application of radiation sources in medicine, industry, education and research.

The Advisory Committee for Review of Safety Research (AC-RSR) advises on generic safety research topics/ issues and joint research projects with other institutions in the areas of interest to regulatory body.

The Advisory Committee for Security (ACS) advices on generic security issues concerning nuclear safety aspects for nuclear power plants.

8.1.2.3 Organisation of AERB

AERB has its office located in Mumbai to assist it in its regulatory functions. It comprises of seven technical divisions and a safety research institute located at Kalpakkam, Tamil Nadu. These are: Operating Plants Safety Division (OPSD), Nuclear Projects Safety Division (NPSD), Nuclear Safety Analysis Division (NSAD), Radiological Safety Division (RSD), Siting & Structural Engineering Division (SSED), Information and Technical Services Division, (I&TSD) and Industrial Plants Safety Division (IPSD). The organisation of AERB is given in Annex 8-1. The functions of the technical divisions of the secretariat are briefly summarised below:

Operating Plants Safety Division

- Enforcement of Atomic Energy (Radiation Protection) Rules, 2004 in operating NPPs
- Enforcement of Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 in operating NPPs and other Nuclear and radiation facilities
- Safety Review of Nuclear Power Plants and Research Reactors
- Issuance of Technical Specifications for operation of Plants and Facilities
- Licensing of Operating and Management Personnel
- Regulatory Inspection of operating NPPs
- Review of Emergency Preparedness at NPPs
- Renewal of Licence for operation of NPPs
- Authorisation for Radwaste Disposal
- Review of Nuclear security aspects

Nuclear Projects Safety Division

- Enforcement of Atomic Energy (Radiation Protection) Rules, 2004 in NPP projects
- Enforcement of Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 in NPP projects
- Safety Review of Nuclear Power Projects under construction and commissioning
- Regulatory Inspection and Safety Audit of Nuclear Power Projects
- Review of Nuclear security aspects

Nuclear Safety Analysis Division

- Nuclear Safety analysis and assessment including Probabilistic Safety Assessment
- Regulatory R&D activities

Radiological Safety Division

- Enforcement of Atomic Energy (Radiation Protection) Rules, 2004 in radiation installations other than Nuclear Fuel Cycle Facilities
- Safety Review of Accelerators and Irradiators
- Transportation of Radioactive Material
- Enforcement of Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 in radiation installation other than Nuclear Fuel Cycle Facilities
- Review of security aspects of radiation facilities.

Siting and Structural Engineering Division

- Review of applications for Siting consent
- Siting & Structural Engineering issues related to Operating Plants and New Projects.
- Inspection and Enforcement of Civil & Structural Engineering safety
- Earth Science and Earthquake Engineering Aspects

Industrial Plants Safety Division

- Industrial and fire Safety Review
- Regulatory Inspection related to Industrial Safety
- Licensing of Personnel
- Occupational Health of Workers Inspection and Enforcement of radiological safety in fuel cycle facilities other than NPPs

Information and Technical Services Division

- Public Information
- Regulatory document development
- Technical Services
- Organisations of Board meetings and follow up of its decisions.
- Training of AERB staff

The Directors of the above divisions are members of the AERB Executive Committee, which meets periodically with Chairman, AERB and takes decisions on important policy matters related to the management of the Secretariat of the Board.

8.1.2.4 Technical Support

AERB constitutes advisory committees for various regulatory activities and document development. The technical support to these Committees is provided by the experts from AERB, BARC, IGCAR, national laboratories, and industrial and academic institutions in the country. The Advisory Committees are supported by various other committees. The administrative and regulatory mechanisms, which are in place, ensure multi-tier review.

AERB constitutes advisory committee for project to carryout safety assessment of proposed NPPs and advise AERB during siting, construction and commissioning stages of the NPP projects. At present, the following Advisory Committees are functioning.

- Advisory Committee for Project Safety Review for PHWR based NPPs and PFBR (ACPSR-PHWR/PFBR)
- Advisory committee for Project Safety Review for Light Water Reactors (ACPSR-LWR),
- Advisory Committee for Project Safety Review for Fuel Cycle Facility (ACPSR-FCF),
- Advisory Committee for Project Safety Review of Fast Reactor Fuel Cycle Facility and Demonstration Fuel Reprocessing Plant, IGCAR, Kalpakkam (ACPSR-FRFCF),

AERB has several other committees to advise it for development of safety documents.

- Advisory Committee for preparation of Code & Guides on Governmental Organization for the Regulation of Nuclear & Radiation facilities (ACCGORN),
- Advisory Committee on Codes, Guides & Associated Manuals for Safety in Design of NPPs (ACCGD),
- Advisory Committee for Codes, Guides & Associated Manuals for Safety in Operation of NPPs (ACCGASO),
- Advisory Committee for Codes & Guides for Quality Assurance for Nuclear Power Plants Safety (ACCGQA),
- Advisory Committees for Regulatory Documents on Nuclear Power Plant Siting (ACRDS),
- Advisory Committee on Safety Documents relating to Fuel Cycle Facilities other than Nuclear Reactors (ACSDFCF),
- Advisory Committee for Regulatory Documents on Civil and Structural Engineering (ACRDCSE),

BARC is one of the main technical support providers to AERB. BARC provides strong technical support in the areas of development of safety documents, radiological and environmental safety, review and assessment of safety cases and inspection and verification functions. Some of the other important areas where BARC provides extensive technical support to AERB are Reactor Physics, Reactor Chemistry, Post-irradiation Examination, Remote Handling and Robotics, Control and Instrumentation, Shielding, Thermal Hydraulics, Probabilistic Safety Assessments, Seismic Evaluation, Quality Assurance and In-service Inspection. BARC is currently involved in the following R&D activities for improving the analytical capabilities in the areas related to nuclear safety:

- Development of an integrated severe accident code PRABHAVINI for PHWRs
- Development of CFD code for Molten Fuel Coolant Interaction specific to PHWRs
- Generic containment benchmarks and alternate TMI benchmark exercises under SARNET programme to improve the understanding of severe accident code ASTEC
- Adaptation of code ASTEC for PHWR severe accident analysis and development of models for Passive Autocatalytic Recombiners
- Experiments on ultimate load capacity of containment using BARC containment model (BARCOM) facility

AERB also utilizes the expertise available with Indira Gandhi Centre for Atomic Research (IGCAR). Experts from Council for Scientific & Industrial Research (CSIR) and various Indian Institutes of Technology (IITs) also provide technical supports to AERB in its review and assessment functions. AERB also appoints consultants having long experience in the national nuclear programme in various capacities for supporting it in the regulatory activities. AERB may also invite experts from other organisations having specific expertise. Another important resource for AERB's safety review and safety documents development work is the large cadre of retired senior experts.

8.1.2.5 Human Resources

The staff of AERB mainly consists of technical & scientific experts in different aspects of nuclear and radiation technology for meeting the requirement of consenting, safety review, research, inspections and analytical works. Besides AERB's own staff, required expertise is drawn from Technical support organisations, academic institutions and retired experts. The staff of AERB was augmented from a total of 215 in 2010 to 310 in 2013, an increase of about 45 %. Fresh technical & scientific staff is inducted from various training schools and nuclear training centres as well as from Indian Institutes of Technology. Direct recruitment of experienced professionals is also done through open advertisements. The recruitment and training process is as follows:

i. Engineering graduates are absorbed after basic training in nuclear training centres at NPP sites. They undergo 2 years field training at NPPs to gain the system knowledge including simulator training before obtaining the NPP operations licence. Some are also deputed during construction/commissioning activities of NPP to obtain the field experience.

ii. Engineering/Science graduates are also absorbed after their basic training from BARC training Schools. They are given on-job training at operating NPPs. They generally pursue specialisation in the areas of reactor physics, nuclear and radiological safety, transport safety and waste management and also complete post graduation in their field.

iii. AERB sponsors a few students annually to complete the post graduation from Indian Institutes of Technology. They are further trained in nuclear technology and given on-job training at NPPs after which they are assigned analytical works.

iv. AERB through its Safety Research Institute sponsors some of its employees for Post Doctoral courses to develop expertise in the areas of regulatory interest. AERB also encourages persons to take up higher studies in the field of nuclear engineering.

In addition, AERB organizes in-house orientation training programs for newly inducted staff. This program covers the subject such as legislative and regulatory framework (Acts, Rules, Codes, Guides and Manuals), functioning of AERB, regulatory processes followed and basic aspects of nuclear, radiation and industrial safety in nuclear and radiation facilities. These training programs are of approximately two months duration.

In-house refresher courses are conducted on various topics of regulatory and safety aspects. AERB colloquia are organised frequently on topics of current interests and on new developments in various fields. The staff is provided opportunity to participate in conferences, seminars, and workshops in India as well as abroad to keep them abreast of the new developments in the areas of relevance. In addition, seminars / theme meetings, technical talks are arranged by the respective divisions of AERB to encourage more and more interaction with the members of other divisions.

8.1.2.6 Financial Resources

AERB has full powers to operate its budget, which it prepares and submits to the Central Government for approval. The Central Government allocates the budget in the separate account

heads of AERB. The budget of AERB in the year 2013-2014 is about 410 million rupees. This budget does not include the cost of Technical Support provided by different organisations.

8.1.2.7 Safety Research

A large part of safety research important to regulatory activities is carried out by BARC, the main technical support organisation. AERB also has its own Safety Research Institute (SRI) at Kalpakkam near the city of Chennai in order to achieve independent research and development capabilities and to complement the ongoing research and development work done in other R&D centres. The areas of research at SRI ranges from Light Water Reactor Physics, Fire Modelling Studies, Radiation Shielding & Transport and Criticality Computations, Assessment of Beam Characteristics of Medical linear particle accelerators, Reliability and Probabilistic Safety Assessment, Structural and Seismic Studies, Remote Sensing and Geographic Information System Applications, Safety Assessment of near surface disposal facilities. The institute helps building up competent human resources of high merit for regulatory purposes. It also organizes workshops and seminars on specific safety topics of current importance.

AERB also promotes and funds radiation safety research and industrial safety research as part of its programme and provides financial assistance to universities, research institutions and professional associations for holding symposia and conferences on the subjects of interest to AERB. AERB Committee for Safety Research Programmes (CSRP) frames guidelines for the same and also evaluates and monitors the research projects.

8.1.2.8 Quality Management in AERB

AERB activities are conducted as per the Safety Code, AERB/SC/G, on "Regulation of Nuclear and Radiation Facilities" and various guides issued under it. These documents give in detail the consenting process, obligations of the consentee, conduct of regulatory review & assessment, inspection regime & enforcement provisions for the nuclear power plants, Research reactors, other nuclear fuel cycle facilities and radiation facilities. AERB has developed a Quality Assurance programme through which activities of each division are assessed for conformance to the prescribed procedures. In recognition of this programme, AERB has obtained ISO 9001:2008 certifications for its activities pertaining to consenting, inspection and development of safety documents.

8.2 STATUS OF THE AERB

8.2.1 Government Structure and the Regulatory Body

The laws pertaining to atomic energy are enacted by the Parliament and enforced by the Central Government. The Atomic Energy Act 1948 was the first legislation for the atomic energy in the country. In the same year, the Government of India constituted a high powered Atomic Energy Commission to implement the Government policy with regard to atomic energy. Subsequently in the year 1954, Government of India created Department of Atomic Energy (DAE). With the creation of DAE, AEC was reconstituted in accordance with the Government resolution dated March 1, 1958, to advise the Central Government on matters pertaining to Atomic Energy. Later, Central Government set up the Atomic Energy Regulatory Board (AERB) in 1983 and delegated to it the power to exercise the regulatory and safety functions envisaged under the Atomic Energy Act 1962. AERB updates the AEC through annual report on all safety related matters pertaining to nuclear and radiation related activities in India.

8.2.2 Obligations of the Regulatory Body

The presidential (gazette) notification, forming the regulatory body, issued by the Central Government in the year 1983 empowers AERB for issue of consents, regulatory inspection and

enforcement of safety provisions for nuclear and radiation facilities in India. According to the same notification, the functions of AERB also include:

i. Development of necessary rules and regulations to implement the provisions of the Act in the area of nuclear and radiation safety.
ii. Prescribing acceptable limits of radiation exposures and environmental releases of radioactive substances.
iii. To take necessary steps to keep the public informed on major issues of radiological safety significance.

8.2.3 Effective Separation between Regulation and Promotion Activity

The Atomic Energy Commission (AEC) is a high level body dealing with policy matters concerning nuclear energy in the country. The responsibility of siting, construction and operation of NPPs and nuclear fuel cycle facilities rests with the Department of Atomic Energy (DAE). The DAE fulfils this responsibility through its units like NPCIL and BHAVINI for NPPs, and through units like Uranium Corporation of India Ltd. (UCIL) for mining and milling of uranium and Nuclear Fuel Complex (NFC) for fabrication of fuel etc. All these are government owned corporations.

AERB, the national regulator, is a separate body constituted by the Central Government specifically for exercising certain regulatory and safety functions envisaged under the Atomic Energy Act 1962. Funding for AERB activities is provided by Government of India. AERB is totally independent of DAE and the reporting of AERB to AEC generally comprises of AERB presenting its Annual Report and Budget Proposals only to AEC once in a year. This structure provides complete and effective separation to AERB in its regulatory work.

To further strengthen the legal framework for regulation of safety in nuclear facilities, Government has introduced the 'Nuclear Safety Regulatory Authority (NSRA) Bill 2011' to strengthen India's nuclear safety regulatory framework by conferring statutory status to regulatory body. With the promulgation of the Nuclear Safety Regulatory Authority (NSRA) Bill 2011, NSRA will subsume the activities of AERB. The bill has subsequently undergone review in the standing committee of parliament and now in the final stage of approval.

8.3 CO-OPERATION WITH INTERNATIONAL BODIES

AERB has been actively involved with various international bodies for exchange of information and in co-operation in the field of regulation of nuclear activities for peaceful purposes. AERB experts have been actively participating in various activities of IAEA and have been contributing at various fora. Some of these co-operation activities are brought out as follows:

i. International Atomic Energy Agency (IAEA)

AERB has been actively participating in the activities of IAEA. The staff of AERB participates in various Technical and consultants meetings organised by IAEA on a range of topics for fuel cycle activities, radiation facilities, transportation of radioactive materials and illicit trafficking of radioactive materials. AERB has been participating in IAEA Coordinated Research Programme (IAEA-CRP).

AERB is the national coordinator for IAEA - INES and IAEA - Incident Reporting System (IRS). AERB participates in all activities related to their functioning.

These interactions help AERB in keeping abreast with the developments in the related fields, safety issues and the evolving safety standards. The experience helps AERB in developing national standards and guidelines.

Post Fukushima accident, top officials of AERB participated in the IAEA ministerial conference in 2011 & 2012 and IAEA Fact Finding Mission to ascertain factual information and to identify initial lessons learned from the accident. AERB has participated in the various meetings organised by IAEA and presented the review findings, actions taken/proposed. AERB has been participating in some specific IAEA activities related to external events. AERB has recently joined the activities of International Seismic Safety Centre (ISSC) of IAEA and is participating in four work areas viz., Seismic Safety Evaluation, Tsunami Hazards, Engineering Aspects of protection against sabotage and site evaluation and external events safety assessment.

AERB hosted an IAEA workshop in October 2012 on the safety of Multi-Unit Nuclear Power Plant sites against External Natural hazards to share information among the international nuclear community on the scientific and technical issues related to multi-unit NPP sites following the Fukushima Daiichi nuclear accident. The workshop covered the following major topics:

- Lessons learned from past earthquakes affecting NPPs
- Assessment of external natural hazards at a site housing multi-unit NPP(s) and other nuclear installations
- External event PSA
- Risk integration
- Site safety assessment for external events

This workshop attracted good participation from various units of DAE, AERB and international nuclear community (about 50 persons from India and 30 persons from overseas). The discussions provided direction for development of guidance material for the safety assessment of NPP sites, especially for the multi-unit sites, in relation to external events. These discussions were taken up as a part of Work Area 8 (WA8) of the IAEA's international seismic safety extra budgetary programme.

ii. CANDU Senior Regulators Forum

AERB is a member of the forum for the CANDU Senior Regulators for exchange of information on issues specifically related to safety of PHWRs. The November 2011 meeting of the forum was held after Fukushima accident. Actions taken by the regulatory bodies of all the participant countries were discussed. The national reports for the 2nd EOM of the convention by the member countries were peer reviewed by the forum in a special meeting held in April 2012.

AERB is one of the key contributors in CANDU PSA Working Group established by IAEA as suggested by CANDU senior regulators forum. The objectives of the CANDU PSA Working Group are to support regulatory authorities, utilities and designers in their area of PSA by harmonizing regulatory approaches and utilities practices on the use of PSA and to make recommendations to CANDU Senior Regulators Forum.

iii. VVER Regulators Forum

VVER Regulators Forum is for exchange of information and experience on issues specifically related to safety of Russian VVERs. AERB is a member of this forum. AERB's participation in this forum helps in understanding events and generic safety issues in VVER reactors, based on which corrective steps as may be necessary are initiated in KKNPP, which is under advanced stage of commissioning in India.

iv. United States Nuclear Regulatory Commission (USNRC)

Cooperation in nuclear safety between AERB and USNRC was resumed in February 2003. Since then ten meetings have been held between AERB and USNRC both in India and USA. The objective of these meetings continues to be furthering the dialogue regarding Nuclear Safety between US and Indian Governments.

A delegation from USNRC led by Chairman, USNRC visited India during November 2011. The recommendations arising from review of Fukushima accident in India and USA were discussed during the meeting between AERB and USNRC delegation.

As a part of co-operative safety activities, standard problem exercise on 'Performance of pre-stressed concrete containment vessels (PCCV) under severe accident conditions' has been taken up by AERB and USNRC. The analyses carried out by both the sides provided detailed insight into the containment performance during beyond design basis condition, validity of the analytical models and ultimate capacity of pre-stressed concrete containment.

Some of the areas of Technical exchange have been:

- Probabilistic Risk Assessment
- Fire Safety
- Severe Accident Analysis
- Reactor Containment Structural Safety
- New and Advanced Reactor Designs
- Tsunami hazard assessment
- Ageing management of concrete structures
- Digital Instrumentation and Control

v. ASN and IRSN, France

AERB and Nuclear Safety Authority (ASN), France discussed safety issues of mutual interest including emergency preparedness and management of post accidental situations and safety reviews carried out after Fukushima accident. A two day workshop was also conducted with safety experts from both the countries presenting the latest practices adopted by them. Both the countries have conducted such meetings and workshops in the past also under the Nuclear Safety Co-operation Arrangement between the two organizations that was signed in July 1999 and further renewed in 2005 and 2010.

Another agreement on technical cooperation between AERB and Institute for Radiation Protection and Nuclear Safety (IRSN), France was also signed for collaboration in the area of nuclear reactor safety covering areas such as exchange of staff, exchange of materials or software, joint studies and joint projects etc.

vi. Radiation Safety Authority, Russia

AERB and the Federal Nuclear and Radiation Safety Authority of Russia ROSTECHNADZOR entered into an agreement for cooperation in the field of safety regulation of nuclear energy for peaceful purposes. This agreement came into force on February 15, 2003 and is valid till Kudankulam NPP begins regular operation. Four Workshops have been held between AERB and ROSTECHNADZOR for information exchange on nuclear safety.

vii. Nuclear Energy Agency

India has been involved in the activities of committees of NEA and their various working groups such as Committee on Safety of Nuclear Installations (CSNI) and Committee on Nuclear Regulatory Activities (CNRA). India has participated in the following various working groups:

- Working Group on Operation Experience (WGOE),
- Working Group on Inspection Practices (WGIP),
- Working Group on The Regulation of New Reactors (WGRNR),
- Working Group on Risk Assessment (WGRisk),
- Working Group on Analysis and Management of Accident (WGAMA)

- Senior Level Task Group on Long Term Operation (STG on LTO)
- Senior-Level Task Group on the impacts from Fukushima Daiichi accident (STG Fukushima).

viii. CNCAN, Romania

A Memorandum of Understanding (MoU) was signed between AERB and National Commission for Nuclear Activities Control (CNCAN) of the government of Romania on September 19, 2012. The MoU is signed for the exchange of information and co-operation in the field of regulation of nuclear activities of peaceful purposes such as application of radiation for societal benefit in industry, medicine, agriculture and research & field of regulating nuclear and radiation safety.

ix. SNRIU, Ukraine

A Memorandum of Understanding (MoU) was signed AERB and State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) on December 10, 2012. The MoU is signed for the exchange of information and co-operation in the field of regulation of nuclear activities of peaceful purposes such as regulatory process, nuclear safety, radiation protection, emergency planning, environmental impact evaluation of nuclear facilities, quality assurance and sharing of operating experience including information concerning research and development programs.

x. Multinational Design Evaluation Programme (MDEP)

AERB became a member in Multinational Design Evaluation Programme (MDEP) on April 4, 2012. AERB is actively participating in different working groups for mutual sharing of experience in the following areas:

- Code and Standards Working Group (CSWG)
- Digital Instrumentation and Control Working Group (DICWG)
- Vendor Inspection Co-operation Working Group (VICWG)

India is also participating in the activities of EPR working group and its subgroup working in the areas such as digital instrumentation, severe accident, and technical specification. In view of the envisaged programme of DAE which includes setting up of nuclear power plants of different technologies, India's participation in MDEP will be very useful while performing the safety review for these reactor designs and carrying out licensing activities. The enhanced cooperation among regulators on an international platform will improve the effectiveness and efficiency of the regulatory design reviews of new reactors, leading to more efficient and more safety focused regulatory decisions.

xi. IAEA-Integrated Regulatory Review Service (IRRS)

India is planning for an IAEA-IRRS mission for peer review of its regulatory system. Initiative has been taken as a part of AERB's internal assessment to carry out a study on how the regulatory requirements and processes followed in India compares with the requirements stated in various IAEA documents.

8.4 INFORMATION TO PUBLIC

AERB provides all necessary information to its stakeholders through its periodic newsletters, annual reports, web-site, press releases/ briefings and TV interviews. The AERB annual reports contain information on safety status of nuclear facilities and findings of regulatory reviews. It also includes information on safety significant events reported by licensee and the regulatory inspectors.

Formal sharing of information with any member of the public on request is a statutory responsibility of AERB under the “Right to Information” Act, 2005. AERB’s mandate includes such steps as necessary to keep the public informed on major issues of radiological safety significance. AERB explains the decision-making process to its stake holders; involves the relevant stake holders and experts in development of regulatory documents. AERB regularly conducts regulatory awareness programme which includes seminars, discussion meetings, conferences and feedback meetings.

Addressing public concern in the wake of Fukushima accident

Immediately after Fukushima accident, to create awareness in the public domain on the nuclear safety aspects of Indian NPPs, salient actions taken are as follows:

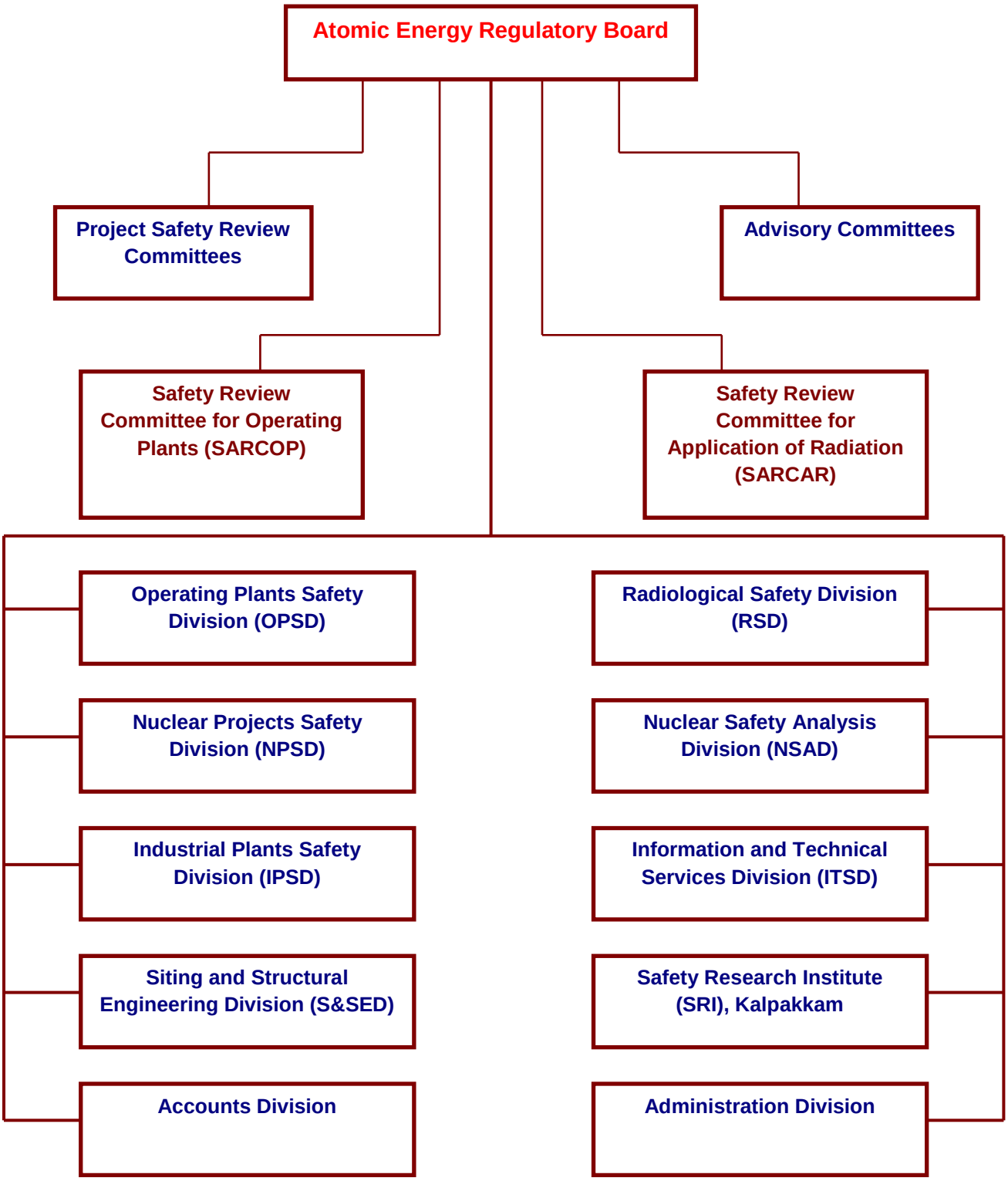
i. Briefing to the Press and media at AERB, NPCIL HQ and at each NPP site was done from time to time.
ii. Presentations were made to the Indian parliamentarians, the state legislators and to the government officials for appraisal of Fukushima event and situation in India.
iii. Posting and updating of information on the management of Fukushima accident was done on AERB, NPCIL and DAE web site.
iv. Quick replies to the queries from various sections of public were given.

A nation-wide public outreach programme was undertaken by AERB and NPCIL. NPCIL has partnered 21 professional organizations for supplementing its outreach program and extending it further. AERB has also taken steps to utilize the scientific and technical forums outside the nuclear industry, seminars / conferences in various universities and academic institutes, for delivering talks / lectures / presentation on the post Fukushima assessments and safety enhancement of NPPs.

8.5 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

As atomic energy programme in India is expanding, the regulatory body also has to keep pace with the developments. Since its constitution in 1983, AERB has built up its technical and managerial capabilities to meet these requirements. The position of AERB in the government set up ensures administrative and financial independence in its functioning. Technical support is drawn from various national laboratories as well as from other national academic and research institutions. The Central Government provides the financial resource to AERB according to its proposed budget. There has never been shortage of finance towards fulfilling its mandate and responsibilities. The statutory and legal provision of the Atomic Energy Act & various rules framed there under and the powers conferred by the gazette notification provides AERB with the authority for its independent and effective functioning. Hence, India complies with the obligation of Article 8 of the Convention.

Annex 8-1: Organisation Structure of AERB



ARTICLE-9: RESPONSIBILITY OF THE LICENCE HOLDER

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

9.0 GENERAL

One of the important functions of the Atomic Energy Regulatory Board (AERB) is to develop safety policies in nuclear, radiation and industrial safety areas. Towards this, AERB has issued the Safety Code, AERB/SC/G: 2000, on "Regulation of Nuclear and Radiation Facilities", which establishes the obligations of the licensee towards safety.

Nuclear Power Corporation of India Limited (NPCIL) is a Public Limited Government company, under the Companies Act 1956, fully owned by the Government of India. It undertakes design, construction, operation & maintenance and decommissioning of NPPs in the country. The mission of NPCIL is to develop nuclear power technology and to produce nuclear power, as a safe, environmentally benign and an economically viable source of electrical energy to meet the increasing electricity needs of the country. The Government of India has also established another company Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) in 2003, fully owned by it to pursue construction, commissioning, operation and maintenance of subsequent Fast Breeder Reactors for the generation of electricity.

Licensee responsible for design, construction, operation and maintenance of NPPs is solely responsible for safety. It is the responsibility of the licensee and their constituent units to perform their activities as per the regulatory requirements and demonstrate to the regulatory body that all the activities of the NPP meet the established safety norms.

The report describes, inter alia the systems and organizational set-ups in NPCIL. All high level requirements/obligations as applicable to NPCIL are also applicable to BHAVINI. Hence, all aspects discussed in the report relating to NPCIL are also to be read as applying to BHAVINI too. However, as NPCIL is currently involved with light water and heavy water reactors and BHAVINI with fast breeder reactor, specific requirement related to the respective reactor technologies would be different. Presently, BHAVINI is involved in construction of Fast Breeder Reactor at Kalpakkam and does not operate any nuclear power plant.

9.1 NATIONAL LAWS AND REGULATIONS

Atomic Energy Act 1962 and the rules framed there-under provide the main legislative and regulatory framework pertaining to atomic energy in the country and provide for the development, control and use of atomic energy for the welfare of the people of India and for other peaceful purposes and matters connected therewith. 'Atomic Energy (Radiation Protection) Rules, 2004' issued under the Atomic Energy Act define the 'Responsibilities of Licensee'. As per the rules, the Licensee shall ensure compliance with the safety Standards and Safety codes issued by the competent authority (AERB) from time to time.

AERB Safety code on 'Regulation of Nuclear and Radiation facilities AERB/SC/G:2000'', brings out requirements and obligations to be met by nuclear or radiation facility to qualify for issue of regulatory consent at every stage. As per the safety code, the licensee is solely responsible for ensuring the safety in siting, design, construction, commissioning, operation and decommissioning of a Nuclear Power Plant and shall demonstrate to regulatory body that the safety is ensured at all the times.

9.2 RESPONSIBILITIES OF LICENSEE AND MEANS TO FULFILL OBLIGATIONS

The applicant seeking consent shall submit all the necessary information to the AERB as laid down in the requisite regulation in support of the application for consent. It shall be the responsibility of the licensee to make proper arrangements with vendor(s) and/or contractor(s) to ensure availability of all the required information. It shall also be the responsibility of the applicant to keep the regulatory body constantly informed of all relevant additional information or changes in the information submitted earlier. The licensee is responsible for any false statement in the application for consent or in the supplemental or other statement of facts required of the applicant.

The licensee has the responsibility for compliance with the stipulated requirements, regulations and conditions referred or contained in the consent or otherwise applicable. The licensee is responsible for carrying out the activities in accordance with the approved Quality Assurance program and to ensure that every step is carried out keeping safety as the overriding priority. The responsibility of the licensee includes:

i. The licensee shall make sure that the operation of NPP is carried out according to the relevant laws, regulations and condition of the licence granted.
ii. The licensee shall develop, preserve, update and maintain a complete set of records related to the safety of the plant.
iii. The licensee shall provide the authorized representatives of AERB full access to personnel, facilities and records that are under the control of consentee.
iv. The licensee shall keep AERB fully and currently informed with respect to any significant events or potential for significant event or changes in the considerations, information, assumptions, or expectations based on which the consent was issued.
v. The licensee shall take such corrective actions or measures as required by AERB for safety.
vi. The licensee shall not undertake any activity beyond those authorised in the licence, without the prior approval of AERB.
vii. The licensee shall report all accidents and events related to safety.
viii. The licensee shall keep AERB informed of the changes in station management positions.
ix. The licensee shall ensure that an adequate level of safety shall be maintained during operation through proper operational and maintenance procedures.
x. The licensee shall establish policies to achieve high standards of safety and promote safety culture in the organisation.
xi. The licensee shall make sure that the organizational structures and training & qualification of the operating personnel are adequate to achieve required level of safety.
xii. The licensee shall make sure that the stated procedures for surveillance, operation, maintenance and emergency planning are up to date and followed.
xiii. The licensee shall make sure that radiation protection of the public and the plant personnel is according to the radiation protection regulation. Radiation doses to the public & plant personnel & radioactive discharges from the NPPs are consistent with the principle of ALARA.
xiv. The licensee shall make sure that after a stoppage mandated by AERB, the cause of stoppage has been resolved to the satisfaction of AERB.
xv. The licensee shall make sure that the conditions for renewal of consent as prescribed by AERB are met.

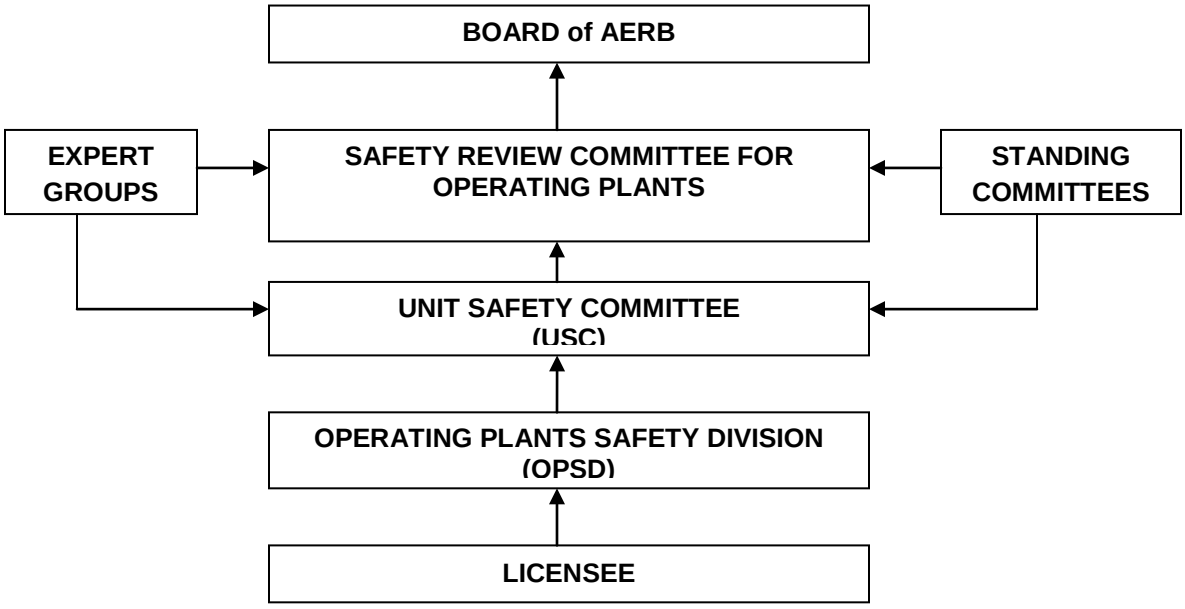
NPCIL Quality Management System elaborated in the document “Corporate Quality Management System Requirements” provide the necessary directives for implementation, maintaining, assessment, measurement and continual improvement of the management system for compliance with the regulatory requirements and intents in all phases of the NPPs. The chapter on Article-13 on Quality Assurance describes the Safety Management System of NPCIL. The chapter on Article-14 describes the assessments and verification of safety carried out within the utility. A typical organisation put in place at an operating NPP to discharge its responsibilities is given in chapter on Article 19 (Operation).

9.3 REGULATORY MECHANISMS TO ASSESS SAFETY PERFORMANCE OF UTILITY

The regulatory control for assurance of safety during all the stages of NPPs is exercised by AERB through a system of consenting, which authorises the specified activity and prescribes requirements and conditions. The AERB prescribes the safety requirements for all stages of NPPs through its regulatory documents, directives and licensing conditions and ensures their compliance by utilities.

For NPPs under construction as well as during operation, AERB monitors safety and ensures compliance with the regulatory requirements by establishing mechanisms of review and assessment, regulatory inspection and enforcement. The licensing process for the NPP is described in detail in Chapter on Article 14 (Assessment and Verification of Safety) of this report. A typical mechanism for regulatory control of an operating NPP is described below:

i. AERB follows a multi-tier review system of safety committees to carry out review and assessment for different stages of consent.
ii. For each operating NPP, the Unit Safety Committee (USC), the Safety Review Committee for Operating Plants (SARCOP) and the Board of AERB constitute the multi tier review organs for regulatory control.
iii. The USC constituted for every station or a group of stations having NPPs built to the same design, assists SARCOP in the review and assessment function to ensure comprehensive safety review on a regular basis.
iv. SARCOP is an executive committee for monitoring the safety status and enforcing the regulatory norms applicable to the NPPs in operation and other associated facilities.
v. SARCOP has also established various Standing Committees and Expert Groups to review and submit its observations and recommendations to USC and SARCOP on the subjects referred to them.
vi. The Operating Plants Safety Division (OPSD) is the nodal agency within AERB for coordinating the functioning of various safety committees and synthesising their decisions.
vii. This system of safety committees function on the principle of "regulation by exception" following a graded approach and are based on principles and requirements laid down by AERB.
viii. The safety issues of greater significance are considered in the higher-level safety committees for resolution. The decisions of these committees concerning major policy issues and important consents require endorsement of the governing Board of AERB.
ix. The multi-tier review mechanism followed for an operating NPP is shown below.



The USC and SARCOP periodically review the safety performance of the respective units to derive assurance that the NPPs are being operated within the conditions specified in the licence for operation and that the overriding priority to safety is the corner stone of the policy of operating organisation. OPSD carries out the periodic regulatory inspection, both announced and unannounced, to verify the compliance of regulatory requirements at NPPs. The areas of review, assessment, regulatory inspections and enforcements are described in chapter on Article 14 (Assessment and Verification of Safety).

9.4 OPENNESS AND TRANSPARENCY

Openness and transparency are two key attributes to achieve confidence of the stakeholders. NPCIL organises press briefings and issues press releases on all important issues and developments, NPCIL is also involved in a number of corporate social activities around the NPP sites. NPCIL also shares information with any member of public on request as a statutory responsibility under Right to information Act, 2005. Also, NPCIL promotes open information system concept for sharing information with the public.

9.4.1 Right to Information

Right to Information Act, 2005 was enacted by the Parliament of Government of India for setting out the practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority. The act was amended suitably by the Parliament with latest revision in the year 2011. NPCIL is a Government of India enterprise and hence the provisions of the act are applicable.

NPCIL being a responsible organisation practices openness and transparency within framework of above and other applicable legal provisions of the country.

9.4.2 Open information system concept

In general NPCIL has web based information system, where the information about NPPs is available. In addition Citizens are free to post questions about NPP and prompt information is provided. Citizens are also free to request visit to any NPP and NPCIL arranges the visit to NPPs and provides necessary information to the visitors with link at web address, http://www.npcil.net/npcil/main/knowmore_Nuclear_Power.aspx.

9.5 INTERNATIONAL PEER REVIEWS

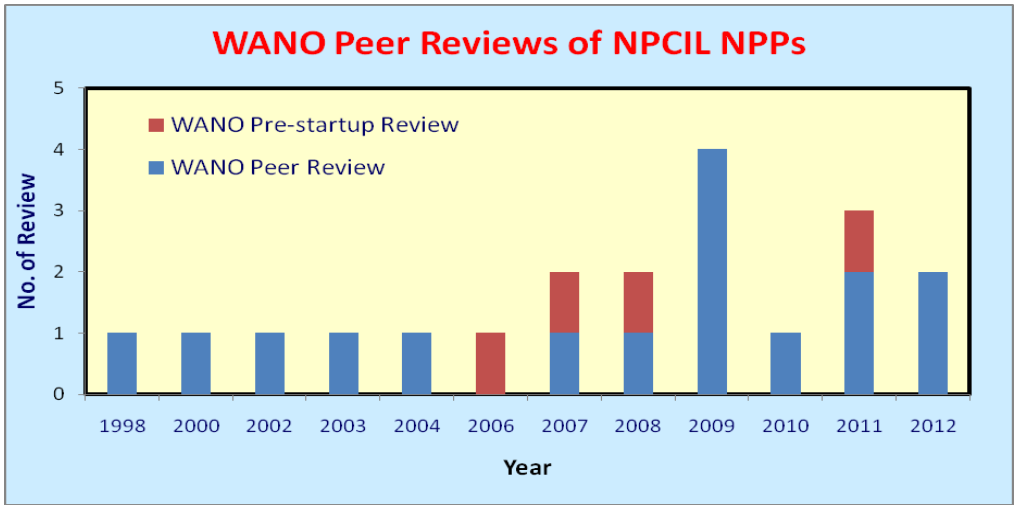
NPCIL is committed to international peer review of all its NPPs to bring home learning opportunities from international peers. The details on such reviews are as follows:

9.5.1 WANO Peer Reviews

NPCIL is one of the founder members of WANO and has been actively participating in all its programmes like Operating Experience, Peer Review, Professional & Technical Development Programme (workshops, seminars) and Technical Support & Exchange of good practices, performance indicators, technical support missions.

Being committed to international peer review programme of all its NPPs, NPCIL first invited WANO Peer Review team in 1998 to one of its plants. Since then, first round of WANO peer review is completed for all the operating NPPs in India and second round is nearing completion. NPCIL was the first member under WANO Tokyo Centre, which invited WANO Pre-Startup Review team for its construction plant in 2006. So far WANO Pre-Startup review of its four plants at construction stage has been completed including KKNPP.

NPCIL has also agreed to the recommendations of a high level commission appointed by WANO Governing board for setting up future directions to strengthen WANO in post Fukushima era. NPCIL has a team of about 75 engineers who have undergone Standard Peer Review Training conducted by WANO. NPCIL has provided the services of about 50 reviewers to WANO to support its Peer Review programme. The bar chart shown below is an indicative of WANO Peer Review and Pre-Start-up Review of NPCIL plants since its first peer review in 1998.



1998	2000	2002	2003	2004	2006	2007	2008	2009	2010	2011	2012
KAPS	NAPS	KGS-1&2	RAPS-3&4	TAPS-1&2	TAPS-3	MAPS RAPP-5	KAPS KGS-4	RAPS-2 RAPS-3&4 TAPS-3&4 NAPS	KGS-1&2	TAPS-1 RAPS-5&6 KK-1	MAPS KGS-3&4

9.5.2 IAEA OSART Mission

Government of India invited IAEA OSART mission in 2012, as per commitment made during IAEA general conference in 2011, for review of Rajasthan Atomic Power Station 3&4 of NPCIL. The OSART mission was completed in November 2012. The OSART team identified a number of good practices of the plant, some of them are as follows:

- The power plant's safety culture cultivates a constructive work environment and a sense of accountability among the power plant personnel, and gives its staff the opportunity to expand skills and training;
- The power plant's Public Awareness Programme provides educational opportunities to the local community about nuclear and radiation safety;
- The power plant has a Management of Training & Authorization system for effective management of training activities;
- The power plant uses testing facilities and mockups to improve the quality of maintenance work and to reduce radiation doses.

The OSART team also made recommendations and suggestions related to areas where operations of Units 3 & 4 of the Rajasthan nuclear power plant (NPP) could be further reinforced. Examples include the following:

- The plant should enhance actions to maintain electrical cable conditions at a high standard;
- The fire doors inspection and maintenance programme should be enhanced to identify and correct fire door function;

- Certain aspects of the plant's surveillance testing programme should be further enhanced; The plant should enhance root-cause analyses to systematically identify all learning opportunities.

A comprehensive action plan for addressing all the identified recommendations and suggestions has been drawn up and the actions will be completed. AERB has also reviewed the OSART recommendation with respect to the existing regulatory process and requirements. A follow-up OSART mission has also been planned in February 2014.

9.6 SHARING INFORMATION INTERNATIONALLY

NPCIL has been sharing information internationally by active participation in operating experience programme of WANO, COG and other international organisations; participation in international meetings and workshops; participation in technical exchange visits.

i. Operating experience

Event sharing under operating experience programme of WANO supports prompt information exchange so as to learn from each other and eliminate recurrence of events. On an average NPCIL shares about 40 events having lessons to be learnt. Following chart demonstrates the sharing of events in the recent past:

Also, a Head Quarter Instruction (HQI), a technical order, has been issued by NPCIL Corporate Office to guide the stations in implementing OE programme. Each station has an Operating Experience Review Committee (OERC) which periodically reviews and discusses the OE information. In addition, there is an Operating Experience Committee at HQ, which reviews events for which root cause is related to design. The implementation status of the OERC recommendations is regularly monitored.

NPCIL fulfils its international obligation of OE sharing and thus promoting global nuclear safety across the world by periodically sending the event reports of its plants to WANO in the standard event reporting formats. These reports bring out the root cause of the events and the lessons learnt which may be useful to other plants.

ii. Performance indicators

NCPIL shares all the performance indicators (PI) data through web based data entry system through WANO with all the operating NPPs of the world. The PI programme provides opportunities to improve safety and reliability of our NPPs. All performance indicators are shared on quarterly basis

with WANO and industry. While NPCIL shares with nuclear industry performance indicators of NPPs, it also utilises this programme for benchmarking the indicators with nuclear industry elsewhere in the world to support long term improvement in safety and reliability.

iii. WANO Meetings, workshops and seminars

NPCIL has been deputing its officials for participating in various workshops, seminars and training courses conducted by WANO. The above programmes provide a forum for exchange of information on wide ranging topics in the field of nuclear power production, its safety and reliability.

iv. Technical Exchange Visits

Technical Exchange visits provide an opportunity to exchange information between various NPPs and WANO helps in establishing the first contact between the host and visiting NPPs. First such exchange visit in the world was from MAPS, Kalpakkam to a plant in Moscow region. Technical agenda of the exchange visit is set with mutual consultation between host plant and visiting plant. Under this programme, NPCIL team of experts has visited several NPPs in countries like South Korea, Argentina, China, Ukraine, Romania, Russia and Canada.

Teams from other countries have also made visits to NPCIL plants. These visits have been very useful as NPCIL teams could discuss various issues related to plant operations, safety and operating experience.

v. Sharing information with CANDU Owners Group (COG)

NPCIL is active member of COG and event reports are shared among PHWR operators providing focused exchange of information. NPCIL is also member of industry team formed by COG post Fukushima.

9.7 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

The responsibility for the design, construction, operation and maintenance of NPP for producing electrical energy in a safe manner has been assigned only to Government Companies. ‘Atomic Energy (Radiation Protection) Rules, 2004’ and the AERB Safety Code, AERB/SC/G, on "Regulation of Nuclear and Radiation Facilities" clearly assigns the responsibility of safety to the licence holder and spells out the obligations of the licensee towards safety. AERB through its multi-tier system of review and assessment ensures that the licensee meets its responsibility towards safety. Hence, India complies with the obligations of the Article 9 of the Convention.

ARTICLE 10: PRIORITY TO SAFETY

Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

10.0 GENERAL

Atomic Energy Regulatory Board (AERB) and the utilities have policies which emphasize priority to safety in all their activities. Adherence to these policies nurtures and maintains the safety culture developed over years of experience. The requirements for a strong safety culture are laid down in AERB codes for quality assurance and operation.

Immediately after the accident at Fukushima (Japan), Hon'ble Prime Minister of India reemphasized that safety of nuclear power plants is a matter of highest priority for the Government and called for safety audits of Indian Nuclear Power Plants (NPPs). Nuclear Power Corporation of India Ltd. (NPCIL) constituted task forces to review safety of NPPs depending on types of reactor designs. These task forces assessed safety of NPPs with postulated scenario of non-availability of offsite & onsite electric power and water supply sources. Plant Managements were asked to conduct walk downs and inspect all important provisions required to withstand flood and fire events. Recommendations arising out of these reviews were included in the Indian National Report to the Second Extra Ordinary Meeting of the Convention. India is also committed to implement IAEA Action Plan on Nuclear Safety.

10.1 REGULATORY REQUIREMENTS TO PRIORITIZE SAFETY

Atomic Energy Act 1962 and the rules framed there under mandate AERB to formulate Safety codes and standards for design, construction and operation of specific equipment, structures, systems and components of NPPs. Safety codes establish the objectives and set minimum requirements that shall be fulfilled to provide adequate assurance for safety.

AERB Safety Code on 'Quality Assurance in Nuclear Power Plants' [AERB/NPP/SC/QA, Rev.1 :2009] provides basic requirements to be adopted for establishing and implementing quality assurance programme for assuring safety and requires that utility management shall promote and support a strong safety culture by:

i. Ensuring a common understanding of the key aspects of the safety culture within the organisation;
ii. Providing the means by which the organisation supports individuals and teams to carry out their tasks safely and successfully, taking into account the interactions between individuals, technology and organisations;
iii. Reinforcing a learning and questioning attitude at all levels of the organisation;
iv. Providing the means by which organisation continually seeks to develop and improve its safety culture.

AERB Safety Code on 'Nuclear Power Plant Operation' [AERB/NPP/SC/O (Rev.1): 2008] which lays down the requirements for safe operation of NPP requires that-

i. The management shall inculcate safety culture in plant personnel and develop a policy which gives safety the utmost priority at the plant, overriding the demands of production.
ii. Training shall be oriented to develop safety consciousness and safety culture at all levels of the plant organisation structure.
iii. The management programmes relating to operation review and audit should aim at ensuring that an appropriate safety consciousness and safety culture prevails.

Utilities comply with the AERB requirements by issuing and adhering to their safety policies and accord the highest priority to safety in all their activities.

10.2 SAFETY POLICIES AND PROGRAMMES

The NPPs in India are designed, constructed, operated and maintained by the fully owned utilities of Government of India. Utilities responsible for design, procurement of manufactured equipment and components, construction, commissioning and operation of NPPs in India, carry out their functions with a commitment to safety and complying to regulatory requirements. Priority to safety is embedded in the corporate mission statement of utilities and each NPP carries out its prime function as per the declared safety policy, covering both nuclear and conventional safety aspects. Well-established safety principles and procedures are adhered to give priority to safety in all its activities. The consultants and contractors that carry out assignments and activities for utilities also follow the safety and quality assurance norms of the utility. Utilities have management systems in place to ensure that safety is accorded priority in its activities.

The management of NPCIL that owns and operates all the currently operating NPPs accords utmost importance to Nuclear, Radiological, Industrial and Environmental Safety overriding the demands of production or project schedules by

- maintaining high standard for safety within plant as well as in the surrounding areas
- ensuring that health, safety and environmental factors are properly assessed for all NPPs
- ensuring that all employees, contractors, transporters working for NPPs adhere to safety requirements while carrying out their responsibilities
- keeping the public at large informed about the safety standards and regulatory practices that are being adopted at NPPs

Each NPP ensures that their work place is safe and their employees including that of contractor's adopt safe working procedures. Individual units also ensure that they have effective on-site and off-site emergency plans, which are implemented and rehearsed periodically so that in the unlikely event of any accident, the impact on the public and environment is minimized. Some of the important activities for implementation of safety policies are

- Setting up targets for safety performance parameters and their periodic monitoring.
- Carrying out safety audits and reviews at different levels viz. Internal, corporate, regulatory and international like WANO peer review and IAEA OSART mission.
- Assessment and enhancement of safety culture.

All Indian NPPs are ISO-14001(Environmental Management System) and IS-18001 (Occupational Health and Safety Management System) certified. At NPCIL Headquarters, Quality Assurance, Engineering, Procurement, Reactor Safety Analysis, Health Safety & Environment, Research & Development, Knowledge Management, and Information Technology Divisions have obtained ISO-9001: 2008 certification. BHAVINI also issued its safety policy in 2005 which gives paramount importance to safety.

For pursuing stated policies, certain general safety principles are followed in all aspects pertaining to NPPs and their regulation. A strong safety culture is developed at the utilities.

10.3 GENERAL SAFETY PRINCIPLES

Nuclear installations are designed and operated by keeping the safety objectives as a priority goal. The Codes, Guides and Standards issued by the AERB are the primary documents detailing principles, requirements, practices and policies for safety in design and operation of NPPs. These Codes, Guides and Standards have evolved over years taking into account experience gained from Indian NPPs, relevant documents issued by IAEA and regulatory bodies of other countries.

The broad concepts of Defence-in-Depth and ALARA are the main guiding principles followed in design and operation of plants.

The Management Systems / Quality Assurance practices as detailed in chapter on Article 13, assure that the safety requirements are implemented and adhered to during design, construction, operation and maintenance.

In general, the safety principles, practices and procedures are adhered to during various phases of NPP and are described in the following sub-sections:

10.3.1 Design, Construction & Commissioning of NPP

All through the process of design, manufacturing, construction and commissioning the QA systems (refer chapter on Article 13) are implemented effectively to assure that safety principles are given highest priority. These processes are indicated below:

i. A thorough and systematic approach is followed in the design, review and approval in line with applicable quality requirements.
ii. Safety design criteria defined in the different design documents are reviewed and approved by AERB. The safety design criteria also take into account feedback from the operating experience. The design is based on National and International codes and guides.
iii. The detailed safety design is presented through design notes, design calculations and drawings. QA procedures are followed for preparation, review and approval of all design documents.
iv. Proper control is exercised for implementing design changes and 'as-built' drawings are maintained.
v. At appropriate stage, plant systems are formally handed over from construction group to operations group. This transfer is systematically documented in the form of construction completion certificates and system transfer docket.
vi. For each system commissioning procedures are prepared to verify design through individual equipment and integrated tests. During commissioning, base line data is collected for future reference. Commissioning reports for each system are prepared and preserved.
vii) For computer based systems, independent verification and validation is carried out as per AERB safety guide Computer based systems of PHWRs (AERB/SG/D-25).

NPCIL Safety Review Committee on design regularly reviews the safety related design documents to ensure that safety principles are adhered to in design. The committee reviews features related to safety in new designs, design changes in already approved safety and safety related systems, the Technical Specifications for Operation which translates the design requirements to safe operating policies, feedback from any safety related event at operating units etc. The reviews also assure that the outcome of regulatory reviews has been effectively considered.

Similarly, IGCAR Safety Review Committee regularly reviews the design safety aspects of PFBR project.

10.3.2 NPP Operation

The NPP operations are governed by safety policies, safety culture and the good operating practices with the following elements:

i. In the normal operation regime, ALARA is the governing principle. Dose limits for normal plant operation are specified by AERB which are in line with ICRP recommendations.
ii. NPP operation is carried out within the limits specified in the Technical Specifications for Operation approved by AERB. Adequate margins between safety limits and operating parameters are maintained by appropriate interlocks and administrative measures. Proper protections are provided against the operating parameters reaching the safety limits.

iii. NPP is operated by only the qualified and licensed staff. The license to operating personnel is issued by following a well established procedure approved by AERB.
iv. Annual Collective radiation dose budgets for normal operation and for special maintenance campaigns are prepared by NPPs and approved by AERB after multi-tier review. As a part of regulatory review, compliance to approved dose budget is ensured.
v. Equipments and instruments are subjected to regular surveillance as per the frequency defined in Technical Specifications for Operation and other governing documents.
vi. In-service inspection is carried out according to the approved ISI document at all NPPs.
vii. NPPs are periodically subjected to corporate safety audit, regulatory inspection and peer reviews.
viii. NPP operation, incidents and safety issues are reviewed by Station Operation Review Committee (SORC) at NPP level. The station management keeps AERB informed of the outcome of these reviews. Submissions made by NPP for regulatory clearances are first reviewed by this committee and then by Safety Review Committee (Operations) at the Corporate office of NPCIL.
ix. For all significant events, root cause analysis is carried out.
x. For non-standard jobs involving safety, special procedures are made and regulatory approval is obtained. Appropriate mock ups are also carried out wherever necessary.
xi. The Station Health Physics Unit maintains a close watch on radiological status and events at plant and submits periodic report to AERB (refer chapter on Article 15).

The QA group and the Technical Audit Engineer at NPP give independent feedback to the station management on operation and maintenance of plant. NPCIL's corporate QA group also conducts periodic audits. Each station is subjected to a corporate peer review conducted by a team constituted by corporate office drawn from other stations owned by NPCIL. This review is carried out once every three years for each NPP. In addition NPCIL stations also undergo WANO peer reviews.

Well-defined procedures exist within NPCIL which address issues related to safe operation. These are detailed below:

i. The normal plant operation is governed by Technical Specifications for Operation, which is approved by AERB. The Limiting Condition of Operation (LCO's) for various systems and their surveillance frequency are a part of the Technical Specification. Protection system actuation set points are defined through Limiting Safety System Settings (LSSS) and the set points are tested as per frequency defined in Technical Specification for operation. In addition Safety Limits are specified in Technical Specifications. Further, fall back actions and countermeasures are also defined in case normal configuration of certain redundant equipment is not met for a predefined limited period. For routine operations, NPPs maintain Operating Procedures cum Check Lists (OPCC), Maintenance Procedures, Operating Instructions, QA Procedures, ISI Procedures etc.
ii. Event based Emergency Operating Procedures (EOPs) for internal and external events are prepared for NPPs. These EOPs are part of control room operator licensing and to the extent practical are implemented on simulators for training purposes. Symptom based EOPs have been prepared and are under implementation.
iii. The Emergency Preparedness and Response Plans for both On-site and Off-site emergencies are available all NPPs. Emergency exercises are carried out routinely to ensure the adequacy of these plans. (refer chapter on Article 16).

10.4 SAFETY PRINCIPLES OF AERB

AERB is entrusted with the responsibility for regulating activities related to safety in nuclear installations. The safety principles followed by AERB are as follows:

i. Permits activities according to the mandate given to it, through a consenting process. AERB stipulates and enforces the conditions of consent.

ii. Develops safety standards, codes and guides taking into account the Indian conditions, requirements for the country, recommendations of international organisations and the best practices of other countries.
iii. Encourages compliance to safety guides but accepts other approaches if safety objectives and requirements can be met.
iv. Adopts the principle of “management by exception” following a graded approach through a system of safety committees where issues of greater safety significance are given consideration in higher-level safety committees for resolution.
v. Encourages self-regulation by the licensee.
vi. Considers licensee as a partner in safety and extends all necessary assistance in the interest of safety, where appropriate.
vii. Invites participation of utilities in the regulatory process.
viii. Conducts periodic inspections of NPPs and channels its resources according to the safety performance of the licensee.
ix. Encourages licensee to achieve high level of safety culture.
x. Learns from the experience feedback and adapts to improve its functioning and effectiveness.
xi. Conducts its activities in an open and transparent manner.

AERB carries out a multi-tier review for the new and operating NPPs through a system of safety review committees (refer chapter on Article 14). The activities of siting, design, construction, commissioning, operation and related regulatory consents follow procedures and policies prioritizing safety.

10.5 SAFETY CULTURE AND ITS DEVELOPMENT

NPCIL is in the process of formalizing safety culture in an HQI with following objectives:

- institutionalizing nuclear safety culture assessment process, which will bring in common understanding and will foster a strong nuclear safety culture
- creating an objective method to measure safety culture

Arrangements for safety management, safety monitoring and self-assessment, independent safety assessments are elaborated in chapter on Article 14 (Assessment and Verification of Safety).

10.6 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Safety is given overriding priority by all organisations engaged in activities directly related to nuclear installation. AERB and utilities have stated safety policies that give utmost priority to nuclear safety. Principles, practices, procedures and the review mechanisms adopted towards meeting the objectives of these policies ensure that the safety is given an overriding priority in all the activities related to safe operation of NPPs. Therefore, India complies with the obligations in the Article 10 of the Convention.

ARTICLE 11: FINANCIAL AND HUMAN RESOURCES

1. **Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.**
2. **Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.**

11.0 GENERAL

This chapter describes 'Financial and Human Resources' of the utilities. The resources of AERB are described in Chapter on Article 8: Regulatory Body.

11.1 FINANCIAL RESOURCES

The Nuclear Power Corporation of India Limited (NPCIL) is a Public Sector Enterprise under the administrative control of the Department of Atomic Energy (DAE) of Government of India. NPCIL was formed in September 1987 by converting the erstwhile Nuclear Power Board, a Central Government department into a government owned corporation in accordance with the provisions of Atomic Energy Act-1962. At the time of formation of NPCIL, all the assets (except the first unit of Rajasthan Atomic Power Station RAPS–1) were taken over by NPCIL. RAPS-1 has been retained as a Government owned unit, being managed by NPCIL on behalf of the Government. The main objective of the company has been to produce electricity using nuclear fuel resources.

NPPs under construction and operation were fully funded by Government of India earlier. The formation of NPCIL facilitated operational flexibility and the ability to borrow capital from the market so that the financial resource base can be increased to step up the nuclear power programme.

NPCIL is a wholly owned company of Government of India and is registered under Indian Companies Act-1956. The company has a fully subscribed and paid up share capital of ₹ 101740 Million. The company has reserves in excess of about ₹ 146260 Million. The gross block of the company at its inception (comprising of TAPS - 1&2, RAPS - 2 and MAPS - 1&2, totaling 960 MW) was only ₹ 4480 Million which has now grown to (4460 MW) about ₹ 217150 Million as on end March 2012. NPCIL is a profit making company and has been paying annual dividends of the order of 20% to 30% to the Government of India.

The financial resources of NPCIL come from budgetary support from Government of India, borrowings from capital market and internal surpluses. NPCIL raises finances for the construction of new projects through a combination of Government budgetary support, market borrowings (in the form of short term and long term debt instruments) and internally generated resources by sale of electricity. In the last 5 years, NPCIL had not availed the budgetary support from government as its internal surplus was sufficient to meet the equity requirements for the ongoing projects. It has adequate internal surplus to take up additional 8000 MW of generation capacity. In case the growth envisaged is higher, then only external infusion of equity will be required. Adequate financial discipline and prudence are exercised in borrowing money from the market. Gestation periods of the projects are progressively optimized so as to keep financing cost including interest during construction, at a reasonable level. Due diligence is exercised about debt obligations and there is no default in repayment of principal and/or interest. The credit rating of NPCIL by agencies like CRISIL, CARE, is AAA denoting the highest safety, which helps the company to borrow money from the capital market at the most competitive rates.

BHAVINI is a fully owned Enterprise of Government of India. Mandate of BHAVINI is to construct, commission and operate the first 500 MWe PFBR at Kalpakkam in Tamil Nadu and follow it up with future Fast Breeder Reactors. The government will finance 76% of the cost of PFBR through equity, 4% equity will come from NPCIL and remaining 20% will be obtained through market borrowings.

11.1.1 Operation and Maintenance

NPCIL, as the owner of NPPs has the absolute obligation to provide adequate finances for operating the nuclear power plants in a safe manner as per the requirements of AERB and its own mission.

NPCIL generates its revenue primarily by sale of electricity. Its present annual revenue is typically `80000 Million. In line with the provisions of the Atomic Energy Act 1962, the tariff for electricity from each station of NPCIL is notified by DAE in consultation with Central Electricity Authority. The parameters such as the capital cost, the market borrowings, input costs are factored into arriving at the various components of tariff.

NPCIL sells its electricity to 21 State Electricity Boards (SEBs) / distribution companies primarily located in Northern, Western and Southern regions of the country. The monthly invoices based on the approved tariff along with the fuel price variation adjustment are raised on State Electricity Companies at the end of the month based on the metering done by the system operator and accounted for by the Regional Power Committee. The State Electricity Companies hold a revolving letter of credit in favour of NPCIL for their monthly power invoices and payments are received during the subsequent month.

The Operation and Maintenance (O&M) expenditure for each station is budgeted every year. It is being funded by internal resources generated by the NPCIL every year. In addition, whenever it is necessary to finance any major works/purchase or replacement of major components, the resources are raised through borrowings or from internal surplus/ budgetary support as appropriate. Since the tariff is similar to the principle of cost plus basis, O&M expenditures are covered through tariff in addition to recovering the capital charges such as giving a return on equity capital and providing depreciation subject to the units operating at normative capacity factors. The internal surpluses are deployed for the nuclear power plants in operation as may be required and for nuclear power projects under construction. The financial resources are budgeted on a yearly basis and in five-year plans. Adequate financial planning and forecasting is done for the complete life of the plant to ensure availability of financial resources throughout the life of the plant. Thus there is no constraint, either existing or foreseen, on financial resources for the safe operation and maintenance of the NPPs.

11.1.2 Renovation and Modernization (R&M)

R&M activities for NPPs in operation are of two types. The first involves routine replacement of operation and safety related components and equipment based on their performance requirements in which expenditure is relatively small. Expenditure on this type is met through the revenue budget of the respective stations and is covered by the tariff as part of O&M expenditure. The second type involves funding for major safety up-gradations in line with the regulatory requirements generally based on a PSR or based on operating experience feedback both national/international events (such as Fukushima) or refurbishment of the major components of the plant because of operation requirements or technological obsolescence (R&M activities are brought out in chapter on Article-6). Such activities involve shut down of reactor for extended periods of time and involve major expenditure.

Recognizing that renovation and modernization activities would entail major expenditure, a renovation and modernization levy of about 5 paise per KWhr was started in the year 1996 primarily with the intent of carrying out the renovation and modernization of older generation reactors. The

money collected through R&M levy was kept in a committed reserve account. R&M levy was started in 1996 and after accumulating adequate reserves, the same was stopped from 1st December 2003. Situation will be reviewed from time to time, taking into account the adequacy of resources available with the corporation. In case, in future, the reserves are found to be inadequate, the consumers of electricity (SEBs) who are already familiar with concept, may be approached for its re introduction.

A holistic analysis on expenditure and resource mobilization in regard to all the units in operation is done at NPCIL Corporate Office by proper financial planning, monitoring and resource mobilization.

11.1.3 Decommissioning and Waste Management

The commercial life of NPP has been taken as 25 years. With improvements in design methodologies and better understanding of safety margins, retrofitting, better materials and equipment, the reactors can now operate safely for much longer periods of 40 to 60 years.

Out of the 20 operating nuclear power reactors, the two boiling water reactors at Tarapur are the oldest. They were commissioned in the year 1969 and have been progressively retrofitted. Similarly, the PHWR based NPPs have been undergoing renovation and modernization programmes. In this connection, En-masse Coolant Channel Replacement (EMCCR) and En-masse Feeder Replacements and necessary safety up-gradations of RAPS-2, MAPS-1&2, NAPS 1&2 and KAPS-1 have been completed as applicable. These major jobs have given a very good insight of technical capabilities and financial requirements for decommissioning.

Realizing the quantum of financial resources that will be required in future for de-commissioning of reactors, a de-commissioning levy at the rate of 2 paise per KWhr is being collected as part of tariff. The present de-commissioning fund appears to be adequate to take care of de-commissioning expenses. The provisions in this regard will be reviewed in future, based on experience and technological development. Tariff of Nuclear Power Plants in India is fixed once in every 5 years. In future the levy could be revised if need arises through such reviews.

Routine radioactive waste management during the operation of the NPPs is included as part of the O&M expenses. Since Indian energy security policy necessitates adoption of the closed nuclear fuel cycle, the fuel is considered as the property of the Government. The spent fuel from the first stage is taken by the Government from NPCIL either for reprocessing or for storage as necessary for the subsequent stages of the programme. The re-processing of spent fuel and the associated waste management are carried out by the Central Government.

11.2 HUMAN RESOURCES

Availability of qualified and trained manpower for the nuclear power programme has been one of the greatest strengths in India. Realizing the importance of qualified and trained manpower, DAE started Human Resource Development programme in early 1950s, well before the launching of nuclear power programme in the country. A training school at Bhabha Atomic Research Centre (BARC) was established in August 1957. University qualified engineers and science graduates were recruited on an annual basis and they were trained in the BARC Training school, a premier institute for training in nuclear science and technology through one-year rigorous training course including theoretical and practical aspects of nuclear engineering and sciences. Subsequently when the training needs for the operating nuclear power stations arose, the Nuclear Training Centres (NTCs) were set up at the NPP sites. The core of the manpower for the nuclear power programme came through these training centres. These personnel had also the benefit of experience in the construction and operation of the research reactors. In addition, experienced manpower from conventional power and industry were inducted. This combination provided the base from which subsequent developments took place.

The country's universities, engineering diploma institutes and industrial training Institutes form the basic educational infrastructure from which engineers/scientists, technicians and skilled tradesmen are recruited and subsequently trained to suit the job needs.

Networking with the Indian Institutes of Technology has been strengthened and post-graduate courses in nuclear engineering have been started at several institutes. Sponsored post-graduate program called 'DAE Graduate Fellowship Scheme' were started at all the IITs. Board of Research in Nuclear Sciences (BRNS) under DAE provides another avenue for networking by sponsoring research projects in the field of Nuclear Science and Engineering at various educational institutes. 'Homi Bhabha National Institute' established under DAE pursues post-graduation and PhD programs in areas of nuclear science and technology.

Dedicated Knowledge Management groups have been set up in all organisations of the DAE to pool and disseminate the available knowledge base and further augment knowledge base to meet the challenges of the future. Engineers and scientists of BARC and NPCIL participate in several international training programmes conducted by the IAEA and other organisations to further enrich their capabilities.

11.2.1 Arrangements and Regulatory Requirements for Human Resources at NPPs

NPCIL's technical manpower includes engineering graduates from prestigious engineering colleges/universities in the country. Freshly recruited engineers go through one year of training in DAE/BARC Training School or in Nuclear Training Centres of NPCIL. After such training, they are placed at NPCIL Corporate Office for functions like design, QA, procurement etc, or construction sites or operating units based on the needs and suitability for the job. While persons appointed at NPCIL Corporate Office are encouraged to do M.Tech / MBA course in their areas of specialization, those at plant sites are regularly/periodically trained for taking up higher responsibilities. They undergo licensing/ qualification examination before they are actually assigned the higher responsibility. In addition, NPCIL also carries out direct recruitment. Engineering diploma holders with 3-4 years of Diploma Course in Engineering (after High School ,10+2) conducted by the polytechnic institutions and tradesmen with two year industrial training after high school, conducted by industrial trade institutes are other levels of recruitment. NPCIL provides challenging work environment and excellent quality of life at its residential colonies. Infrastructure facilities like health, education and transportation are adequately taken care of and recreational facilities are also provided to motivate personnel to continue their career with NPCIL. Off-site support from the NPCIL Corporate Office is provided to NPPs based on requirement. During the past three years NPCIL has recruited 680 Scientific and Technical personnel at various levels and the staff strength of NPCIL as on 31.12.2012 was 11633.

The initial manpower required for construction, commissioning and operation of the Fast Breeder Reactor has been inducted from NPCIL and IGCAR. BHAVINI has also undertaken recruitment of graduate engineers and staff at various grades. IGCAR training centre will cater to training school needs for Fast Reactors. The operation staff is currently in training at FBTR, NPCIL plants and on the commissioning training at PFBR. The qualification and licensing of the staff will be in line with the norms established by AERB for operation of PFBR.

The assessment of the demand for recruitment of the manpower for the projected growth of nuclear power generation capacity generally starts with the clearances obtained for the new projects. It is pertinent to mention that since the nuclear power programme in the country has been a continuous one and the structured recruitment and training programme has always kept pace with the requirement. With the availability of large number of science and technology institutes in the country, the supply constraints are not likely to be faced for the projected growth of the nuclear power programme. In addition to the above, the country also has a large pool of retired experts in nuclear science, whose services are frequently utilised for specific areas of the nuclear power programme.

The regulatory requirements for staffing, qualification, training and retraining of staff for NPPs are given in AERB safety Code, on 'Safety in Nuclear Power Plant in Operation' (AERB/SC/O, Rev.1):

2008 and AERB Safety Guide, on 'Staffing Recruitment, Training, Qualification & Certification of Operating Personnel of NPPs' AERB/SG/O-1. The Radiation Protection Rules (2004) and AERB regulatory documents give the requirements regarding the qualification, training and retraining of personnel working in the radiation areas.

11.2.2 Competence Requirements and Training Needs of NPP Personnel

Detailed procedures for staffing, qualification, training and retraining of staff for NPPs are approved by AERB. The operating station organization of a typical Indian PHWR NPP has six levels (Management Level and Level I to Level V) in five major functions viz. Operation, Maintenance, Quality Assurance, Technical Services and Training functions. Level-I, II &III control room positions are for Shift Charge Engineer (SCE), Assistant Shift Charge Engineer (ASCE) and Control Engineer respectively. These positions for operation and fuel handling operations require licensing through a procedure approved by AERB. Operations personnel normally working in field (levels IV, V) are certified by the plant management. Special training procedures are established and being followed before deputing the contract workers in NPPs.

NPCIL has qualified and trained manpower meeting the job requirements at all levels, be it technicians, supervisors or engineers and scientists. The staff strength of NPCIL as on 31st December 2012 was 11633 out of which 9474 belong to technical and scientific cadre. Competence requirements and training needs of all key persons are ensured before they are deployed for carrying out the safety related activities in nuclear installations

The Corporate Training group focuses on development of trainers and training systems using SAT (Systematic Approach to Training) methodology. Various NTCs implement orientation-training programmes for each category i.e. engineers, supervisors, and technicians, recruited as trainees based on approved recruitment and selection procedure. The course contents and other administrative guidelines for initial and retraining have been established for each category of employee. NTC's are equipped with necessary infrastructure for implementing the courses as per approved syllabi. Based on Job-Task-Analysis, tasks for each position have been defined and a performance oriented checklist against each task is developed for effective assessment of On-Job training. The Corporate Training group is responsible for ensuring uniform standards of training at each training centre by developing guidelines for orientation training programme. For ensuring uniform standards of assessment, licensing examinations are coordinated by the corporate office.

Around 100 training officers are posted in all the training centres to look after the initial induction training, qualification and re-training requirements at stations. Additionally, for imparting training in a specific field / area, experts from stations, as well as other organisations including AERB are invited. The trainers have operation and maintenance experience. Some of the trainers are licensed control room operators who also provide training on simulators.

A total financial resource of approximately 2% of the revenue budget is allocated to all training centres in NPCIL towards training, qualification, re-training and training infrastructure requirement.

11.2.3 Training of Operations Staff

The training and licensing scheme of the operating staff is as per AERB requirement. Presently, NPCIL has six Nuclear Training Centres and two Station Training Centres, where graduate engineers and technicians are trained. NPCIL has full-scope training simulators at RAPS, KGS, TAPS-3&4 and KKNPP. These training simulators provide necessary training to the operating personnel. Symptom based Emergency Operating Procedures are being modelled in these simulators.

11.2.3.1 Induction and Initial Training

This involves verification of completion of entry-level competency requirement to enter certification stage of licensing / qualification.

i. Academic Qualification and Experience

The personnel occupying positions at level I, II and III need to be graduate engineers with relevant work experience of 8, 6 and 3 years respectively. Those who are diploma in engineering can occupy positions at level III and IV after having relevant work experience of 9 and 4 years respectively. Similarly, requirements have been established for personnel occupying level IV & V from other streams of education.

ii. Training

Successful completion of' appropriate Orientation Training programs of 1, 1½ and 2 years duration is an essential entry Level pre-requisite for those entering directly at Level- III, IV & V respectively. Training mainly focuses on providing sound foundation on nuclear reactor fundamentals, a typical station specific equipment and system knowledge, training towards 'nuclear and industrial' safety, radiation protection, radiation emergency preparedness and work controls.

11.2.3.2 Licensing, Qualification and Certification Programme

i. Authorisation Based Training

After completing the initial training, a candidate for acquiring licence at level III and qualification at level IV is required to complete the authorisation based training programs such as Radiation Protection Training , Station Protection Code (SPC) and Electrical Authorisation (as applicable) before taking up final certification examinations.

ii. On Job Training

To gain the job experience, task based checklists are developed for Level – III, IV and V. If a task could not be performed on plant systems/ equipment due to lack of opportunity, alternate methods like performance on simulator or on mock-up or through technical discussions including enactment of the procedure (virtual conduct of the task) is to be deployed. Those due to acquire first time licence at level-III should have acquired minimum of three months of control room experience under supervision after completion of eighteen month on job training and participated in at least one start up / shut down activity at the plant.

iii. Simulator Training

Simulator training mainly provides experiential learning of control room operation. Training is based on the approved guidelines for normal operations i.e. start-ups / shutdowns, handling of anticipated operational occurrences (AOOs) and emergency operating procedures (EOPs) related to main plant. In respect of fuel handling system operations, it provides necessary practice of safe Fuel Handling operation and handling of AOOs. In the absence of plant simulator at a plant, the requirement of simulator training is met by providing training at a simulator located at a plant having similar design.

iv. Licensing / Certification Stage

Licensing examinations for Level-III and II for Main plant / Fuel Handling (FH) operation personnel are conducted under the control of NPCIL Corporate Office. Prior to this, walkthrough for these personnel is conducted under plant management control. The last stage of verification is final assessment interview for medically fit candidates, conducted under AERB control for Level-III, II and I

for main plant, Level-III, and II for FH operation personnel. Qualification process (written examination, walkthrough and final assessment interviews) for Level IV &V is done under plant control.

For the first time licensing, candidate has to satisfy all the entry-level requirements as detailed above before appearing for the written examination for levels III & II. The walkthrough test is conducted when a candidate has qualified in all the applicable written examinations and is applicable for Level-II, III. Through this test, the practical knowledge of the candidate is evaluated by a minimum of three field examiners. The evaluation process covers various phases of plant/systems operation covered in the 'walk through' checklist to provide assessment for the candidate's physical, practical and procedural knowledge of Systems, Structure and Components of NPPs.

Medical fitness tests as per approved guidelines are conducted for all candidates appearing for licensing, as a pre-requisite for the final assessment interview.

A candidate after successfully completing the pre-requisites of licensing procedure appears before the Final Assessment Committee. Final Assessment for level–I, II & III position is conducted by a committee constituted by AERB and based on their performance the candidate is licensed for the given position. For Level IV & V position, this task is performed by a Committee constituted by NPCIL.

v. Certification

The personnel occupying level-IV & V positions in control room are certified by the plant management and the process of certification is performed under its control.

vi. Management Training for level-1 position

This is an essential entry level pre-requisite for Level-I candidates only and a candidate for Level-I has to successfully complete the 'Management Training' programs such as Codes and Guides of regulatory body, Quality Assurance aspects of NPP Operation, Safety culture, Operation Management, Personnel Management, Procedural knowledge related to administration and finance, vigilance and security aspects.

vii.Senior Management Qualification

Senior Management Qualification is covered under specific instructions issued by NPCIL for meeting the regulatory requirements. The aim of this qualification is to assess candidates through written examinations and interviews for their technical knowledge and overview of safety management. AERB qualifies the successful candidate after a final assessment interview conducted by its committee. The management structure at the NPP is included in the Technical specifications for operation approved by AERB. Accordingly any change in management structure has to be reviewed and approved by AERB.

11.2.3.3 Re-training/Re-Licensing Process

i.Re-training Process

This is applicable for all licensed positions as a pre-requisite for Re-licensing**.** The retraining duration for licensed positions is at least four weeks per year during the validity of licence. During re-training, efforts are made to train the entire crew together as a team on simulator exercises. The course content covers refresher of fundamentals and safety practices, modifications made in the plants and procedures, Root Cause Analysis, Safety Analysis, good practices and EOPs and simulator retraining/ alternate retraining in lieu of simulator retraining.

ii. Re-Qualification Process

A licence / qualification is valid for three years. A candidate needs to be re-licensed/ re-qualified before the last date of validity of the licence/ qualification. A person licensed for a particular position can be re-licensed to the same position provided he meets the prerequisites such as medical

fitness, Electrical Authorisation and mandatory re-training programs as applicable and is found fit by the final assessment committee.

iii. Re-authorisation Process

Persons absent from the licensed position duty continuously for more than one month are re-authorized after a formal assessment to ensure that they are updated with plant specific changes introduced during the absence with respect to plant modifications, procedural changes, and incidents/events etc.

11.2.4 Plant Simulators

Each Nuclear Power Plant has a training centre. The training centre can be either a Station Training Centre (STC), which is for captive use of the station for plant specific training, or a Nuclear Training Centre (NTC), which has a STC plus a centralized nuclear orientation school for induction training as well as advanced training facility such as simulator. These training centres conduct approved training programmes under supervision of corporate training group of NPCIL.

At present, there are four full-scope simulators located at RAPS-1&2, RAPS-3&4, KGS and TAPS-3&4. The simulator at RAPS-1&2 caters to imparting training for personnel working in old plants i.e. RAPS-1&2 and MAPS, while the other simulators at RAPS-3 & 4 and KGS site are based on the design of standardised 220 MWe reactors and cater to the requirements of all the other 220 MWe PHWRs. The fourth located at TAPS-3&4, is based on the design of 540 MWe PHWR. VVER based simulator has been commissioned and in operation at KKNPP site to take care of the training requirements of 1000 MWe reactors of VVER design. With these simulators, NPCIL is able to provide simulator training to all the operating personnel working in NPPs. In addition, there are three soft panel based Fuel Handling System (FHS) simulators at KGS, RAPS-3&4 and TAPS-3&4 for imparting training in Fuel handling operations.

These simulators are capable of providing training covering normal operations i.e. start-ups / shutdowns and handling of “Anticipated Operational Occurrences” (AOOs) and Emergency Operating Procedures (EOPs) related to Main Plant. In respect of Fuel Handling System operations, it provides necessary practice of safe Fuel Handling operation and handling of AOOs.

To ensure effective simulator training, dedicated trainers who are required to maintain their supervisory license (level-II) are deployed to ensure maintenance and effective utilization of the simulator for achieving optimum training.

11.2.5 Training of Maintenance and Technical Support Staff

NPCIL has qualified and trained manpower meeting the job requirements at all levels, be it technicians, supervisors or engineers and scientists. Competence requirements and training needs of all key persons are ensured before they are deployed for carrying out the safety related activities in nuclear installations.

Arrangement for initial training, qualification and retraining of maintenance and technical support staff also exists at all NPPs in line with operation staff. By ensuring the maintenance of operational licence and qualification of personnel deployed in Technical Services, Training and Quality Assurance sections their rotations have become feasible.

11.2.6 Improvements to Training Programmes

NPCIL regularly organises special training programmes for experienced operation engineers conducted by international organisations like WANO on a variety of topics such as “Operations Decision Making”, “Advanced Simulator Instructor Training”, “Training Effectiveness and its Evaluation” etc and also provided them opportunity to interact with their peers working in NPPs

abroad. Within the organization, workshops are organized to share operating experiences e.g. “Just-In-Time” type operating experiences etc.

Training centres at all NPPs conduct regular training courses and refreshers courses to cover new insights from safety analysis, operating experience, industrial/fire safety, radiological safety and regulatory issues etc to maintain the personnel competency. Only qualified and licensed trainers along with line managers and experienced operation engineers are maximally utilised to impart training to fresh and experienced operations persons to provide insights to safety analysis and operating experience.

Updated e-training manuals ensure that licensed personnel have easy and assured access of these manuals any time they desire. The training centres are equipped with various mock ups and training aids such as cut-away-view of complex mechanisms e.g. Fuelling machine ram assemblies, separator assemblies, breakers of various types, Control valves etc. Computer based training packages (mostly in-house) are utilized to promote understanding of difficult dynamic devices.

11.2.7 Sufficiency of Staff at Nuclear Installations

Key personnel for O&M are identified and located prior to commencing commissioning operation and the full staff strength is progressively built up. O&M personnel gain valuable experience during commissioning of the Unit. Recruitment, Training and Qualification processes proceed in a planned manner so that the required complement of trained and qualified staff stipulated by AERB guide “Staffing, Recruitment, Training, Qualification and Certification of Operating Personnel of Nuclear Power Plants” (AERB/SG/O-1: 1999) is in position prior to start-up of the unit.

Minimum staff requirements are met as a part of Limiting Conditions of Operation (Technical Specifications for Operation) and any non-compliance may attract the regulatory enforcement. In addition, there is administrative control regarding the number of Senior Managers to be present at site to ensure safety of NPPs.

11.2.8 Use of Contract Personnel

The contractors’ competencies to meet desired task /work requirement is evaluated during pre qualification of a contractor/vendor agency after which only the agency becomes eligible for submitting tenders documents/offers. Some of the attributes considered for pre qualification are technical capability, financial status, resources (Man & Machine/Infrastructure back up), Quality assurance organization, safety organization, ISO certification etc. Feedback regarding credentials, past work experience and in-house design capability is also obtained for assessment of contractor’s competency.

Contractor’s personnel are not allowed to carry out any jobs without departmental supervision. They are not deployed for carrying out any operations in the control room and vital areas.

Contract personnel have appropriate training and instructions in radiation safety as per the Atomic Energy Radiation Protection Rules (RPR, 2004) in addition to the appropriate qualification and training required for performing their intended tasks.

11.2.9 Regulatory Review and Control Activities

The training procedure and programmes are subjected to audit by NPCIL corporate office as well as by AERB for verification of adherence to the procedures. For each training & qualification related activity, NPCIL has developed standards/ guidelines in consultation with AERB so as to meet the regulatory standards. Training & retraining, licensing & re-licensing, qualification & re-qualification of the plant personnel are carried out in accordance with the procedures approved by AERB and are described in section 11.2.3 above.

Plant managers also have to acquire management certification based on AERB approved guidelines. The licensing procedure prepared based on regulatory documents provides various standards including the methodology to deal with the exceptions, assumptions etc. The checklists are always kept current through periodic revision.

To facilitate effective re-training to the licensed engineers, as per the regulatory requirement, availability of six crews for shift operation at each station is ensured. This provides uninterrupted opportunity for one crew to undergo training at respective training centres.

11.3 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

From the information provided above in this Article, it is evident that adequate financial resources are available to support the safety of each nuclear installation throughout its life. There is a well-developed system to assess the needs, generate and provide financial resources. The performance of the NPPs, operating base, centralized management, tariff mechanism, credit worthiness of the utility, etc are factors strongly in favour of meeting the obligations of this Article. With regard to human resources, an early start well ahead of the launching of the nuclear power programme has enabled a sound framework to be in place. This apart, systematic development has also been carried out over the years through experience and the evolving needs. The requirements stipulated by AERB through its Codes are quite exhaustive. This has been followed up by the Utility through its own systems and procedures. The necessary training infrastructure has been built to meet the needs. Therefore India complies with the obligations of Article 11 of the Convention.

ARTICLE 12: HUMAN FACTORS

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

12.0 GENERAL

Human factors are considered during design, construction, commissioning and operation of NPPs to ensure that the capabilities and the limitations of human performance are taken into account.

12.1 REGULATORY REQUIREMENTS

AERB Code of Practice on Design for Safety in PHWR based NPPs, AERB/SC/D (Rev.1, 2009) establishes the requirement for design for optimised operator performance. This includes the need for designing working areas and environment according to ergonomic principles and a systematic consideration of human factors and the man-machine interface. Several design safety guides issued under the Code viz. Safety Related Instrumentation and Control for Pressurised Heavy Water Reactor Based Nuclear Power Plants (AERB/SG/D-20) and Radiation Protection in Design (AERB/SG/D-12) provide guidance regarding design for optimum human performance. AERB safety code on operations (AERB/SC/O) gives requirements to reduce the human errors. AERB document on 'Human reliability analysis (methods, data and event studies) for NPPs' (AERB/NPP/TD/O-2) provides various methods and illustrative examples for estimation of human error probabilities for PSA studies.

Organizational factors and managerial aspects have a major impact on the behaviour of individuals. AERB code on quality assurance in NPPs (AERB/SC/QA, Rev1, 2009) covers the managerial commitment to improve human factors to enhance the safety in NPPs. It requires that management shall determine the competence requirements for individuals at all levels and shall provide training or take other actions to achieve the required level of competence.

12.2 HUMAN FACTOR CONSIDERATIONS

12.2.1 Design

The design of systems, structures and components and the plant layout is carried out in accordance with the applicable design codes and guides as stipulated by AERB and prevalent international practices. The design is aimed at limiting the effects of human errors during normal operating conditions, transients and during maintenance. The man-machine interface is designed to provide the operators with comprehensive and easily manageable information. Wherever operator actions are required, it is ensured that required information and adequate time are available for taking necessary actions. PSA insights are used to identify situations where human error could have significant contribution to CDF and the efforts are made to reduce them by introducing appropriate design changes. The control panels are ergonomically designed. Working areas are designed with due consideration for personnel comfort to avoid the human errors. Availability of a training simulator is a mandatory regulatory requirement for licensing of NPP.

Human factors are considered during the design modification as a part of configuration management. Necessary changes in the relevant documents, training and O&M procedures are carried out after every modification.

12.2.2 Operation

The units are operated within the limits specified in the technical specifications. To ensure a high degree of quality in operation of an NPP, all control room operators are graduate engineers who are trained and licensed as per the licensing procedures approved by AERB. All activities including surveillance testing are performed using approved procedures to minimize errors due to human factors. All operations in the control room as well as in the field are carried out only after adequate pre-job briefing and planning. NPCIL establishes plant configuration control procedures to prevent human errors during outage management, maintenance and implementation of engineering changes. Post job debriefing is done for certain types of jobs to identify the areas of improvement with respect to best practices and taking appropriate actions for enhancing human performance.

12.2.3 Training

Training of staff for normal and abnormal operating conditions on full scope simulator is a mandatory regulatory requirement for their licensing. The simulator training focuses on reinforcement of expected behaviours like adherence to procedures and use of tools to prevent human errors like window alarm response sheets, pre-job briefing, three way communication, peer check, self check and control room team building to minimize probable errors due to human factors. Performances based training, need based training and training at manufacturers place is also imparted for error free maintenance. Human response studies have been initiated on plant simulators at KGS-1&2, RAPS-3&4 and TAPS-3&4. Human reliability experiments on crew response to plant transients & accident scenarios and the recording of respective timelines for PSA studies has been regularised as a part of crew training program.

Special training courses are also arranged for all the concerned personnel on the design changes that are carried out. Training sessions relevant to human performance are also organized at different plants in coordination with international organisations like WANO.

Training of the NPP staff is described in detail in chapter on Article 11: Financial and Human resources.

12.2.4 Event Analysis

An event reporting system is adopted and maintained to report events of varied significance to bring out underlying weaknesses in the system. All the events including low-level events are reported and analysed at various levels in NPCIL. The Significant Event Reports (SERs) are also reviewed in AERB. During these reviews due consideration is given to aspects related to human performance. The lessons learnt and corrective actions taken are disseminated through an operating experience feedback system. The weaknesses and areas of concern including safety culture highlighted by the event analysis are specifically addressed during training /retraining of the operation staff. The event reporting and analysis is carried out at station as per the guidelines given in the Head Quarter Instructions on "Event reporting to headquarters including SER for sending to WANO, review and processing" (No. 0303 R-2, Issue-1, May 2013) and on "Root cause analysis of the events" (No. 0549 R-0, Issue-1)

The low level event management programmes are implemented at NPPs as per the guidelines given in Head Quarter Instruction no. 0534 (Revision-2, Issue-1, April 2013). As per these guidelines, the low level events, which are large in numbers, are monitored and trended for identifying latent weaknesses. The remedial measures are implemented by way of design modifications, procedural changes or through specific training modules.

12.2.5 Maintenance

Performance monitoring of maintenance activities with respect to the human factors is carried out on a regular basis. Maintenance activities are carried out adhering to the approved procedures

with appropriate stop points to ensure trouble free operation. Use of appropriate tools like training on mock-up facilities, pre-job briefing, three way communication, peer checking, self check, Stop Think Act Review (STAR) principles are inculcated to minimize probable errors due to human factors. Post job de-briefing is done for certain types of jobs to identify the areas of improvement with respect to best practices and taking appropriate actions for enhancing human performance. Easy maintainability, ambient conditions and access to the equipment for carrying out the maintenance are considered during design stage for better human performance.

Human performance enhancement programme is implemented at NPPs as per the guidelines given in NPCIL Head Quarter Instruction no. 0550 (Revision-0, Issue-1, July 2011).

On the request of the NPPs, Technical Support Missions (TSM) are conducted with the cooperation of WANO on human performance aspects with the aim of improving the human performance programme. Since year 2009, three WANO TSMs have been carried out on human performance related issues and two WANO TSMs have been carried out on self assessment.

12.3 SELF-ASSESSMENT OF MANAGERIAL AND ORGANIZATIONAL ISSUES

Self-Assessment and Corrective Action Program has been implemented in all the NPPs with the objective of continuous improvement in equipment condition, plant performance, work practices and safety culture. Human performance, managerial and organizational aspects have been adequately emphasized in the process of self-assessment. The self assessment programme is periodically reviewed considering the operating experience and international feedback on such programmes and headquarter instruction is suitably revised. The following peer-assessment activities are carried out at NPPs:

i. Corporate Peer Review of NPPs

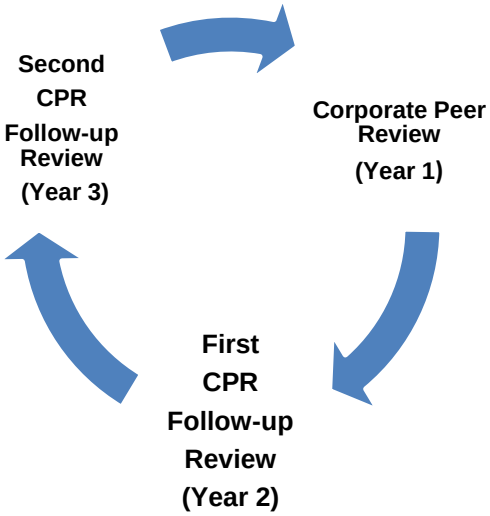
Corporate Peer Review (CPR) of NPPs is performed once in three years by a team of experts constituted by NPCIL headquarters for duration of 9 days. The review is carried out as per Head Quarter Instruction (HQI) no. 0535 (Revision-2, Issue -1, May 2013). Most of the team members are qualified reviewers and have attended WANO Peer Review Standard training. Some of the team members have WANO peer review experience also. This review is performed based on the document “Corporate Review – Performance Objectives & Criteria, Revision-0, June 2006”, which is similar to the document “WANO Peer Review Performance Objectives & Criteria”. The team reviews eleven main functional areas and seven cross functional areas and submits its report to plant management and the corporate office. Team leader of the corporate review team makes a detailed presentation in the Apex Committee for Review of Operating Station Safety (ACROSS) meeting. The concerned Station Director briefs about the actions taken on the observations of the corporate review team. The status of corrective actions implemented by the station is submitted to headquarters which is further reviewed by the apex committee at headquarters.

All NPPs have developed comprehensive corrective action programme to address issues identified during the above self assessment activities, review and analysis of low level events, near misses, events and significant events. These issues are discussed, prioritized, agency for taking corrective actions identified and due date for taking corrective actions are decided. Subsequently, these issues are entered into the corrective action programme of the station. Status of corrective action is periodically discussed in the meeting to ensure their timely completion. An action taken report is sent to HQ on the issues identified during the corporate review. Implementation status of the issues identified in corporate review is also tracked by ACROSS.

ii. Corporate Peer Review Follow-up

Each Corporate Peer Review is followed by two CPR Follow-up Reviews in the next two years; First Follow-up Review (FFR) in the second year and Second Follow-up Review (SFR) in the third

year. Thus, in a cycle of three years, there is one CPR, one FFR and one SFR as shown in the sketch below:



FFR and SFR is done based on the document "Corporate Review – Performance Objectives and Criteria (Rev-0, June 2006)". The team is constituted by Station Director of the respective NPP drawing experienced reviewers from the host plant. Some team members are taken from headquarters and other NPPs. The duration of FFR and SFR each is 6 days. After the review, the NPPs submit the Action Taken Report on the observations made during the FFR and SFR to ACROSS.

iii. Routine Self Assessment

Routine self-assessments include work space inspections or observations, communications with workers to ensure that expectations are understood properly, identification of performance weaknesses, review, analysis and trending of important operating parameters, review of deficiency reports and low level event reports, event investigation, outage/post job critiques, system/equipment inspections & document review, practice of industrial safety & fire protection, evaluation of plant & external operating experience and periodic management review of performance.

iv. Safety Culture

The management of all NPPs prepare a list of safety culture indicators applicable to their site. The plant management is also required to carry out assessment of safety culture through written questionnaire, interviews and audit activities. The assessment is used to identify good practices and areas for improvements. The aspects related to safety culture are also assessed in the Corporate Peer Review and WANO Peer Review programmes. NPCIL has hosted WANO Technical Support Mission for strengthening the existing programmes for improving safety culture.

12.4 EXPERIENCE FEEDBACK ON HUMAN FACTORS AND ORGANIZATIONAL ISSUES

An NPCIL Head Quarter Instruction (HQI) no. 0540 (Revision-1 , Issue-1, April 2013) provides guidance to plant management for the implementation of a structured operating experience programme (please refer sections 19.6 & 19.7). This helps in identifying further issues and areas related to human factors. To address such issues, suitable training programmes are developed and organized viz. training program on team building, root cause analysis and human performance enhancement. Refresher training programs for operation and maintenance personnel are organized periodically by training centres at respective NPPs.

12.5 REGULATORY REVIEW AND CONTROL ACTIVITIES

AERB has specified the requirement for addressing aspects relating to human performance in the design of NPPs. These topics form one of the important areas of regulatory review and assessment. During operation phase, AERB establishes a multi-tier system for regular monitoring of safety at NPPs. Events, design modifications for systems important to safety, operational performance and radiological performance are also reviewed as they have close relationship with human factors. Human factor, which is one of the safety factors of PSR is assessed periodically.

12.6 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Human factors are given adequate consideration during design and operation of NPPs. Training and retraining of operating personnel, use of simulators, lessons learnt from the events, maintaining a stress free working and living environment, operational feedback and regulatory control have been adequately established. Hence, India complies with the obligations of Article 12 of the Convention.

ARTICLE 13: QUALITY ASSURANCE

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied in each stage of the life of nuclear power plant such as siting, design, construction, commissioning, operation and de-commissioning.

13.1 ARRANGEMENTS AND REGULATORY REQUIREMENTS FOR QUALITY ASSURANCE

Quality Assurance Programme in India has evolved and is continually improved following National Standards and Codes of practices, which are in line with International Standards and Codes of practices followed in the Nuclear industry. The AERB Code of Practice on 'Quality Assurance in Nuclear Power Plants (NPPs)' AERB/NPP/SC/QA (Rev. 1), 2009 provides the basic requirements for establishment, implementation and continual improvement of QA programme for all stages of the nuclear power plant viz. siting, design, construction, commissioning, operation and decommissioning. Several safety guides issued under the Code provide guidance to achieve the objectives envisaged in the Code. The AERB code makes extensive use of IAEA safety standards GS-R-3, on 'The Management Systems for Facilities and Activities' among other documents on the subject. The code includes requirements on resource management, configuration management, infrastructure and work environment, safety culture, management commitment, communication, managing organizational change, development of process and its management and assessment and improvement of QA programme. The review and assessment carried out by the AERB during these stages of consenting/licensing considers applicant's QA management system, which has been described in chapter on Article-14 on Assessment and Verification of Safety.

Requirements of NPCIL quality management system are given in NPCIL document "Corporate Management System - Quality Management System Requirements". The document emphasises on integrated approach for the management system for Safety, Health, Environment, Security, and Quality requirements. The document is based on AERB codes and guides, IAEA Safety Standard GS-G-3.1 on "Application of Management System for Facilities and Activities" ISO standards and other relevant documents. BHAVINI also has issued its quality policy and maintains an effective quality management programme.

The following paragraphs provide the summary of the corporate management system as established and maintained in NPCIL. Similar practices are being followed at BHAVINI.

13.2 QUALITY ASSURANCE POLICIES AND MANAGEMENT SYSTEMS

13.2.1 Organisational Policies:

The Head of the NPCIL has issued the "Statement of Policy and Authority" for the Organisation. The statement directs that a management system for Quality in the various phases of the NPPs viz. Siting, Design and Development, Procurement, Manufacture, Construction, Commissioning, Operation and de-commissioning be adopted so that the safety of the NPPs, plant personnel and public is assured. In the said statement sufficient authority has been delegated to the Heads of functional wings for ensuring implementation, maintenance and continual improvement of the Management System at all time.

13.2.2 Quality Management System:

The 'Integrated Quality Management System' elaborated in the "Corporate Management System Document-Quality Management System Requirements" of the NPCIL ensures implementation

of the applicable AERB codes and guides. These documents provide the necessary directives for implementation, maintaining, assessment, measurement and continual improvement of the management system for compliance with the regulatory requirements and intents in all stages of the NPPs.

The document has been implemented since last six years. Departments at NPCIL HQ responsible for engineering, procurement, safety and quality assurance functions have been subjected to ISO 9001: 2008 certifications. Similar controls are exercised on vendors and contractors.

13.2.3 Documentation:

The policies, management system requirements, authority, responsibilities, procedures, work instructions, reports, processes, activities, data and records and other relevant supporting information describing management of the work, performance and assessment are duly documented and controlled. These documents reflect the characteristics of the processes, activities and their interactions. The documents are categorised into three levels as follows.

i. First Tier Document.

This is the "Corporate Management System" document of the NPCIL describing policy statement, management system, organisation structure and functional responsibilities, accountabilities, levels of authority and processes. This document further defines the interfacing and integration of the various processes and activities.

ii. Second Tier Document

This document derives directives from the 1st tier Corporate Management System Document and consists of Management System Manuals and all other related documents translating the corporate policies and commitments to practices and details.

iii. Third Tier Documents.

These documents consist of Quality Management/Assurance System Manuals, Procedures, Instructions and Practices of the vendors and contractors of NPCIL to the extent they are relevant in meeting the Corporate Management System Programme.

13.2.4 Process Management

The processes needed to achieve the mission and objectives of the NPCIL are duly identified. These processes are planned, developed, implemented, assessed and continually improved for delivering the products in accordance with the requirements of the Management Systems. The management processes are assessed for integrating the effect of technical, safety, health, environment, security, quality and financial performances, monitoring achievement of the objectives and effectiveness, and taking corrective measures where required.

Processes and activities involved in siting, design, procurement, manufacture, construction, operations, de-commissioning and all other supporting processes are duly documented. Process requirements, sequence and interaction of processes and activities, criteria and methods needed for implementation and control, process inputs and outputs are specified, and their effectiveness is ensured, Interfaces and activities of various functional directorates are planned, managed, effectively communicated to groups and individual concerned for the specific processes, responsibilities assigned and implemented.

13.2.5 Graded Approach

It is recognised that Systems, Structures and Components (SSCs), processes and services are required to be of specified quality consistent with their importance to safety and use to which they are to be put, and accordingly classified and graded. Management System Programme has provision for such graded approach for different processes, items and services.

13.2.6 Document Control

Personnel preparing, revising, reviewing and approving the documents are specifically authorised for the work and provided with all the relevant information and resources. All relevant documents and records generated in the various phases of NPPs are duly controlled and maintained.

13.3 QUALITY ASSURANCE PROGRAMME

13.3.1 Organisation and Responsibilities

i. Organisation

The NPCIL is managed by a Board of Directors, headed by the Chairman and Managing Director (CMD). The CMD is responsible for all technical, financial and administrative functions and is assisted by the designated Technical, Financial, Administrative and other Functional Heads.

The Functional Heads are assisted by qualified personnel to perform the assigned functions, activities and applicable processes, for establishing, implementing and maintaining the Quality Management System elements in their respective areas of responsibilities.

ii. Responsibilities

“Statement of Policy and Responsibility” as defined by the NPCIL CMD, promotes a culture of conformance with the statutory and regulatory requirements, stakeholders satisfaction, continual improvement and other requirements as elaborated in the corporate level document. The Functional and Unit Heads are responsible for managing, performing and controlling activities and processes to ensure that the products supplied and the services rendered meet the specified requirements. Functional Heads are also responsible for ensuring that the authorised personnel performing the functions are well aware of the organisational objectives, and provide requisite support to the degree necessary in achieving these objectives.

iii. Interface Arrangements

Functional interfacing and cross-functional integration of core processes i.e. Siting, Design, Procurement, Manufacture, Construction, Commissioning, Operations and de-commissioning and also the supporting processes are implemented in a coherent manner to meet the necessary agreed arrangements and responsibilities.

iv. Resource Management

Resources viz. personnel, infrastructure, work environment, information, communication, suppliers and partners, materials and finance essential for the implementation and strategy of the NPCIL mission and objectives are identified, supplied, maintained and improved for ensuring efficient and effective performance.

Requisite human and financial resources are provided for developing, implementing and maintaining the stated competencies in achieving the stated mission of the Utility. For this

purpose suitably skilled, qualified and authorised task performers are deployed, skills continuously upgraded by suitable training processes, thus enhancing their competence level.

13.3.2 Quality Assurance in Siting

The details of siting phases are described in Siting QA manual prepared by NPCIL. The QA in siting is ensured at different stages, namely, Site Selection, Site evaluation and Site confirmation. Site Selection is carried out by committee appointed by DAE and includes experts from NPCIL. For Site evaluation and Site confirmation of newly approved NPP sites a composite group is formed by CMD, NPCIL. The group is assigned with the responsibility of various pre-project activities.

Site evaluation includes data collection, actual site investigation, detailed site evaluation and analysis of site related characteristics important to safety such as seismicity, metrology, geology, hydrology as well as human activity in the vicinity of site, etc. Site confirmation includes confirmation of compliance with the requirements specified in regulatory codes, guides and MOEF notification. Siting activities are executed through reputed contractors/ Government approved agencies/ expert specialised agencies following approved procedures.

13.3.3 Quality Assurance in Design and Development

Design and development processes and activities are performed following the Quality Management System Manual of Engineering Directorate of the NPCIL developed in line with the 'Corporate Management System Document'. Engineering Directorate is responsible for design, development and engineering activities undertaken by the NPCIL. Design from concept to completion is undertaken, reviewed, evaluated, analysed and validated.

13.3.4 Quality Assurance in Procurement

Procurement Directorate is responsible for procurement of SSCs for NPPs. The Directorate establishes and implements procurement management processes, consistent with the requirements stated in "Corporate Management System Document". The objective of implementing Management Systems in procurement is to ensure that procurement of SSCs is made from duly qualified and approved Suppliers, and that they meet the applicable regulatory, statutory and other stated requirements specified in the Procurement Document(s).

13.3.5 Quality Assurance in Manufacturing

Quality Management System during manufacturing assures that stated requirements for manufacturing process of SSCs are complied. It is the responsibility of each organisation participating in the manufacture and supply of SSCs to establish and implement Quality Management System Programme so that the product meets the design intent. The Manufacturers shall also maintain the documentation, as per the Quality Management System, throughout the lifetime of the product.

Manufacturers supplying SSCs for the NPCIL are responsible for the Quality Management processes at their supplier's premises also. The NPCIL monitors the supplier's Quality Management System Programme by the established verification processes.

The NPCIL or their authorised representative(s), have access to relevant areas where work involving the concerned contract/purchase order is in progress for carrying out quality surveillance. This includes access necessary to verify implementation of all aspects of the Quality Management System / Quality Assurance Programme, products and to their supplier's premises also.

13.3.6 Quality Assurance during Construction

Quality Management Systems are elaborated in the respective project level document derived from the 1st tier corporate level document for Construction of the NPP, to ensure that civil works, erection, installation and associated testing of Reactor, Piping, Mechanical, Electrical and Control and Instrumentation systems, and SSCs are carried out safely and meeting the specified requirements.

The Head of the NPP construction site is responsible for establishing and implementing the Management systems during project construction. He is duly supported by independent groups headed by competent personnel for the civil, mechanical, reactor, electrical, piping, control and instrumentation works and auxiliary systems. Independent Field Engineering and Quality Assurance Groups are also set up for overseeing design and quality aspects respectively during the construction phase.

13.3.7 Quality Assurance in Commissioning

Commissioning activities commence after completion of respective construction activities. The transfer of responsibility from construction to commissioning is documented through Construction Completion Certificate (CCC) and System Transfer Documents (STDs). All commissioning work is systematically planned, accomplished and documented. Quality Management system implemented during commissioning assures commissioning is performed as per the approved procedures. The verification confirms that the acceptance criteria specified in the applicable documents are met and deficiencies, if any, are corrected. For this purpose inspection and conformity checking is done to verify compliance. All specific or general deficiencies are identified, documented, investigated and closed. All corrective and preventive actions as required are implemented on due analysis of non-conformances / potential non-conformances.

13.3.8 Quality Assurance during Operation

Quality Management Systems implemented during operation assure that the NPPs together with its components and systems are operated safely, in accordance with the design intent and within the specified operational limits and conditions as stipulated in the technical specifications. Head of the Directorate of Operations at the corporate level is responsible for the operating plants. Plant Management at each NPP is headed by a Station Director (SD) reporting to the Head of Operations at Corporate level. SD is responsible for establishing, implementing and effectiveness of the Management system Programme for safe operation of the station. He has the overall responsibility for safe operation of the plant, in implementing all relevant requirements, instructions and procedures laid down by the NPCIL, AERB and Statutory Bodies. Responsibilities and authorities of plant management and functional positions have been stated in the Station Policies for each station. The QA group at NPP is responsible for inspection, testing, quality control, surveillance, verification, auditing, carrying out ISI, monitoring and assessing the effectiveness of QMS and its improvement, for all activities of station operation and following NPP Station QMS Document.

13.4 IMPLEMENTING AND ASSESSING QUALITY ASSURANCE PROGRAMMES

The Management System of the NPCIL has the requisite processes and systems to monitor and measure levels of performance achieved in effective implementation of the QMS (QA programme). The levels of performance are based on use of performance indicators, measuring with reference to the objectives set by the management and delivered product. Measures for continual improvement are initiated in the management system accordingly.

The Senior Management identifies, prevents and corrects management problems that hinder achievement of the NPCIL objectives. By due assessment process at all levels effective implementation of the company programme is realised. Self-assessment at all levels is considered to

be an effective tool to achieve these objectives. All the Managers and Task Performers periodically perform self-evaluation in their areas of work to compare current performance to management expectations in respect of worldwide industry standards of excellence (bench marking), meeting stakeholder requirements and expectations, regulatory and statutory requirements, and to identify areas based on any incidences that takes place worldwide or any other inputs received needing improvement.

13.5 REVIEWS AND AUDIT PROGRAMME

A system of planned and documented audits/reviews within the NPCIL organisation like functional directorates, units under construction and operating stations is established and carried out to verify compliance, determine effectiveness of implementation of all aspects of the Management System Programme and for continual improvement of the programme. Similar audits are also carried out in the organisations of suppliers and sub-suppliers.

13.6 REGULATORY REVIEW AND CONTROL ACTIVITIES

As mentioned above, the review and assessment by AERB includes consideration of the applicant's organisation, management, procedures and safety culture, which have a bearing on the safety of the plant. It is required that the applicant should demonstrate that there is an effective management system in place that gives the highest priority to nuclear safety and security matters. Specific aspects as mentioned in the AERB Safety guide "Consenting Process for NPPs" (AERB/SG/G-1) subject to review and assessment, include:

i. Whether the applicant's safety policy emanates from senior management and shows commitment at a high level to safety requirements and the means to achieve them.
ii. Whether the applicant's organisation is such that it can implement the commitments made in the safety policy, through existence of adequate procedures, practices and organisational structure.
iii. Whether the applicant has procedures to ensure that there is adequate planning of work, with suitable performance standards, so that staff and managers know what is required of them to meet the aims and objectives of safety policy.
iv. Whether the applicant has a system in place to periodically audit its safety performance.
v. Whether the applicant has procedures in place to review periodically all the evidence on its safety performance in order to determine whether it is adequately meeting its aims and objectives and to consider where improvements may be necessary.
vi. Whether the applicant has culture, commitment, organisation, systems and procedures, to meet the nuclear security requirements.

The review and assessment by AERB covers all aspects of the applicant's managerial and organisational procedures and systems which have a bearing on nuclear safety such as, operational feedback, compliance with operating limits and conditions, planning and monitoring of maintenance, inspection and testing, production of safety documentation related with and control of contractors and addressing and implementation of any safety issues/additional features needed arising out of any incidences worldwide.

13.7 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

The comprehensive Quality Management System (QMS) in the utilities has been developed in accordance with the national and international standards and the same is being maintained and further improved through programme of monitoring and assessment of its effectiveness. The regulatory review and assessment activities ensure that there is an effective safety management system in place that gives nuclear safety and security matters the highest priority. Therefore, India complies with the obligations of the Article 13 of the Convention.

ARTICLE 14: ASSESSMENT AND VERIFICATION OF SAFETY

Each Contracting Party shall take the appropriate steps to ensure that:

i. comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;

ii. verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

14.0 GENERAL

The assessment and verification of safety is an integral part of the nuclear power programme. AERB Safety Code, AERB/SC/G: 2000, on "Regulation of Nuclear and Radiation Facilities" spells out in detail the obligations of the licensee and the responsibilities of the AERB.

The utilities perform their own assessment and verification functions. They carry out these functions during design, manufacturing, construction, commissioning and operation through their Directorates of Engineering, Safety, Projects and Operation. Separate corporate level safety committees for the projects (plants under construction and design) and for operating plants are constituted for safety review and assessment. All the information generated during the entire design, construction and commissioning phases is documented and handed over to the Plant Management before the commencement of reactor operation.

AERB establishes its programmes for assessment and verification of safety during all the consenting stages viz. Siting, Construction, Commissioning and initial Operation, and also during regular plant operation. These programmes are based on routine and special reports from the licensee and regulatory inspections carried out by staff of AERB. The objective of assessment and verification programmes by AERB is to ensure that the utility's own programmes are adequate and satisfactorily implemented. A multi-tier system of safety committees is followed for carrying out regulatory review and assessment during all the consenting stages.

14.1 ASSESSMENT OF SAFETY

14.1.1 Regulatory Process for Safety Assessments

14.1.1.1 Consenting Process

AERB Safety Guide AERB/NPP&RR/SG/G-1 on "Consenting Process for Nuclear Power Plants and Research Reactors" explains the entire consenting process for nuclear installations followed in India. The safety guide defines the regulatory consenting process at all the major stages of a nuclear installation. It gives in detail the information required to be included in the submissions to AERB, document, schedule for submissions, and areas of review and assessment for granting the regulatory consent. Assurance of safety during various stages of NPP is derived through this process. Under the process, consent is issued for siting, construction and commissioning. Regulatory clearances are issued for intermediate stages during construction and commissioning. License is issued for operation of NPPs. The consents and licenses are issued by AERB on the basis of its safety review and assessment of the submissions made by utility.

License for operation of NPP is issued for five years. The renewal of license for operation is issued by AERB based on safety reviews as specified. These are (a) safety review of application submitted in the prescribed format, three months prior to completion of five years of operation and (b) Review of Report on Periodic Safety Review (PSR) every ten years of operation. Thus in a ten year cycle, NPPs seek two license renewals for operation, first after five years and the second after ten year based on PSR. In case of NPP of new design, the first PSR is carried out after five years of operation and the subsequent PSRs of these NPPs are carried out at 10 year intervals.

14.1.1.2 Safety Review Mechanisms

i) Utility

In accordance with the regulatory requirements of an independent internal review of design and operational aspects of NPPs, utilities have set up internal review mechanisms. For new designs, design of structures, systems and components is reviewed by persons with appropriate qualification and design experience. In case of repeat design, any change in design involving a new concept (e.g. software based system compared to hardwired system) goes through an independent review. All the issues raised by the independent reviewer are resolved. Subsequently, Safety Review Committee (Projects and Design) of the utility organisation independently reviews the documents and after satisfactory resolution of the identified issues, documents are submitted to AERB. The observations / issues coming out of review in AERB are resolved, documents are revised and re-submitted to AERB for formal clearance. The document finally cleared by AERB forms the basis for the detailed design and further engineering.

Elaborate organisational structure (please refer chapter on Article 19) is established at each plant for reviewing safety aspects during operation. Station Operation Review Committee (SORC) headed by Station Director is established at each NPP. SORC reviews station operations on routine basis to detect potential safety issues. At the corporate level, Safety Review Committee (SRC) for operating NPPs with representation from design, safety, operation and quality assurance groups at utility headquarters reviews all safety related proposals, including engineering changes, which require review and concurrence by AERB. The recommendations made by SRC are incorporated before the proposal is forwarded to AERB unit safety committee / SARCOP.

ii) Regulatory Body

AERB adopts a multi-tier review process for safety review and assessment of NPP during all the consenting stages.

During siting, construction and commissioning, the first level of review and assessment is performed by Site Evaluation Committee (SEC), Project Design Safety Committee (PDSC)/Specialist Groups and/or Civil Engineering Safety Committee (CESC), as appropriate. These Committees are comprised of experts in various aspects of NPP safety. The next level of review is conducted through an Advisory Committee on Project Safety Review (ACPSR). This committee is a high-level committee with members drawn from AERB, Technical Support Organisations (TSOs), other national laboratories having specialised expertise and academic institutions. It also has representation from other governmental organisations like Ministry of Environment and Forests, Central Electricity Authority and Central Boilers Board. This advisory committee reviews the application for consent together with the recommendations of the first level committees on the related consent and gives its recommendations to AERB. After considering the recommendations of first level committee and ACPSR, the Board of AERB decides on the consent. Annex 14-1 to 14-4 illustrate the review process followed during siting, construction, commissioning and operation stages.

During operation, AERB follows a multi-tier approach involving review at three levels viz. Unit Safety Committee (USC), Safety Review Committee for Operating Plants (SARCOP) and the Board of AERB. ‘Unit Safety Committees’ consists of representatives from AERB, experts in various aspects of

nuclear technology drawn from Technical Support Organisations and representatives from utility. SARCOP is the apex body to decide on the matters of nuclear safety and has members from AERB staff, experts drawn from TSOs, retired experts and one member from the Directorate of Health and Safety of the utility. The third-tier is the Board of AERB, which based on the recommendations of SARCOP, considers major safety issues pertaining to NPPs. Chairman, SARCOP is an ex-officio member of the Board of AERB. Annex 14-5 gives the aspects of safety review during operation of NPP. The system of safety committees function on the principle of "management by exception" following a graded approach. Safety issues of greater significance are further reviewed in higher-level safety committees for resolution. The recommendations of these committees are accepted by AERB after ensuring that they are in line with the safety goals, principles and requirements laid down by AERB.

14.1.2 Safety Reviews during Consenting Process

14.1.2.1 Safety Review for Siting

The first stage of consenting i.e. Siting, involves the review of the various site related safety aspects considering the conceptual design and issuance of siting consent for locating the NPP. This requires submission of a Site Evaluation Report which includes the salient features of the proposed site, basic design information of the proposed NPP, site characteristics affecting safety and impact of the proposed plant on surrounding population and environment. The Site Evaluation Report should contain information as per requirements specified in the AERB Code of practice for Siting of NPP (AERB/SC/S, 1990) and various other relevant AERB Siting guides.

The objective of the review for this stage is to ensure that the proposed site is suitable for the construction and operation of an NPP in a safe manner. In evaluating the suitability of a site for locating a NPP, the following major site-specific aspects are considered:

i) Effect of site characteristics including external events (natural and human induced) on the plant
ii) Effect of the plant on the environment and population, and
iii) Feasibility of implementation of Emergency Preparedness and Response plans in the public domain.

Other aspects such as soil characteristics, cooling water requirements, thermal and chemical pollution, power evacuation, transportation of over dimensioned consignments, etc, are also considered.

Revision of the AERB safety code on siting is under progress and AERB safety guide on ‘Seismic Studies and Design Basis Ground Motion for Nuclear Power Plant Sites’ (AERB/SG/S-11) is being revised in line with the recommendations of the AERB’s high level committee (AERBSC-EE) to review safety of Indian nuclear power plants against external events of natural origin, constituted after Fukushima accident. While revising these documents, lessons learned from Fukushima accident are also being incorporated. Interim guidelines have been prepared to evaluate extreme external events beyond design basis for margin assessment in operating plants.

14.1.2.2 Safety Review for Construction

The second stage of consenting i.e. Construction, involves review of the design safety aspects and issuance of construction consent. This requires on the part of the applicant, submission of Preliminary Safety Analysis Report (PSAR) in the prescribed format, the applicant's site construction Quality Assurance manual, construction schedule and construction methodology document for the proposed NPP. As a supplement to PSAR, separate design reports of items important to safety, having relevance to construction authorisation are required to be progressively made available for

review before consent for construction is issued. AERB also reviews the documents related to industrial safety such as Construction Safety Management Manual, Job Hazard Analysis Report, etc and monitors their compliance.

Depending on the request from the applicant, AERB may issue the consent for construction as a one time authorisation for total construction activities or as clearance in three stages viz. clearance for excavation, clearance for first pour of concrete and clearance for erection of major equipment. If consent for construction is issued in these clearance stages, PSAR reviews are organized according to the specified requirement for these stages.

14.1.2.3 Safety Review for Commissioning

Commissioning activities in NPP are initiated in parallel to construction during the later period of construction. Various equipment and systems are individually commissioned as and when the prerequisites for their commissioning are met. The first regulatory clearance within the commissioning consent is required when the applicant desires to initiate the integrated commissioning activity e.g. hot conditioning (integral testing and passivation of primary heat transport system) in the case of PHWR based NPPs. Following this, there are a number of intermediate commissioning stages at which also regulatory clearances are required. The consent for commissioning is given in several interim stages as deemed necessary by AERB. Some of these interim stages e.g. containment integrity test, fuel loading, approach to first criticality, low power physics experiments, etc. are witnessed by the representatives of AERB, if required.

For commissioning consent, AERB reviews the final or 'as built design' of the nuclear power plant as a whole. AERB satisfies itself that (a) the plant has been built in accordance with the accepted design and meets all the regulatory requirements, (b) the required level of quality has been achieved and (c) the safety review and assessment of all relevant systems including the required tests have been satisfactorily completed.

The review and assessment by AERB also covers all aspects of the applicant's managerial and organizational procedures and systems, including the availability of required trained and qualified personnel for operation, which have a bearing on safety.

AERB requires that at this stage, the utility should establish following programs:

i. Surveillance, maintenance and in-service inspection programs.
ii. Performance review and operational experience feedback programmes
iii. Programmes for Ageing Management
iv. Emergency Preparedness and Response plans
v. Training program for operating personnel

14.1.2.4 Safety Review for Licence for Operation

The 'Licence for Operation' is issued for regular operations after review of NPP performance at rated power for a period which is typically 100 days. During this period, specified tests are conducted to confirm behaviour of the plant as per design. To obtain, the licence for regular power operations, the applicant has to submit a Final Safety Analysis Report (FSAR) reflecting the 'as built' design of the NPP approved by AERB and detailed performance reports, in support of the application.

Before granting licence for operation, the AERB reviews the results of commissioning tests and performance data at various power levels for their consistency with design information and with the prescribed operational limits and conditions. Inconsistencies, if any, have to be resolved to the satisfaction of AERB

After completion of the reviews, AERB issues license for operation of NPP for a specified period.

14.1.2.5 Safety Review during Operation

Operation of the nuclear installations in India is carried out in conformance with the AERB safety code on 'Nuclear Power Plant Operation, AERB/NPP/SC/O (Rev. 1): 2008 and the safety guides made there under (AERB/SG/O-1 to O-15). During regular operation, reviews are carried out to ensure that the operation of the plant is being carried out in accordance with the approved Technical Specifications, AERB code and guides and the licensing conditions. These reviews include:

i. Routine safety reviews and assessments

The safety supervision during operation mainly includes continual monitoring and assessment of operational and safety performance, radiological safety, maintenance and in-service inspection activities and the results thereof and findings of regulatory inspections.

ii. Periodic safety assessments

For licence renewal once in every five years, utility has to submit application in a prescribed format, which covers operational safety performance, operational experience feedback, physical status of plant and public concern in operational safety. The report is submitted to AERB three months prior to the expiry of the operating licence. AERB conducts a detailed review of the same and issues the licence after being satisfied that the plant could be operated in a safe manner for next five years at the power levels authorised for the plant within the operational limits and conditions specified in "Technical Specifications for Operation" and that the continued operation of NPP till the next renewal would not pose undue risk to the plant, plant personnel, public and the environment.

PSR is carried out in accordance with the guidelines given in AERB safety guide AERB/SG/O-12. Safety assessments performed during PSR takes into account improvements in safety standards and operating practices, cumulative effects of plant ageing, modifications, feedback of operating experience, probabilistic safety assessments and development in science and technology. Through this process of PSR, the strengths and shortcomings of the NPP against the requirements of current standards are identified. The report on the PSR is subjected to regulatory review in the multi-tier review process for satisfactory resolution of the shortcomings.

During the last three years, Periodic Safety Review (PSRs) have been conducted for KGS-1&2, RAPS-3&4, NAPS-1&2 and TAPS-3&4. A dedicated group having multi-disciplinary skills, vast experience of regulatory inspections and safety reviews & assessment was constituted in AERB for PSR activities. Sub-groups with necessary expertise were constituted for completing the review of the identified safety factors of PSR in a time bound manner. Planning and management of the review was done so as to ensure multi-tier review of PSR report. The experience gained from the review of PSR of one NPP was effectively utilised in reviewing the PSR of the subsequent NPPs. This facilitated in efficient and effective review of the large number of PSR reports submitted by the stations in the past three years.

The first PSR of 540 MWe PHWR units (TAPS-3&4) has given useful insights on the safety performance of its First of A Kind (FOAK) systems. These insights provided inputs for safety review of systems to be used in 700 MWe reactors under construction. Additionally, rich experience gained from these reviews was taken as feedback in the currently ongoing revision of the AERB safety guide on PSR of NPPs (AERB/SG/O-12). A discussion meet had been arranged to get feedback from all the expert groups. Inputs from this discussion meet as well as the recently revised IAEA guide on PSR for NPPs (IAEA Safety Standards Series SSG-25) were also considered during the revision.

14.1.3 Regulatory Review and Control Activities

14.1.3.1 NPPs under construction

As has been brought out, AERB carries out safety review during various consenting stages like Siting, Construction, Commissioning and Operation. During these stages, there are a number of intermediate commissioning stages at which regulatory clearances are required. These stages act as checkpoints where the results of previous activities and prerequisites for further activities are reviewed till the plant is brought to operational state.

Responsibility of QA & QC during manufacturing, fabrication, construction and commissioning rests with the Utility. Regulatory process calls for setting up mechanisms within the utility to carry out internal audits by specifically constituted groups of various activities/jobs executed by the constructors, vendors, Utility etc. Regulatory Inspection teams check these audit reports in addition to physical verification and scrutiny of various documents/ records related to QA & QC, preservation and storage, industrial and fire safety aspects, adherence to regulatory stipulations etc. Observations and recommendations of Regulatory Inspection are required to be complied with and responded to by the utility. The Utility is asked to check and apply these observations / recommendations suitably on similar types of jobs/ activities.

Regular safety review and assessment for NPPs during construction and commissioning is conducted by the designated AERB staff that also has the responsibility of organizing and follow up of the regulatory inspections. In addition to normal regulatory inspections, AERB also identifies a list of important activities during construction and commissioning as hold points for which the licensee is required to inform the AERB in advance for deputing its representative to witness these activities as observers. The reports on these activities including the remarks by AERB observers are taken into account for giving clearance for further work during construction/commissioning. AERB staff participate in all the review and assessment functions, regulatory inspection and witnessing of the important activities. Due to this arrangement of regulatory supervision, all the important activities having bearing on safety get adequate regulatory coverage.

14.1.3.2 NPPs in Operation

Licence for operation of NPP is issued by AERB for a specified period. During this period, the operational NPPs undergo routine and special safety reviews as described below:

i. Reports to AERB

Events and Significant Events are reported to AERB as per the event reporting system (refer section 19.6). In addition, AERB obtains various reports from the NPPs such as monthly and annual performance reports, report on long outages for carrying out surveillance, in-service inspection & major maintenance and reports of special investigation committees and/or special regulatory inspections following an event of major safety significance.

ii. Training and qualification of operating staff

The Technical Specification identifies the qualification levels for operating staff and the management. The curricula of different licensed positions are prepared by the utility and vetted by the AERB. The operating staffs undergo system of classroom training, on the job training, checklist, walk through and simulator training and are interviewed by the AERB Committee on Qualification of Operating Personnel. Similarly, AERB evaluates the personnel in the management positions through an AERB Committee on Licensing of the Station Management Personnel for the initial licence and renewal of Licence. The licence is generally valid for three years after which the candidate undergoes a retraining exercise and again appears before the appropriate AERB Committees. The details of the entire training programme are given in chapter on Article 11.

iii. Radiological safety status

Environmental Survey Laboratory (ESL) stationed at the site is independent of the Plant Management. The ESL, which is established at the site before the start of the operation of the reactor, carries out extensive monitoring of air, water, soil, flora and fauna within the plant area, exclusion zone and emergency planning zone.

Each NPP has a Health Physics Unit (HPU) for implementing the radiation protection programme in the plant. The HPU functions are under the control of Directorate of Health, Safety and Environment at the utility Head Quarters and have direct channels of communication with the plant management in enforcing the radiation protection programme. HPU provides services related to radiological monitoring and also advises the Plant Management on radiological safety.

AERB gets periodic reports from the HPU and the ESL on the radiation and environment safety of the NPP. AERB committees review these reports along with the response of NPP management on the same.

iv. Management of radioactive waste

The performance of radioactive waste management system established at NPPs is reviewed to ensure that appropriate methods and management practices continue to be in place and the generation of radioactive waste is kept to as minimum as practicable in terms of activity and volume.

v. Design modification in safety and safety related systems

Any design modification in the safety and safety related systems of the plant has to pass an in depth regulatory review and approval procedure. For such modifications, the utility submits the plant modification proposal in the prescribed format, which must be accompanied by a safety assessment report both by the station staff and designers at the corporate level. The modification proposals are then reviewed in USC and SARCOP. AERB may seek the opinion of experts or refer the matter to any of the national laboratories or academic institutions for independent analysis for verification of the claims of the utility.

vi. Emergency Preparedness:

The NPPs carry out periodic exercises for plant, site and off site emergency according to the prescribed frequency. The reports of these exercises are reviewed in AERB. Various state and central agencies participate in the offsite emergency exercises. AERB also deputes its representatives as observers to oversee the conduct of the off-site exercise. Emergency Preparedness and Response plans are periodically updated based on the changes in organisation and infrastructure.

In addition to the above, special reviews are undertaken following an event or observations of major safety significance occurring abroad, for their applicability in the Indian NPPs and need for any corrective measures. Subsequent to Fukushima accident, to ascertain and evaluate the response and coordination among different agencies during offsite nuclear emergency, National Disaster Management Authority (NDMA), NPCIL and AERB took up review of existing Emergency Preparedness and Response plans at all NPP sites. Details are provided in chapter on Article 16 (Emergency Preparedness).

14.2 VERIFICATION OF SAFETY

14.2.1 Regulatory Requirements for Verification of Safety by the Licensee

AERB Safety Code on “Design of Pressurised Heavy Water Reactor based Nuclear Power Plants” AERB/NPP-PHWR/SC/D (Rev.1) 2009, requires that a comprehensive safety assessment

shall be carried out to confirm that the design, as used for construction and as built, meets the safety requirements set out at the beginning of the design process and the utility shall ensure that an independent verification of design and the safety assessment is performed by an independent group, separate from that carrying out the design, before it is submitted to the AERB.

"Code of practice on safety in nuclear power plant operation", AERB/NPP/SC/O:2009 (Rev.1) establishes requirements related to operation of NPPs and several safety guides issued under this Code, describe and make available methods to implement specific requirements of the Code. The code requires establishment of management programmes related to operation review and audit with the aim of ensuring that an appropriate safety consciousness and safety culture prevails. In accordance with the requirements, an elaborate verification programme is established at NPPs and the adequacy of the programme is periodically monitored. Audits are conducted by plant management and also the utility headquarters to verify that that the safety verification programmes are being followed at the plant. AERB exercises regulatory control over the nuclear power plants following a system of safety monitoring, inspection and enforcement and periodic assessment for renewal of Licence.

14.2.2 Programmes for Continued Verification of Safety

As per the regulatory requirements, the plant management is required to establish the following programmes before a licence for operation is granted:

i. Maintenance Programme - The maintenance programme is put in place to ensure that (i) safety status of the plant is not adversely affected due to ageing, deterioration, degradation or defects of plant structures, systems or components since commencement of operation and (ii) their functional reliability is maintained in accordance with the design assumptions and intent over the operational life span of the plant. The NPP prepares a preventive maintenance schedule for systems, structures and components. In addition, system for trend monitoring of the important equipment is used for predictive maintenance. The preventive maintenance includes surveillance and verification, periodic preventive maintenance and predictive maintenance.

ii. Surveillance Programme - The surveillance programme for safety systems and systems important to safety are included as part of the Technical Specifications for Operation. Through this, it is verified and ensured that the safety of the plant does not depend upon untested or unmonitored components, systems or structures. The programme includes tests like functional tests, calibration checks for Protection Systems, Emergency Core Cooling System, Containment Systems, Emergency Power Systems and various other important Systems, Structures and Components (SSC) important to safety.

iii. In-service Inspection Programme - As per this programme, plant components and systems are inspected for possible deterioration in safety margins and their acceptability for continued operation of the plant and to take corrective measures as necessary. SSCs important to safety of the plant are identified in the In-service Inspection manual, which gives the requirements with respect to (a) areas and scope of inspection (b) frequency of inspection (c) method of inspection and (d) the acceptance criteria.

iv. Performance Review Programme - The basic purpose of this programme is to identify and rectify gradual degradation, chronic deficiencies, potential problem areas or causes. This includes review of safety-related events and failures of SSC of the plant, determination of their root causes, trends, pattern and evaluation of their safety significance, lessons learnt and corrective measures taken.

v. Establishment of programme related to life management - This programme is used to obtain information on behaviour of the SSCs, as identified for ageing management purpose, under

reactor environment and to undertake necessary studies/experiments with respect to their residual life assessment.

vi. Programme to update Probabilistic Safety Assessment - The programme for collection of plant specific failure data at NPPs is established for evaluation of reliability of safety systems. These data are judiciously used to update the results of PSA studies. The proposals for design modifications or revision in technical specification requirements are required to be supported by the results of PSA studies.

Arrangements for internal review by the utility both during projects and operation are described in section 14.1.1.2.

14.2.3 Regulatory Inspection and Enforcement

(i) Regulatory Inspection

Compliance to the regulatory requirements is monitored by conducting periodic regulatory inspections. The regulatory inspections of NPPs are carried out during all stages of licensing to verify and ensure compliance to the regulatory requirements. During regulatory inspection, documented evidences for compliance to the regulatory requirements are examined. The regulatory inspections are carried out as per the guidelines given in AERB safety guide on 'Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities (AERB/SG/G-4)'. The provisions of the guide are elaborated in safety manual on Regulatory Inspections, (AERB/NPP/SM/G-1). Depending upon the requirements, AERB staff carries out periodic regulatory inspections as well as special unannounced inspections with specific objectives as deemed necessary.

During construction and commissioning stages, the inspections are carried out at a frequency of four inspections in a year. Regulatory Inspection team consisting of typically eight members carries out inspection for a period of about one week. Composition of team and areas to be inspected are pre-decided, taking into consideration the status of the project. In addition to normal regulatory inspections, AERB also identifies a list of important activities during construction and commissioning as hold points for which the licensee is required to inform AERB in advance for deputing its representative to witness these activities.

During operations, these inspections are carried out twice a year. Special regulatory inspections are carried out subsequent to an event, depending on the safety significance or after major modifications in the plant and form the basis for considering clearance for restart of the unit. In addition to these, unannounced inspections are carried out at the discretion of AERB for assessing the prevalent safety status at the NPP on any normal day.

In general, the following areas are covered during a typical regulatory inspection of an operating NPP.

- Operation, Maintenance and Quality Assurance Programme.
- Adherence to the technical specification.
- Compliance to various regulatory recommendations.
- Adequacy of licensed staff at NPPs
- Performance of safety related systems.
- Radiation safety and ALARA practices.
- Emergency Preparedness
- Industrial Safety

Based on the inspection, a detailed inspection report is prepared and the utility is briefed about the findings in an exit meeting. The inspection findings are categorised according to their safety significance.

(ii) Enforcement:

The utility is required to submit an action taken report within a specified time frame on the deficiencies pointed out during the inspection. These submissions are reviewed in AERB for disposition and need for any enforcement action. AERB may also initiate enforcement actions, if in its opinion the licensee has violated the conditions of the license willfully or otherwise or misinformed or did not divulge the information having bearing on safety after specifying the reasons for such actions. The enforcement actions may include one or more of the following:

a. A written directive for satisfactory rectification of the deficiency or deviation detected during inspection;
b. Written directive to applicant/licensee for improvement within a reasonable time frame;
c. Orders to curtail or stop activity;
d. Modification, suspension or revocation of license; and
e. Initiate legal proceedings under provisions of the Atomic Energy Act.

During the past three years AERB asked for satisfactory rectification of the deficiency in a number of cases. One such case where work was stopped was at KKNPP-2 construction site. In this case two fatalities occurred due to electrocution, in quick succession. Immediate review of the incidents brought out certain lapses in adherence to electrical safety practices. AERB suspended the construction activities at the site pending detailed investigations and rectification of the lapses on 9th March 2013. Subsequently, AERB granted clearance for resumption of construction activities on 1st April 2013 after ensuring that adequate measures were taken to avoid such incidents.

There were no such instances where an order for suspension of license was required during the reporting period. During safety review of nuclear power projects and related construction activities many written instructions for improvement within a reasonable time frame were given. All these enforcement requirements were complied with by the utility to the satisfaction of AERB.

14.3 SPECIAL SAFETY ASSESSMENTS FOLLOWING FUKUSHIMA (SSAFF)

Subsequent to the accident at Fukushima NPPs, Japan in March 2011, the Hon'ble Prime Minister of India ordered a fresh review of safety of NPPs with respect to external events.

NPCIL conducted an immediate review to assess available capabilities to deal with the extreme external events by considering extended blackout and loss of ultimate heat sink provided in the existing design.

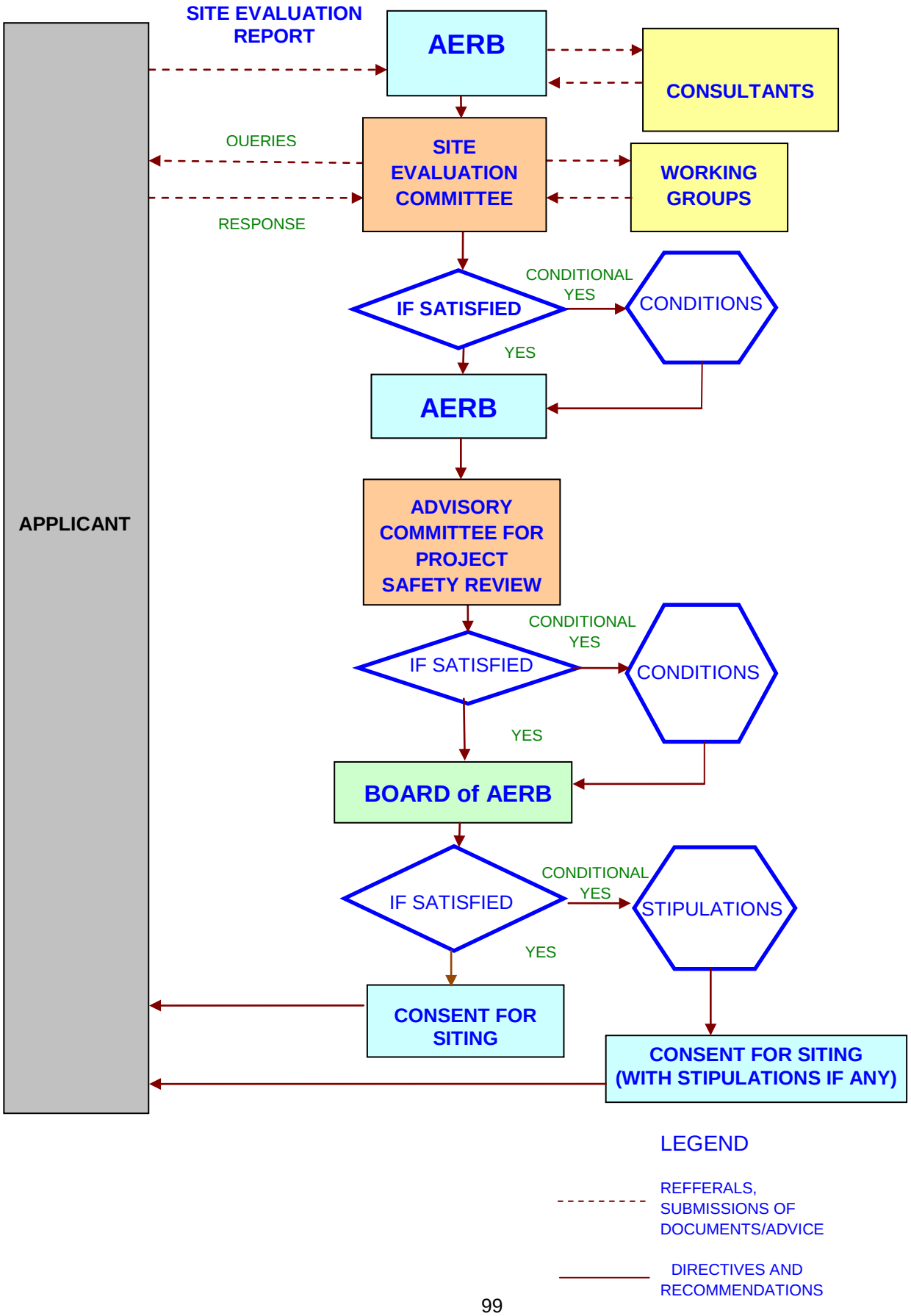
AERB constituted an independent committee (AERB SC-EE) with national level experts in the areas of (i) design, safety analysis and NPP operation, and (ii) external events - seismic science, hydrodynamics and earthquake engineering. Also a number of working groups with specialists in the subject areas were formed for detailed review of plant specific design aspects with respect to functioning of safety systems and components and requirements for further enhancement of safety provisions in the case of extreme external events including combination of related events.

14.4 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

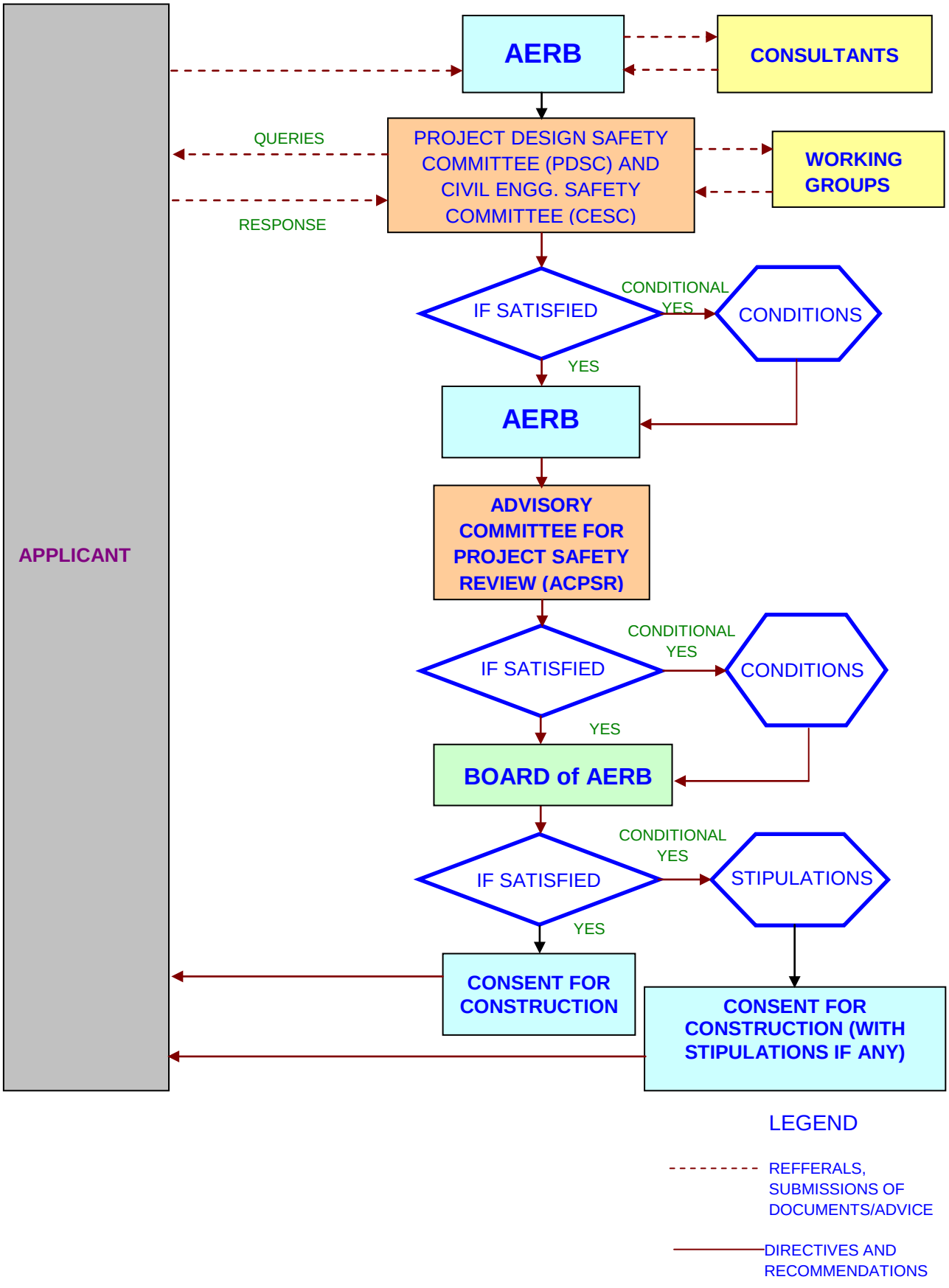
The consenting process established in the country ensures that comprehensive and systematic safety assessments are carried out during siting, construction, commissioning and operation. Changes that take place in the design during construction and commissioning are reflected in the FSAR, which forms one of the licensing documents. All the relevant documents are formally

transferred to the plant management by the construction and commissioning groups by way of system transfer documents and construction completion certificate. Design modifications in the safety and safety related systems are carried out only after regulatory review and approval. Independent assessment and verification programmes are established both within the utility and the AERB. Adequacy and effectiveness of the assessment and verification programmes at the utility is ascertained by AERB through its regulatory control. During operation stage, the AERB checks that the verification programmes established at the NPP and the utility are adequate to demonstrate that the physical state and the operation of a nuclear installation continues to be in accordance with its design and applicable national safety requirements. Therefore, India complies with the obligations of Article 14 of the Convention.

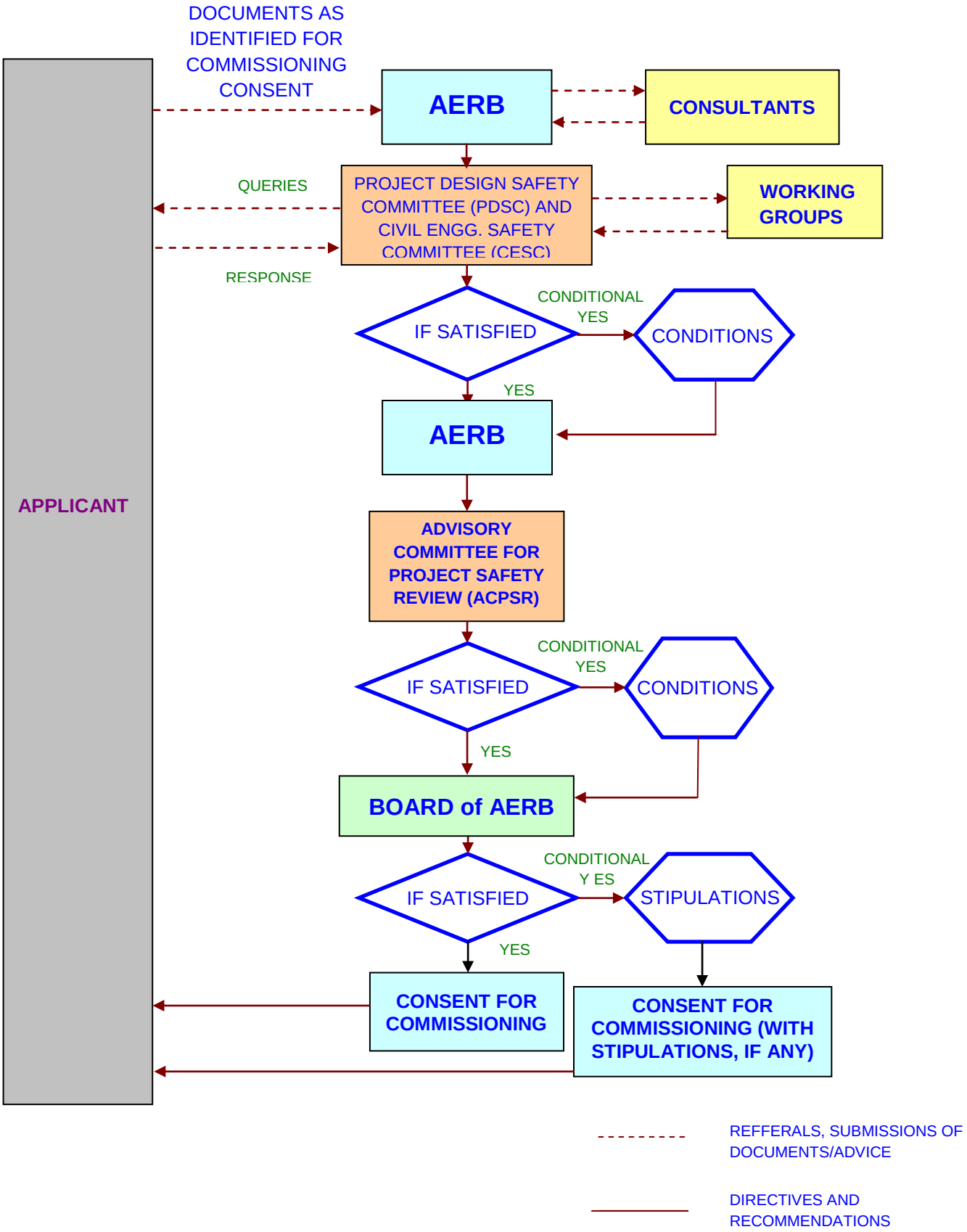
Annex 14-1: Scheme for Consent for Siting



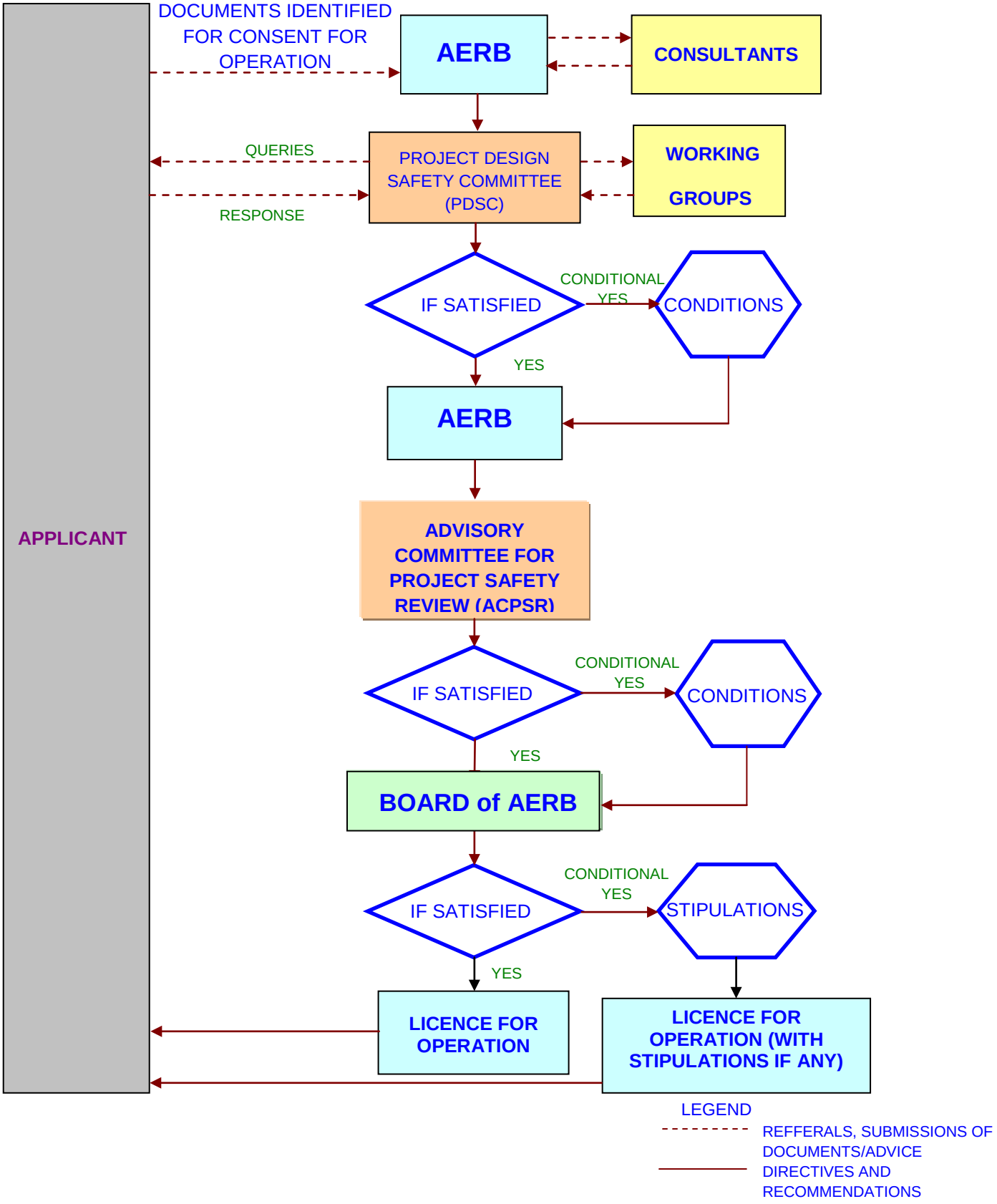
Annex 14-2: Scheme for Consent for Construction



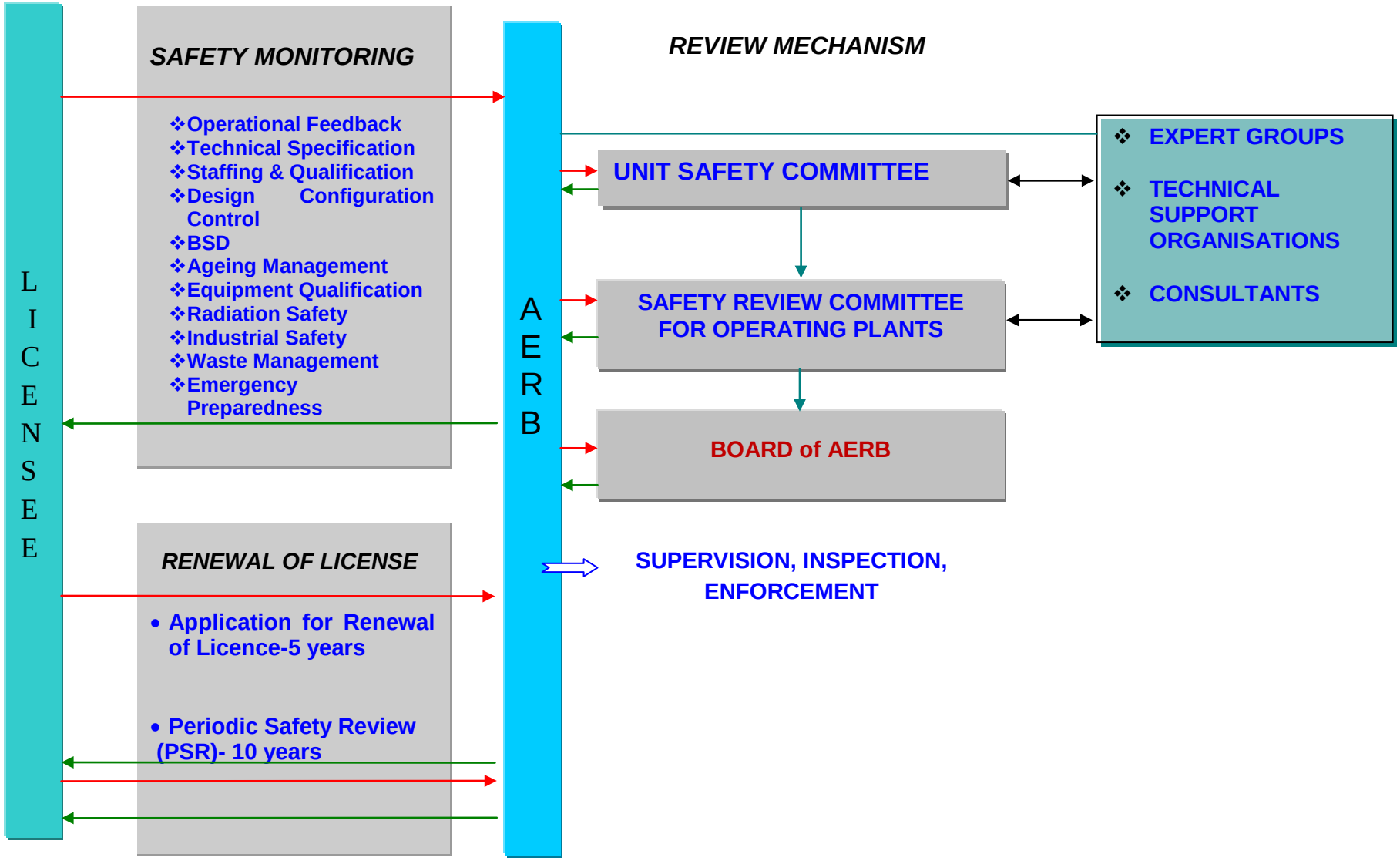
Annex 14-3: Scheme for Consent for Commissioning



Annex 14-4: Scheme for Consent for Initial Operation



Annex 14-5: Safety Review during Operation



ARTICLE 15: RADIATION PROTECTION

Each Contracting Party shall take appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed the prescribed national dose limits.

15.0 GENERAL

Radiation Protection infrastructure and programme in all Indian NPPs is on sound footing and is strengthened on continual basis based on experience and technology development. The safety surveillance and regulatory mechanism of AERB in the area of radiation protection is comprehensive, continual and rigorous.

15.1 REGULATORY REQUIREMENTS RELATED TO RADIATION PROTECTION

Atomic Energy (Radiation Protection) Rules 2004 inter alia covers the requirements of radiation surveillance and its procedures, powers of inspection of radiation installation, sealing and seizure of radioactive materials and the duties and responsibilities of Radiological Safety Officers (RSO). In addition, the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules 1987 specify the requirements for safe disposal of radioactive wastes. AERB ensures compliance with the requirements under the above rules by all the nuclear and radiation facilities. Regulatory requirements for radiation protection for NPPs given in various Codes and Guides are as detailed below:

i) AERB Safety code on “Radiation Protection for Nuclear Fuel Cycle Facilities” (AERB/NF/SC/RP: 2012) covers radiation safety aspects specified in Atomic Energy (Radiation Protection) Rules, 2004 as applicable to the nuclear facilities.

This safety code specifies the basic requirements for radiation safety of the occupational workers, members of the public and the environment. This code specifies the radiation protection requirements to be addressed in siting, design, construction, commissioning and operation of nuclear power plants. The requirements on radiation exposure control, discharge of radioactive effluents, radioactive waste monitoring, environmental monitoring, emergency preparedness, decommissioning and remediation are also addressed. The code also covers the roles and responsibilities of the consentee, the Radiological Safety Officer (RSO) and occupational workers, and the quality assurance programme of radiation protection aspects.

During preparation of this safety code, the safety requirements / guidelines provided in the IAEA documents, ICRP (ICRP 103, 2007) and the operational experience were considered.

ii) The Code of Practice on Design for Safety in Nuclear Power Plants (AERB/NPP-PHWR/SC/D (Rev. 1) 2009) lays down the minimum requirements for ensuring adequate safety in plant design including radiation protection in NPPs. The guidance for implementation of radiation protection in the design of the nuclear power plants consistent with the requirements of the design code is provided in the “Safety Guide on Radiation Protection Aspects in Design for Nuclear Power Plants (AERB/SG/D-12, 2005)”. The guide covers the measures and provisions to be made in the design.

iii) Code of Practice on Nuclear Power Plant Operation (AERB Code No. AERB/NPP/SC/O (Rev. 1), 2**0**08) lays down the requirements including radiation protection to be met in order to achieve safe operation of a nuclear power plant. The code requires establishment of radiation protection programme prior to the commencement of operation of the NPP to ensure protection of site personnel, members of the public and the environment from the adverse effects of ionising radiation

iv) Safety Guide on Radiation Protection during Operation of NPPs (AERB/SG/O-5, 1999) provides guidelines for establishing an effective radiation protection programme. It focuses on the commitment of the Plant Management to follow the exposure control measures during all operational states and accident conditions at the plant.

v) Safety Manual on "Radiation Protection for Nuclear Facilities (AERB/SM/O-2 Rev.4, 2005) provides the technical and organizational aspects of occupational radiation exposure control under both normal and potential exposure conditions. Based on this each plant prepares its own "Radiation Protection Procedures" relevant to its design and functioning.

The dose limits for exposure from ionizing radiation for workers and the members of the public are prescribed by AERB in its Directive No.01/2011 under Rule 15 of the Atomic Energy (Radiation Protection) Rules 2004. These dose limits are as follows:

Dose Limits for Occupational Workers

a. an effective dose of 20 mSv/yr averaged over five consecutive years (calculated on a sliding scale of five years);
b. an effective dose of 30 mSv in any year;
c. an equivalent dose to the lens of the eye of 150 mSv in a year;
d. an equivalent dose to the extremities (hands and feet) of 500 mSv in a year and
e. an equivalent dose to the skin of 500 mSv in a year;
f. limits given above apply to female workers also. However, once pregnancy is declared the equivalent dose limit to embryo/fetus shall be 1 mSv for the remainder of the pregnancy.

Dose Limits for members of public

The estimated average dose to the members of the public due to discharge of radioactive effluents from nuclear facilities at a site shall not exceed an effective dose of 1 mSv in a year.

15.2 RADIATION PROTECTION PROGRAM AT NPPs

15.2.1 Design Phase

The design of NPP is done with due regard to materials chosen for manufacturing, plant lay out and shielding requirements to meet the specified regulatory requirements of radiation exposures to the occupational workers and to optimize the collective radiation dose to the plant workers. Plant layout is optimized and areas are classified according to the expected radiation levels and potential for incidence of contamination in the area. Materials used in plant systems are selected in such a way that the activation products arising from the base material or the impurity content does not significantly contribute to radiation exposures during operation and also during decommissioning.

At the design stage adequate provisions for radiation protection are made to keep radiation levels in plant areas below design levels. Provision of ventilation is made such that

the airborne contamination be maintained below 1/10 DAC in full time occupancy areas of the plant. Occupancy factors are also taken into consideration in the design of ventilation and shielding for the accessible areas of the plant. The shielding shall be such that the dose rate in full time occupancy areas does not exceed 1 μSv/hr. The NPP is also designed to comply with the specifications on radiation levels in plant areas, maximum radiation dose rates in control room and outside reactor building during accident conditions. It also has an elaborate radiation monitoring system to enable verification of design intent. Radiation Monitoring System consists of area radiation monitors, process monitors, environmental monitors and effluent monitors. These monitors are connected to a Radiation Data Acquisition System (RADAS) which gives history, trend and instantaneous readings of the monitors and displays their alarm state in plant control room and health physics office.

Based on the operating experience, many design modifications for exposure control have been incorporated progressively in the Indian NPPs. Some of the design changes such as water filled Calandria Vault Cooling system, CO_2 based Annulus Gas Monitoring system, valve-less PHT system, use of sub-micron filters in PHT system, use of canned rotor pumps, reduction of components in moderator system, use of cobalt-free alloys in in-core components and relocation of equipment from Reactor Building to outside have resulted in significant reduction in exposures.

15.2.2 Operation Phase

Radiation protection programme during the operation of NPPs comprise of organizational, administrative and technical elements. ALARA measures are applied in exposure control of the plant personnel and the public. The plant management makes adequate review of the implementation and the effectiveness of the radiation protection programme. An effective environmental surveillance programme that provides radiological data to evaluate the impact of operation of the NPP on the surroundings areas of the plant site is established at each NPP. The main features of the radiation protection programme at the NPPs covers following elements:

- Organisational structure of the health physics unit at the NPP,
- Area/zone classification of plant areas and access control ,
- Exposure control scheme and work procedures,
- Area radiation monitoring and surveys,
- Environmental radiological surveillance and monitoring,
- Determination of external and internal doses,
- Decontamination procedures and methods ,
- Control, handling, storage and transport of radioactive materials including radioactive wastes,
- Control and monitoring of radioactive liquid and gaseous releases,
- Equipment for personnel protection,
- Training/retraining of personnel including temporary workers in radiation protection and emergency procedures,
- Health surveillance of radiation workers,
- Documentation of data on radiological conditions of the plant, personnel exposures and effluent discharges
- Training and qualification of health physics personnel, and
- QA programme.

i Radiation Protection Organisation:

Each NPP has a Health Physics Unit (HPU), headed by a Radiological Safety Officer (RSO) and comprising of a group of trained and experienced radiation protection professionals. RSO in co-ordination with Plant Management implements the radiation protection programme in the plant. The requirements for RSO are stipulated by AERB according to which each NPP have identified RSO and alternate RSO under the Radiation Protection Rule- 2004 (RPR-2004).The HPUs are entrusted with the responsibility for providing radiological surveillance and safety support functions. These include radiological monitoring of workplace, plant systems, personnel, effluents, exposure control, exposure investigations and analysis and trending of radioactivity in the plant systems. The HPU functions are under the control of Directorate of Health, Safety and Environment at the utility Head Quarters and have direct channels of communication with the plant management in enforcing the radiation protection programme.

ii Infrastructure and Manpower

The plant design provides for radiation protection facilities such as clothing change room, personnel decontamination facility, equipment decontamination facility, transit waste storage room, storage facility for contaminated equipment/tools, active workshops, protective equipment servicing & testing area, active laundry, radiation data acquisition system and portal monitors.

The HPU is provided with trained and qualified man-power, adequate number of radiation monitoring instruments for normal and emergency use, laboratories and radiation instrument calibration facility.

iii Exposure control and implementation of ALARA

All nuclear plants have radiation safety programs and work procedures intended to control the occupational exposures. Exposures to site personnel are controlled by a combination of radiation protection measures such as:

a. Restricting the external exposure by means of shielding, remote operation, source control and minimizing the exposure time;
b. Restricting the internal exposure by means of isolation, ventilation, housekeeping and the use of protective clothing and respiratory equipments;
c. Training of personnel;
d. Review of work procedures, planning, rehearsing the work on mock ups and dose budgeting;
e. On-the-job monitoring and surveillance of individuals in special works.

All NPPs have ALARA committees at station level and sectional level. These committees periodically review the plant radiological conditions and exposure status. The committees also review all dose intensive jobs planned at the facility and their recommendations are incorporated in the job planning. In addition, periodic ALARA reviews are conducted at the NPPs to identify areas for dose reduction and to implement corrective actions. The operating experience on radiological events at NPPs in India and in other countries is reviewed and the lessons learned are communicated to all concerned station personnel. In addition, Station Operation Review Committee (SORC) also reviews the radiation exposure control.

Some of the actions/practices implemented for ALARA exposure at the NPPs are given below:

- Review of planned activities and preparation/ approval of Manrem budget
- Optimisation of man power in each job
- Prompt identification and replacement of failed fuel in PHWRs.
- Draining and hot air drying of the D_2O equipment before maintenance.
- Local ventilation with separate supply and exhaust for in-service inspection of moderator heat exchangers for tritium uptake control.
- Chemical decontamination of coolant system to bring down equipment radiation levels

iv Observance of dose limits

The exposure control consists of application of primary dose limits, action levels such as investigation level and operational restrictions. Operational restrictions are established based on dose, dose rate, air activity and surface contamination levels etc. at workplace such that the exposure of workers does not exceed the applicable dose limits. Individual exposures exceeding the investigation levels are investigated and reported to AERB. All cases of exposures exceeding the annual limits are reviewed by an AERB committee.

All the radioactive works are performed under radiological work permit, which contains radiation level, air borne activity and surface contamination data. Accordingly, protective equipment, dose restrictions, time limits and additional precautions, if any, are recommended for controlling the dose.

The temporary workers employed for working in the controlled areas undergo pre-employment medical check-up and training in elementary radiation protection procedures. They are closely supervised by an appropriately qualified person during their work. A separate control limit on dose and investigation levels is prescribed for temporary workers which are lower than that for the regular workers. The annual effective dose limit for temporary radiation workers is 15 mSv.

The external exposure of radiation worker is determined by the use of TLD. In areas of high or non-uniform radiation fields, additional dosimetry devices such as direct reading dosimeter (DRD), extremity badges (for hands or fingers) are used for control purpose. Neutron monitoring badges as prescribed by the health physics unit are used wherever applicable. Alarm Dosimeters are used by individuals during dose intensive work. Evaluation of the committed effective dose of all radiation workers due to tritium uptake in PHWRs is carried out by routine and non-routine bioassay sampling. Workers are also subjected to routine whole body counting for assessment of internal contamination.

A computerised dose data management system is used in NPPs for effective dose control. Networking of area radiation monitors for obtaining radiation levels on real time basis is provided in the control room and the Health Physics office.

Around 14,000 persons were monitored annually during the reporting period (2010-2012). The average dose of the monitored persons was 1.35 mSv. However, in last three years, three workers received radiation dose above the annual exposure limit of 30 mSv. The maximum Individual exposure was 90.83 mSv in an incident while carrying out house-keeping and painting jobs in Spent Fuel Transfer Duct (SFTD) at KAPS. The incident is briefly described in chapter on Article-6 (Existing Nuclear Installations).

15.3 CONTROL OF RADIOACTIVE EFFLUENTS

i. Method of Disposal and Monitoring

Gaseous wastes from reactor building are filtered using pre-filters and HEPA filters and discharged after monitoring, through ventilation exhaust stack. The release rate and integrated releases of different radionuclides are monitored and accounted for to demonstrate that the releases are within the authorized limits.

The radioactive liquid wastes generated in a NPP are segregated, filtered and conditioned as per procedure and diluted to comply with the discharge limits for aquatic environment. The activity discharged is monitored at the point of discharge and accounted on a daily basis. AERB has prescribed limits on annual volume and activity of discharge, daily discharges and activity concentration at the point of discharge from each NPP and are site specific.

The radioactive solid wastes are disposed off in brick lined earthen trenches, RCC vaults or steel lined tile holes, depending on radioactivity content and radiation levels. The details on radioactive waste management are covered in the chapter on Article 19.

ii. Authorized Limits of Discharge

The discharge of radioactive waste from a NPP is governed by the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules 1987. It is mandatory for a NPP to obtain authorization under these rules from the Competent Authority for disposal of radioactive wastes and file a return annually to AERB indicating the actual quantity of radioactive waste discharge.

The regulatory limits (authorized limits) of radioactive effluents are based on the apportionment of effective dose limit of 1 mSv per year to the public arising from nuclear facilities at a site considering all the routes of discharges and significant radionuclide in each route of discharge. Derived limits of effluent discharge corresponding to the dose apportioned for different radionuclide are established taking into account the site specific parameters, design of NPP and the operating experience.

Discharge constraints are set at a much lower value than the authorized limits to achieve effluent releases at ALARA level. The operating data shows that releases from NPPs have been a small fraction of the specified release limits.

15.4 ENVIRONMENTAL MONITORING

Environmental survey around each NPP site is carried out by Environmental Survey Laboratories (ESLs) of BARC. ESL is established several years prior to operation of a NPP. Extensive surveys are carried out around each Site to collect data on the dietary intake by the population. During the pre-operational phase, annual intake of cereals, pulses, vegetables, fish**,** meat, eggs and milk are established by direct survey. Elaborate studies of the topography of the site, land use pattern and population distributions are carried out systematically during the pre-operational phase. Along with the topographical and dietary studies, the ESL also carries out the work of establishing the pre-operational background radiation levels. Extensive micrometeorological data such as wind speed and wind direction, temperature and rain fall are collected for a few years to identify the predominant wind direction and the critical population.

The basic objective of environmental monitoring and surveillance programme is to assess the radiological impact under all states of the NPP and demonstrate compliance with the radiation exposure limits set for the members of the public by the AERB. This is achieved by carrying out radiological surveillance of the environment by professionals of ESLs. The ESLs are part of BARC and are independent of the utilities and submit periodic reports to AERB on radiological information and the results of environmental surveillance around the NPP.

The ESL continues its monitoring and surveillance programme during the operation phase of the NPP. The samples for analysis are selected on the basis of potential pathways of exposure. Areas up to a distance of 30 km distance are covered under the environmental survey programme. From the radioactivity level in the environmental matrices, intake parameters and dose conversion factors, the population dose is estimated. The annual effective dose to the representative person of the public in the vicinity of the NPPs is estimated to be only a few μSv and detailed in the Figure 6.3 of chapter on Article 6.

Indian Environmental Radiation Monitoring Network (IERMON) has been established across the country for online detection of nuclear emergency. IERMON provides:

- On-line information about radiation levels at various locations in the country.
- Data on background environmental radiation levels and long term shift in the background levels.
- Data for environmental impact assessment following nuclear emergencies.

15.5 RADIOLOGICAL PROTECTION OF THE PUBLIC

AERB has prescribed effective dose (whole body) limit of 1 mSv per year to a member of public due to discharge of radioactive effluents from nuclear facilities at a site.

The sources contributing to generation of radioactive solid, liquid and gaseous wastes and their discharge to the environment are examined with respect to minimization of waste at the source at the design stage itself. The effluent discharges are continuously monitored and restricted within the authorized limits. In addition to the authorized limits of discharge AERB has prescribed “Discharge Constraints” at which the licensee is required to review the situation and report to AERB on the corrective actions planned. The dose to the public resulting from these releases is assessed and if necessary, appropriate design measures to reduce the discharge are introduced. The radiation level in the public domain of NPP site and discharges from NPPs are included in the annual report of AERB and placed on public website.

The design analysis should demonstrate that the calculated dose to the members of the public at the exclusion zone boundary under design basis accident condition does not exceed the reference doses prescribed by AERB.

15.6 REGULATORY REVIEW AND CONTROL ACTIVITIES

AERB enforces control on radiation protection aspects of NPPs through

i. Review of Radiation protection aspects during Project Stage:

During the review of Preliminary Safety Analysis Report of the NPP at the project stage, aspects of radiation protection such as equipment layout, zoning, shielding, material selection etc. are covered. This ensures that during the subsequent operational stage of the NPP, exposure to occupational worker for Operational and Maintenance jobs are limited.

ii. Collective Radiation Dose Budgeting

Annually the collective dose budget is prepared by each NPP based on the jobs that are likely to be executed and collective dose consumed in the previous years as well as the existing radiological condition in the plant. AERB carries out review of the budget at Unit Safety Committee level followed by approval from SARCOP. Further on quarterly basis adherence to the budget is also reviewed so that the planned activities for the year are carried out within the budget. Any upward revision of the budget requires adequate justification by NPP, review and approval by AERB.

iii. Review of Radiological Safety Aspects

Routine quarterly and annual reports on radiological safety aspects are prepared jointly by the RSO of the NPP and Directorate of HS&E at HQ. Subsequently, it is reviewed at Station level in SORC. This report is further reviewed at NPC SRC for operations at HQ and submitted to AERB for review. The reports at AERB are reviewed by Unit Safety Committee and SARCOP. Necessary corrective measures, if required, are recommended to station.

iv. Regulatory Inspection

AERB carries out regulatory inspection of all NPPs every six months to verify the compliance with the safety requirements and to check radiological status. During the inspection environmental monitoring data, effluent discharge data, radioactive waste disposal data and quality assurance programme in Radiation Protection are checked.

v Review of Radiation Exposure to Occupational Workers

Radiation exposure to the occupational workers is controlled by ensuring compliance with the dose limits prescribed by AERB. The radiation exposure to the occupational workers is periodically reviewed by AERB based on the health physics reports. The exposure cases exceeding the regulatory constraints/ limits are primarily investigated by the exposure investigation committee at each NPP and subsequently by the AERB Safety Committees.

15.7 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Appropriate laws, regulations and requirements regarding radiation protection as applicable to NPPs are in place and are being implemented by the utility. Adequate regulatory control is exercised by AERB, through the regulatory mechanism and respective organisations, application of dose limits, authorization for release of radioactive effluents, application of ALARA, environmental surveillance and regulatory inspections. Significant experience and expertise have been gained over the years for systematic implementation of radiation protection programme in NPPs. Therefore, India complies with the obligations of Article 15 of the Convention.

ARTICLE 16: EMERGENCY PREPAREDNESS

1. Each Contracting Party shall take the appropriate steps to ensure that there are onsite and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency.

For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.

2. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.

3. Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.

16.0 GENERAL

Nuclear Power Plants (NPPs) in India are designed, constructed, commissioned and operated in conformity with relevant nuclear safety requirements. These requirements ensure an adequate margin of safety so that NPPs can be operated without undue radiological risks to the plant personnel and members of the public. Notwithstanding these, it is necessary to develop Emergency Preparedness and Response (EPR) plans, as a measure of abundant caution. EPR plan has been an essential requirement for operation of NPPs in India from the very beginning of nuclear power programme. These plans are prepared in accordance with the national laws and regulations and deal with effective management of any eventuality with a potential to pose an undue radiological risk to the plant personnel and the public. The Plant Management and District Authorities / Local Government have a significant role in preparedness and response to emergencies.

16.1 NATIONAL LAWS, REGULATIONS AND REQUIREMENTS

The national legislative requirement for the use of atomic energy is governed by Atomic Energy Act 1962. Atomic Energy (Radiation Protection) Rules 2004 prescribe the rules for implementation of the radiation protection related provisions of this Act. The Rule No. 32 prescribes the directives in case of accidents and the Rule No. 33 prescribes the requirement for emergency preparedness. Government of India has also enacted “Disaster Management Act, 2005” which provides for effective management of disasters including accidents at NPPs which can result in a radiological emergency in the public domain.

Based on these laws and regulations, specific requirements with respect to emergency preparedness in NPPs have been formulated by AERB and are covered in the following safety codes and guides:

(i) The Safety Code “Regulation of Nuclear and Radiation Facilities” (AERB/SC/G, 2000) stipulates the minimum safety related requirements including that for emergency preparedness to be met by a nuclear or radiation facility to qualify for the issue of regulatory consent at every stage. Prior to issuance of licence for operation of a NPP, AERB ensures that the approved emergency preparedness plans are in place and tested.

(ii) The Safety Code "Safety in Nuclear Power Plant Operation" (AERB/SC/O, 2008) stipulates the requirement for development of an emergency preparedness plan and maintenance of a high degree of emergency preparedness by the licensee. The emergency preparedness programme shall provide reasonable assurance that, in the event of an emergency situation, appropriate measures will be taken to mitigate the consequences. This programme has to be in force before commencement of operation.

(iii) The Safety Code on "Radiation Protection for Nuclear Fuel Cycle Facilities" (AERB/NF/SC/RP 2012) stipulates the requirements for providing adequate assurance for radiation safety of the occupational workers, members of the public and the environment against the undue exposure to ionising radiation. It also specifies the requirements for establishing emergency preparedness program and the roles and responsibilities of the various agencies.

(iv) The Safety Guide "Role of the Regulatory Body with Respect to Emergency Response and Preparedness at Nuclear and Radiation Facilities" (AERB/SG/G-5, 2000) describes the role of the AERB with respect to emergencies at nuclear and radiation facilities. It provides necessary information intended to assist the facilities, and other participating/ collaborating agencies, to fulfil the requirements stipulated in the Code. It also elaborates on AERB's review and approval process of the emergency response and preparedness plans formulated by the nuclear and radiation facilities and the review of the reports of the emergency exercises carried out to assess the adequacy of the response plans and the associated preparedness.

(v) The Safety Guide "Intervention Levels and Derived Intervention levels for Off-Site Radiation Emergency" (AERB/SG/HS-1, 1993) provides guidance on the Intervention Levels (ILs) and Derived Intervention Levels (DILs) for initiating countermeasures in the public domain following a nuclear accident or radiological emergency. The document has been recently revised in line with IAEA safety standards and is currently under review.

(vi) The Safety Guide "Preparedness of the Plant Management for Handling Emergencies at NPPs" (AERB/SG/O-6, 2000) supplements the Code of Practice on Safety in NPP Operation. It covers the important considerations relevant to the preparation and implementation of EPR plans by the Plant Management.

(vii) The Safety Guide "Preparation of Site Emergency Plans for Nuclear Installation" (AERB/SG/EP-1, 1999) provides the regulatory requirements for preparing and maintaining an emergency response plan for Site Emergency.

(viii) The Safety Guide "Preparation of Off-Site Emergency Plans for Nuclear Installation" (AERB/SG/EP-2, 1999) provides necessary guidelines for preparation of Off-Site EPR plan. The document has been recently revised and is currently under review.

In addition to the above, the National Disaster Management Authority (NDMA) has issued guidelines for 'Nuclear and Radiological Emergencies in Public domain' in 2009 for effective management of Nuclear and Radiological emergencies.

16.2 EMERGENCY PREPAREDNESS AND RESPONSE PLANS

Successful demonstration of Emergency Preparedness and Response (EPR) plans is a mandatory requirement for granting license for operation of NPPs. AERB ensures that necessary EPR plans are in place and they are successfully demonstrated before issuing regulatory consent for First Approach to Criticality. The regulatory oversight during plant

operation assures that the provisions and procedures to implement these plans are maintained up-to-date and tested periodically. EPR plans cover all emergency situations envisaged so that a graded response consistent with the gravity of the situation can be ensured. AERB reviews and approves the EPR plans and procedures in order to ensure that sufficient means exist to cope with an emergency as per the regulatory requirements. AERB evaluates all the elements of the EPR plans such as emergency detection, classification, decision making, notification, communication, projected dose assessment and ensures the periodic revision. Main features of the EPR plan are as follows:

16.2.1 Zoning Concept and Emergency Planning

For drawing up the emergency preparedness plans, the area around NPPs is divided into three zones as follows:

i) Exclusion Zone

It is an area extending upto a specified radius around the plant, where no public habitation is permitted. This zone is physically isolated from outside areas by fence and is under the control of the Plant Management.

ii) Natural Growth Zone

It is the annulus around the Exclusion Zone and upto 5 km radius from the plant, where only natural growth of population is permitted and developmental activities which lead to growth of population are under administrative control.

iii) Emergency Planning Zone

Emergency Planning Zone (EPZ) is defined as the area around the plant upto 16 km radius providing a basic geographic framework for decision making for implementation of protective measures. The EPZ is divided into 16 equal sectors to provide the maximum attention and relief to the regions affected during an Off-Site emergency.

16.2.2 Classification of Emergencies

In accordance with the severity of the potential consequences, emergency situations are graded as Plant Emergency, Site emergency and Off-site emergency.

i. Plant Emergency

It is an emergency condition in which the radiological/other consequences are confined within the plant or a section of the plant. Plant Emergency Director (Station Director) is identified as the responsible person for the declaration and termination of a plant emergency.

ii. Site Emergency

It is an emergency condition in which the radiological consequences are confined to the exclusion zone of the site. An assessment of such a situation would imply that protective measures are limited to the site boundary only. Site Emergency Director (SED) is the responsible person for the declaration and termination of a Site emergency. For twin unit site, Station Director and for multi unit site, Site Director is identified as SED.

iii. Off-Site Emergency

It is an emergency condition in which the radiological consequences originating from NPP are likely to extend beyond the site boundary (exclusion zone) into the public domain. Off-Site Emergency Director (District Authority / Head of the Local Government) is identified as the responsible person for the declaration and termination of an Off-Site emergency.

16.2.3 Features of On-Site EPR Plan

The Plant Management establishes and maintains the necessary emergency resources and procedures for implementation of Plant and Site EPR plans. The onsite EPR plan includes criteria for declaration of emergency, duties and responsibilities of relevant key personnel, infrastructure for emergency response, mock exercises, and training of plant personnel & public authorities. Main elements of On-site EPR plan are detailed below:

16.2.3.1 Criteria for declaration of emergency:

Plant/ Site emergency is declared by SED if the plant condition is such that actual or projected dose within the plant/site boundary is likely to reach emergency reference level as specified in the EPR plan.

The emergency is terminated by SED after ensuring that the following conditions are met:

i. The plant condition is under control
ii. The sources of incident causing emergency within the plant have been located and confined/ restricted.
iii. Effluent releases from the plant are within acceptable limits.

16.2.3.2 Infrastructure for On-Site Emergency Response

The infrastructure available for conducting various emergency response actions in a systematic, coordinated, and effective manner is as follows:

i. Plant Control Room

In case of plant emergency, the plant control room is identified as the centre to handle emergency operations. Further, in case of site emergency, the plant control room provides first hand information about the emergency situation to the Site Emergency Committee (SEC). If for some reason, the main control room becomes uninhabitable, the status of plant can be monitored from the backup control room.

ii. Site Emergency Control Centre (SECC)

An Emergency Control Centre (ECC) for Site Emergency is suitably located away from the plant but within the site, for use by the Site Emergency Committee to direct emergency actions. Further, it is used for coordinating with off-site emergency authorities, so that control room staff is not distracted from performing control room operations. This facility houses emergency equipment centre, treatment area, personnel decontamination area and has sufficient space to accommodate SEC members, rescue teams, health physics staff, emergency maintenance unit staff, stores and industrial safety group. It is equipped with communication systems, public address system, emergency equipment/instruments, standard operating and emergency procedures, design basis reports, P&I diagrams, maps of EPZ, potassium iodate tablets, isodose curves etc for undertaking emergency response actions.

iii. Communication System

The NPPs have diverse communication systems which are available for emergency purpose. Direct communication link is available between the emergency control centre, fire station and plant control room for communication within the plant. In addition, during on-site emergencies NPCIL Headquarters, CMG-DAE, AERB and District Authorities with Off-Site/ local government are required to be kept informed for which, NPPs have redundant and independent communication system in place. The contact details of the identified key personnel are maintained and updated from time to time by the NPPs. Siren and announcement system with adequate number of points for warning the plant personnel are available. The declaration and termination of emergency is done though this system. Communication system includes wireless, telephone, radio sets, satellite communication and electronic mail facilities which are tested daily to ensure their availability. These systems are available for use at all times.

iv. Emergency Equipment and Protective Facilities

Various equipments required for emergency management are kept available in the NPP. To protect the plant personnel essential facilities such as plant assembly areas, emergency shelters, first-aid centre, treatment areas, de-contamination kits, prophylactics, respirators, ambulance etc are provided within the site area. In addition, for monitoring the radiological conditions, the required number of instruments such as GM survey meter, teletector, iodine sampler, contamination monitor and emergency survey vehicle etc are available.

16.2.3.3 Roles and Responsibilities for On-Site Emergency Response

For management of on-site emergency in an effective manner senior officers of the NPP are identified and various teams/groups are formed. These teams/groups are responsible for specific actions such as advisory, services, damage control, search, rescue, radiation monitoring, medical, transportation, environmental survey etc. For effective coordination between these teams a Site Emergency Committee is constituted with heads/ responsible persons from various sections of the plant. Station Director is the head of the Site Emergency Committee. The duties and responsibilities of key personnel are well defined in the Site emergency plan.

16.2.4 Features of Off-Site EPR Plan

The offsite emergency plan includes details about site characteristics, procedures for declaration of emergency, duties and responsibilities of relevant key personnel, infrastructure for emergency response, requirements for exercises, and training of plant personnel & public authorities / Local Government. Main elements of off-site EPR plan are as detailed below:

16.2.4.1 Site Characteristics

The site characteristics that need to be detailed in the emergency preparedness plan are specified in the AERB guide “Preparation of Off-Site Emergency Preparedness Plan for NPPs” (AERB/SG/EP-2). This broadly covers geographical, meteorological and demographic characteristics of the site. In addition, arrangements for evacuation taking into consideration the condition of main and alternate routes, shelter points, adverse weather condition, and traffic congestion etc are covered.

16.2.4.2 Criteria for Declaration of emergency

Off-site emergency is declared if the actual or projected releases are likely to reach Derived Intervention level (DIL) prescribed in the AERB safety guide “Intervention levels and Derived Intervention levels for Off-Site Emergency” (AERB/SG/HS-1). The intervention levels are expressed in terms of quantities that are directly measurable i.e. exposure rate from ground deposited activity and activity concentration in food stuff and water.

16.2.4.3 Infrastructure for Off-Site Emergency Response

The infrastructure for conducting the emergency response actions in a systematic, coordinated, and effective manner is as follows:

i. Off-Site Emergency Control Centre

An Emergency Control Centre for the off-site emergency is located outside the exclusion zone. This is equipped with the required facilities for handling off-site emergency response operation and is used during Off-Site emergency for monitoring and directing off-site emergency response operation.

ii. Communication System

The Off-Site Emergency Control Centre of NPPs have redundant and independent communication systems for communication with NPCIL Headquarters, CMG-DAE, AERB and other concerned authorities/agencies. Emergency Communication Rooms (ECRs) are maintained at Mumbai at two different locations. The ECRs are equipped with wireless, telephone, facsimile, satellite communication and electronic mail facilities which are tested daily to ensure their availability.

iii. Assessment Facilities

The facilities required to assess the nature and severity of a radiation incident and its impact on the environment are available at the NPP Site. These include environmental survey vehicles, radiation survey and contamination monitors, dosimeters, meteorological data loggers, iso-dose curves, air samplers, maps, standard operating procedures, design basis reports, process & instrumentation diagrams.

iv. Radiation Monitoring during Emergency

Detailed procedures and the required capability for radiation monitoring of the affected population and area during an emergency are available at the Environmental Survey Laboratory (ESL) attached to each NPP site. Meteorological information and model predictions to determine the geographical area likely to be affected by the release of radioactive material provided by ESL is utilized to identify the monitoring and sampling locations. Radiological data required for taking decision on implementation of countermeasures with reference to corresponding intervention levels are generated.

v. Emergency Equipment and Protective Facilities

Various equipments required for emergency management are kept available in emergency equipment centre located in the plant as well as offsite emergency control centre. The equipments such as ambulance, decontamination kits, respirators, emergency equipment kit, and emergency power supplies are kept in working condition. In addition, for monitoring the radiological conditions, the required number of instruments such as, GM survey meter, teletector, iodine sampler, contamination monitor and emergency survey vehicle etc are available at NPPs and Off-Site Emergency Control Centre.

To protect the plant personnel, site personnel and members of public during emergency situation, facilities such as plant assembly areas, temporary shelters, first-aid centre, decontamination centre, radiation emergency ward, prophylactics, thermo luminescence dosimeters (TLDs), direct reading dosimeters (DRDs) and protective clothing etc are available.

16.2.4.4 Roles and Responsibilities for Off-Site Emergency Response

EPR plans, wherein the roles and responsibilities of various agencies are defined, have evolved over the years for the existing NPPs. There is Off-site Emergency Committee headed by the Collector of the concerned District and supported by district subcommittees which ensures implementation of counter measures such as, sheltering, distribution of prophylaxis, evacuation, providing civil amenities and maintaining law and order. The role of National Crisis Management Committee (the apex committee comprising Secretaries of various Ministries) associated with managing the crisis and having control over the resources of the relevant Ministries are also defined.

Government of India has enacted Disaster Management Act in December 2005 for prevention and mitigation of all the disasters including Nuclear and Radiological Emergencies and formed National Disaster Management Authority (NDMA) as the apex body for implementation of its provisions. For effective management of Nuclear and Radiological emergencies NDMA has issued guidelines for 'Nuclear and Radiological Emergencies in Public domain' in 2009 and Incident Response System in 2010.

The roles and responsibilities of various agencies involved in EPR plan for Off-site Emergency are as follows:

i. National Level

The national agencies such as NDMA, NCMC and others have a role in management of all types of disasters including radiological/ nuclear emergency which is as follows:

a. National Disaster Management Authority (NDMA) - NDMA, the apex body is headed by the Prime Minister of India and has the responsibility for laying down policies, plans and guidelines for disaster management in the country. NDMA assists the Central Ministries, Departments and States to formulate their respective disaster management plans. This provides National level organized response for assistance, harmonised approach to command and control responses in case of disasters including Nuclear Disaster.

National Disaster Response Force (NDRF) is constituted under NDMA for handling all kinds of disasters. This is a multi- disciplinary, multi-skill, high-tech force. Ten battalions have been equipped and trained for handling natural disasters including four battalions for combating nuclear disasters.

b. National Executive Committee (NEC) - NEC is the executive committee of the NDMA with Union Home Secretary as the Chairperson. NEC is mandated to assist the NDMA in discharge of its functions and also to ensure compliance of the directions issued by the Central Government. The role of NEC is to coordinate the response in the event of any threatening disaster situation or disaster. The NEC will prepare the National Plan for DM based on the National Policy. The NEC will monitor the implementation of guidelines issued by NDMA.

c. National Crisis Management Committee (NCMC) - The NCMC, under the Cabinet Secretary, is mandated to co-ordinate and monitor the response to crisis situations, which includes all disasters. The NCMC consists of 14 union secretaries of the

concerned ministries including the Chairman, Railway Board. NCMC provides effective co-ordination and implementation of response and relief measures in the wake of disasters. It will be supported by the Crisis Management Groups (CMG) of the Central Nodal Ministries and assisted by NEC as may be necessary. The Secretary, NDMA will be a permanent invitee to NCMC.

d. Crisis Management Group (CMG), DAE - Department of Atomic Energy (DAE) is the nodal agency in the country for providing technical expertise / guidelines in the country for managing nuclear and radiological emergencies in the public domain. For this purpose, a Crisis Management Group (CMG) has been established since 1987. In the event of "Off-Site Emergency", all the Members and Alternate Members of the CMG, DAE, Key Officials in Mumbai, and the Secretary (Security), Cabinet Secretariat will be intimated. The Secretary (Security) is the contact point for DAE with the NCMC.

During nuclear and radiological emergency situation, CMG, DAE will co-ordinate between the local authority in the affected area and the National Crisis Management Committee (NCMC), at the Cabinet Secretariat, which is chaired by Cabinet Secretary. In accordance with the action plan of the NCMC, Secretary, DAE is co-opted as one of its member in the event of any major radiation emergency in the public domain.

e. Technical Support Organisation (TSO) - Director, Health, Safety & Environment Group, BARC who is the ex-officio Emergency Response Director (ERD), DAE will be the lead co-coordinator for providing the radiation measurement, monitoring and protection services to the CMG, DAE. A network of twenty-two radiation Emergency Response Centres (ERC) equipped with adequate radiation measuring and personnel protective equipment and trained Emergency Response Teams have been established by Department of Atomic Energy (DAE) in different parts of the country to respond to nuclear and radiation emergency situations. ERD also establishes the Standard Operating Procedures (SOPs) and co-ordinates with the concerned responsible officers of various locations. During nuclear and radiological emergency situation, the ERC closest to the site of the incident, will be activated by the ERD.

The HS&E group, BARC has established Indian Environmental Radiation Monitoring Network (IERMON) at various parts of the country and with central monitoring station located in Mumbai. IERMON provides online environmental radiation information during both normal and emergency situations.

f. Environment Survey Laboratory (ESL) - A well-equipped Environment Survey Laboratory (ESL) is established at each nuclear power plant site by HS&E group of BARC (TSO) well before the commissioning of the plant and continues to remain functional during the operational phase of NPP. ESL is equipped with environmental radiation monitoring during an emergency situation. During nuclear emergency ESL initiates environmental surveillance outside the exclusion boundary for monitoring any change in environmental radiation levels. It also provides information on meteorological data such as wind speed, wind direction and temperature of the site. It undertakes extensive environmental sampling and radiation surveillance in the affected sectors to facilitate decisions regarding protective measures to be implemented in the public domain.

g. Atomic Energy Regulatory Board (AERB) - AERB lays down the requirements and provides guidance for preparation of EPR plans. It reviews the EPR plans prepared by the NPPs and recommends for approval by the District authority / Local Government. It ensures EPR plans are in place prior to the operation of NPP and are

periodically updated. Periodic inspections are carried out to ensure that the arrangements and infrastructure for effective emergency response are in place. It further ensures that the plans are tested through periodic exercises as prescribed by AERB codes and guides and takes part as an observer. During nuclear emergency, AERB keeps a close watch on the affected NPP, continuously monitors the situation and provides the required advice to CMG-DAE and necessary information to public.

ii. State Level

The State Disaster Management Authority (SDMA) headed by the Chief Minister of the State as Chairperson lays down policies and plans for Disaster Management in the State. It approves the State Plan in accordance with the guidelines laid down by NDMA, coordinates the implementation of the State Plan, recommends provision of funds for mitigation and preparedness measures and reviews the developmental plans of the different departments of the State to ensure integration of prevention, preparedness and mitigation measures.

Each State Government constitutes a State Executive Committee (SEC) to assist the SDMA in the performance of its functions. The SEC is headed by the Chief Secretary (CS) to the State Government, coordinates and monitors the implementation of the National Policy, the National Plan and the State Plan. The SEC also provides information to the NDMA relating to different aspects of Disaster Management.

iii. District Level

All the decisions related to management of emergency in public domain are taken and executed by the Off-Site Emergency Committee. The Chairman of the Off-site emergency committee is the officer-in-charge of the local government authority (District Magistrate) and is responsible for declaration/ termination of an Off-site Emergency, in consultation with the Site Emergency Director, who is a Member of the Off-site Emergency Committee.

DDMA acts as the planning, coordinating and implementing body for management of all types of disasters at district level. DDMA is headed by the District Magistrate, District Collector (DC), Dy. Commissioner as the case may be. It takes all necessary measures for the purposes of disaster management in accordance with the policies and plans laid down by SDMA. The DDMA will also ensure that the guidelines for prevention, mitigation, preparedness and response measures laid down by SDMA are followed by all departments of the State Government at the district level and the local authorities in the district.

16.2.5 Training and Exercise

The required emergency preparedness is maintained by organizing refresher training courses for site and off-site personnel at regular intervals. This includes conducting periodic rehearsals/mock exercises involving all concerned personnel of both site and off-site, updating plant emergency procedures at a specified frequency, making suitable changes in the plan in the light of periodic reviews based on emergency exercises and keeping all emergency equipment and accessories in ready state.

i Training

Appropriate training is imparted at regular intervals to all employees of the NPP, to familiarize them with actions that should be taken during an emergency. Similar training courses are also organized for various Public Authorities. Public awareness programmes are organised for various public authorities and members of public for familiarisation on radiation protection procedures and response actions during emergency.

Training programmes have been organised for training of National Disaster Response Force (NDRF) personnel in radiation protection procedures and response actions during nuclear and radiation emergency. The training is also aimed at qualifying persons to act as trainers in their respective battalions. An arrangement has been put in place through which the training needs of personnel are identified by NDRF and special training and awareness programmes are arranged as necessary with support from BARC, NPCIL and AERB.

ii Exercises

Exercises are conducted at regular intervals and all concerned agencies take part. Exercises are used for the twin purposes: a) familiarize all the personnel concerned with the management and implementation of emergency measures b) assess the adequacy of EPR plans and improve them based on the feedback from exercises. It is also ensured that each Shift Crew of the plant takes part in these exercises at least once a year. The site emergency exercises and off-site exercises are conducted in accordance with the frequency prescribed by AERB. The frequency of plant, site and offsite emergency exercises are once in three months, once in a year and once in two years respectively. The observations made in each exercise are discussed in the Station Operation Review Committee (SORC) meeting and deficiencies are promptly corrected.

In emergency exercises, hypothetical events resulting in off-site radiological implications are considered and efficacy of protective measures such as sheltering, distribution of prophylactics, sample evacuation is tested. Off-site exercises are conducted once in every two years at each site as per regulatory requirements. Based on the feedback from review of the exercise results, improvements in the infrastructure and other facilities are initiated, if necessary. Compliance to these aspects are further verified by AERB.

16.3 IMPLEMENTATION OF OFF-SITE EMERGENCY MEASURES

The emergency measures consist of actions with respect to declaration of emergency, assessment of situation, corrective actions, mitigation, countermeasures and control of contamination. These are detailed in the Off-site EPR plan and are described below:

16.3.1 Emergency Actions

The general sequence of actions during an emergency:

i. Declaration of emergency

At the incipient stage of an accident, based on the adverse plant conditions, plant emergency is declared by Shift Charge Engineer as per the criteria specified in the EPR plan. If the condition further worsens and if actual or projected releases are likely to be within the site boundary, Site Emergency Director (SED) declares the Site Emergency. At this stage, the Offsite Emergency Director (OED) is alerted about the possible escalation of Site Emergency in to Off-Site Emergency. If the situation further worsens, SED advises the OED to declare Off-Site emergency in the affected sector of emergency planning zone.

ii. Assessment Action during Emergency

The assessments of the plant conditions and likely radiological releases are made to enable planning corrective actions and timely implementation of protective measures. The information used for assessment is based on plant parameters available in the main control room, radiation surveys, environmental surveys, meteorological data among others. Each NPP has established facilities to continuously monitor the wind and weather conditions and

to obtain dose projections in the public domain that could form the basis for determining the suitable protective measures. Provisions are also available for establishing the source term by actual measurement. In addition, the information from the Indian Environmental Radiation Monitoring Network (IERMON) is used for assessment of radiation levels in the public domain.

iii. Co-ordination among various agencies

On receiving the information of Offsite emergency from Station Management, CMG of DAE will be activated. While the offsite emergency director will initiate actions as per action plan for handling the emergency in public domain, the CMG will continue to provide necessary coordination between local authorities in the affected areas, the NDMA and National Crisis Management Committee (NCMC) and will provide necessary technical support and directions to the authorities responsible till the emergency conditions are terminated. On the prevailing situation at incident site, the information to the media and other agencies will be given by Information and Media Officer appointed by District Collector/Incident Commander.

iv. Corrective Actions

These actions are taken to correct the plant abnormal situation and to bring the plant under control. Various corrective actions are taken in accordance with the approved Emergency Operating Procedures existing in the plant.

v. Protective Measures

These are actions taken to mitigate the consequences of a radiological event and to protect site personnel, members of public and livestock from radiation. These include sheltering, administration of prophylactics, control on consumption of contaminated foodstuff and evacuation. It is essential to ensure that the response measures would reduce the overall impact on public to a level significantly lower than what it would be in the absence of such measures. The EPR plan gives details of the protective measures and the intervention levels approved by AERB for initiating protective measures to limit radiation exposures.

Evacuation is an extreme measure taken after evaluating the risks and benefits of this countermeasure in terms of the averted dose. If radiation levels in the affected zone continue to exist beyond acceptable levels, then relocating the affected population is resorted to.

vi. Contamination Control

The contamination control measures include segregation of contaminated persons and decontaminating them, decontamination of vehicles, regulating the traffic, access control to prevent unauthorized entry to affected zone, confiscation of contaminated food stuff and supplying fresh food, banning fishing in contaminated sea/river water, banning the consumption of contaminated water and supplying fresh water, identification of contaminated areas requiring excavation and disposal of contaminated soil, decontamination of contaminated dwellings or their disposal, and destroying the contaminated crops and grass.

16.3.2 Assistance to Affected Personnel

In the event of an emergency, the plant management is responsible for providing all necessary assistance to the affected plant personnel in respect of their treatment, sheltering and evacuation as necessary. The responsibility for providing assistance to persons in the public domain rests with the district authority and state government.

i First-aid

Each NPP site has at least one fully equipped first aid centre manned round the clock by trained personnel for providing first aid to the injured/contaminated persons. This is located as close as possible to the personnel decontamination centre.

ii Decontamination

Monitoring the contamination and carrying out decontamination of personnel, equipment, facilities and areas within plant and site is the responsibility of the plant management. It is also responsible for setting up fixed and mobile facilities for carrying out decontamination with adequate supply of water. While it is the responsibility of the district authorities to set up such facilities in the public domain, the actual operations are carried out by incident response team under the guidance of the plant management.

iii Transportation

All necessary resources for transport are mobilized within the plant in the shortest possible time in case of a site emergency to undertake evacuation of non-essential staff. This is done under the supervision of plant management. Adequate stock of diesel oil and petrol is maintained at the NPP at all times to face such an eventuality. Organizing the transport for evacuees in the affected sectors in the public domain is the responsibility of OED. The district authorities are empowered to mobilize even private vehicles, if found necessary.

iv Medical Treatment

The injured and affected site personnel will be treated as necessary in radiation emergency treatment wards in the hospitals managed by site. These wards are equipped with necessary instruments, medicines, operating theatres, beds, decontamination centres etc. and are operational at all times.

The responsibility for treatment of affected persons in the public domain rests with the District Health Authority. However, any guidance needed in the treatment of radiation injuries will be provided by experts of the medical division of the NPP and the Department of Atomic Energy.

16.4 REGULATORY REVIEW AND CONTROL

Appropriate laws, regulations and requirements regarding emergency preparedness as applicable to NPPs are in place and are being complied by the NPP. Adequate regulatory control is exercised by AERB through regulations, review/approval of EPR plans of the NPPs and taking part in the emergency exercises. The EPR plans are updated and maintained taking into account the change in population, demographic conditions and infrastructures in the emergency planning zone. The implementation of emergency plans has to be demonstrated before criticality of the unit. For multi-unit site the plant / site / offsite emergency plans have to be revised before granting construction consent to a new facility.

Periodic Off-site emergency exercises are carried out as per the regulatory requirements and are witnessed by AERB observers to ensure that the emergency planning is adequate and its implementation is effective. The periodic regulatory inspections of the NPPs are carried out to ensure the following:

i. Availability of the updated emergency preparedness plans
ii. Availability of various communication facilities and their periodic testing;
iii. Inventory of equipment at the emergency control centres and their maintenance;
iv. Availability of trained manpower for emergency actions;

v. Availability and maintenance of support facilities like fire fighting equipment, ambulance, first-aid, decontamination, and off-site storage of prophylactics, arrangements for medical management of exposed personnel and other resources.
vi. Rectification of deficiencies observed during previous emergency exercises and regulatory inspections.

16.5 REVIEW AND REVISION OF EPR PLANS POST FUKUSHIMA ACCIDENT

Subsequent to Fukushima accident, AERB made re-assessment of the current EPR plans, regulatory documents for EPR, infrastructure to support EPR actions etc. Mock exercises were conducted at all the NPPs with representatives from NDMA, CMG, AERB and NDRF with public involvement (Fig. 16.1) . Areas for improvements with respect to EPR were identified. The actions resulting from this re-assessment are as follows:

16.5.1 Revision of regulatory documents on EPR

Subsequent to the Fukushima accident, AERB made a re-assessment of the requirements prescribed in the AERB codes and guides for emergency preparedness. Based on these assessments the AERB guide “Preparation of Off-site Emergency Preparedness Plan (AERB/SG/EP-2) revision of which was already in progress to incorporate NDMA guidelines, was extended to address the following:

i. Implementation of Decision Support System (DSS) at NPPs
ii. Establishment of On-Site Emergency Support Centre at NPPs
iii. Establishment of Nuclear and Radiological Emergency Monitoring Cell in AERB

AERB safety guide “Intervention Levels and Derived Intervention Levels for Off-site Emergency (AERB/SG/HS-1) is also being revised to be in line with the IAEA GS-G-2 (2011) and GSR part 7. The criteria specifies protective and other response actions in precautionary action zone (PAZ), urgent protective action planning zone (UPZ), extended planning distance (EPD) and ingestion and commodities planning distance (ICPD) which will replace the existing Space-Time Domain criteria.

Subsequent to the revision of these AERB guides, the Off-site Emergency Response Plan will be revised taking the above into consideration.

16.5.2 Planned Enhancement of infrastructure for Emergency Preparedness

It is planned to strengthen EPR plan by enhancing the infrastructure such as:

i. On-Site Emergency Support Centre at NPPs

A centralized On-Site Emergency Support Centre common to all NPPs at a site is envisaged to be constructed within the exclusion zone. This facility will have capability to withstand earthquake and flood of magnitudes larger than their respective design basis for the NPP. The building will be designed with requisite shielding for protected stay of response personnel for extended duration. From this facility all actions required for controlling the plant parameters for accident management will be coordinated. This will be self sufficient with following features:

- Resting provisions for about sixty persons equipped with food and drinking water facilities for seven days
- Availability of selected plant data from all NPPs at the site including onsite/offsite radiation data.

- Infrastructure such as Diverse communication means, Dedicated air cooled diesel generators, Dedicated survival ventilation system, First aid facilities etc

ii. Decision Support System

Decision Support System (DSS) for nuclear emergencies is intended to provide comprehensive and timely information to emergency managers on an emergency situations arising from a nuclear accident. Based on the radiological monitoring and meteorological conditions, the DSS estimates the projected public dose. These estimates are used to decide appropriate protective actions in the public domain such as administering Iodine prophylaxis, sheltering, areas requiring evacuation.

Two decision support systems are installed, one each at NAPS and MAPS sites on experimental basis. Based on the review of these systems, it is intended to provide DSS at all NPP sites.

iii. Nuclear and Radiological Emergency Monitoring Cell

During nuclear and radiological emergency situation, it is essential for AERB to obtain up to date information about the emergency situation in the NPP, radiological safety of the emergency plant workers, public and the environment in a more formal and continuous basis.

To facilitate this, Nuclear and Radiological Emergency Monitoring Cell (NREMC) at AERB is being established. This facility would contain the required infrastructure and communication facilities, documents and protocols to obtain the information during emergency condition from NPPs and ESL.

NREMC consists of experts to review and assess the emergency situation and also to collect important information including radiation status of the plant, site and off-site. Based on the available information the NREMC will oversee and review the emergency management action / mitigative measures performed by various responsible agencies.

iv. Capacity Building Measures

Training programmes have been organised for National Disaster Response Force (NDRF) personnel in radiation protection procedures and response actions during nuclear and radiation emergency. Ten battalions have been equipped and trained for natural disasters including four battalions for combating nuclear disasters. An arrangement has been put in place through which the training needs of personnel are identified by NDRF and special training programmes are arranged as necessary with support from BARC, NPCIL and AERB.

16.6 INFORMATION TO PUBLIC AND NEIGHBOURING COUNTRIES

16.6.1 Information to Public

Regular training courses are arranged by each NPP for the general public in the surrounding areas by inviting them to the plant. The course contents include an introduction to atomic energy, safety in nuclear industry and about emergency response plan in that nuclear power plant. As a part of this public awareness programme, visits to the Emergency Control Centre and the Environmental Survey Laboratory are also arranged. As a means of creating better public awareness on this subject, a short list of ‘do’s and don’ts’ during a emergency is distributed to the general public.

Emergency preparedness plan provides guidance for communication during an emergency with the media and the public about the incident, its consequences, protective

measures taken by the authorities and advice to the public in the affected and adjoining regions. A pre-designated Information Officer makes arrangements for the reception of media and information briefing.

16.6.2 Transboundary Implications

As per the Indian regulation, the planning for emergency preparedness is carried out for the EPZ, which is designated up to a radial distance of 16 km from the NPP. The population in this zone is kept informed on emergency planning and response. The neighbouring countries are at large distances from the location of operating NPPs and projects under construction. Export of food items will be subjected to thorough contamination checks and clearance in accordance with the international guidelines. Hence, no transboundary implications are expected.

16.7 PARTICIPATION IN IAEA EMERGENCY EXERCISES

India is signatory under the Convention on Early Notification of Nuclear Accidents and Convention on Assistance in case of Nuclear Accident of Radiological Emergency. Under these Conventions India actively participates in the Emergency exercises though CMG-DAE, the national contact point. In the last three years, India participated in two ConvEx- 2b exercises in April 2011 and June 2013.

16.8 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

Appropriate laws, regulations and requirements regarding emergency preparedness as applicable to NPPs are in place and are being implemented by the utility. Adequate regulatory control is exercised by AERB, through regulations, regulatory inspections, approval of emergency response plans of the utilities and taking part in the emergency exercises. Therefore, India complies with the obligations of the Article 16 of the Convention.

Fig. 16.1 Glimpses of Emergency Preparedness Exercises

ARTICLE 17: SITING

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

i. for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;

ii. for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;

iii. for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;

iv. for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their territory of the nuclear installation.

17.0 GENERAL

The present statutory provisions permit only the Central Government or a company established by the Central Government to set up NPPs in India. Standing Site Selection Committee (SSSC) carries out first order assessment of the site and evaluates the suitability of the various sites proposed by concerned state governments taking into account site related factors such as availability of adequate land, cooling water availability, foundation conditions in general and natural hazards in broad way, in addition to socio economic scenario, available infrastructure, population distribution, land use, etc. Based on the recommendation of the SSSC, the Central Government conveys in principle approval of the site.

Setting up of NPPs requires environmental clearance from Ministry of Environment and Forests (MoEF), as per the requirement of Environmental Protection Act 1986, other clearances from Central and State level agencies like National Airport Authority, State Maritime Boards, Ministry of Defence and Ministry of External Affairs, as appropriate besides the agencies mentioned in chapter on Article-7.Utility is also required to obtain siting consent from AERB.

The regulatory consent for siting involves review of the various site/plant related safety aspects. The mechanism of review is brought out in chapter on Article-14 on ‘Assessment and Verification of Safety’. AERB Code of practice on safety in NPP siting, AERB/SC/S, establishes the requirements for evaluation of a site from safety considerations. Several safety guides issued under the code provide guidance for meeting these requirements. A site is considered acceptable, when all the site related issues have been satisfactorily resolved, thus giving assurance that the proposed NPP can be built and operated such that the risk to the public and the environment is within acceptable limits.

17.1 EVALUATION OF SITE RELATED FACTORS AFFECTING SAFETY

Based on the requirements specified in the AERB code on Siting (AERB/SC/S), utility prepares a site evaluation report covering:

i. Site characteristics and effects of external events on the installation.

ii. Impact of the installation on site environment and population.
iii. Factors affecting implementation of emergency measures in public domain.

In addition, the site evaluation report provides brief design information on the proposed project. It should also provide an overview of the proposed NPP. The information helps in evaluating the given site in relation to the type, capacity, number of units etc. It also includes overall safety approach, dose limits, bases for emergency preparedness and offsite power supplies.

The regulatory review and assessment of Site Evaluation Report is carried out to determine the potential consequences of interaction between the plant and the site and the suitability of the site for the proposed plant from the point of view of safety. It also includes assessment of availability of roads & access features for emergency response purposes and aspects on security measures with reference to site characteristics.

The significant areas of review and assessment as per AERB safety guide AERB/SG/G-1:2007 on "Consenting Process for Nuclear Power Plant and Research Reactor" are as follows:

i. Geology and soil mechanics
ii. Topography
iii. Hydrology and hydro-geology
iv. Meteorology
v. Natural phenomena such as earthquakes, floods, tsunamis and tornadoes
vi. Potential external man-induced events such as plane crashes, fires and explosions
vii. Failure of man-made structures such as dams and sea walls
viii. Availability of water for plant cooling and ultimate heat sink
ix. Reliability of off-site electrical power

The effect of various site parameters on engineerability of the site in the context of external and man induced events is assessed. For an external event (or combination of events) the choice of values of the parameters upon which the plant design is based should ensure that structures, systems and components important to safety in relation to that event (or combination of events) will maintain their integrity and will not suffer loss of function during or after the design basis event.

Design provisions against external events (human made and natural occurring) are based on the following considerations:

i. Design basis earthquake ground motion (i.e. peak ground acceleration, response spectrum and spectrum-compatible time history) considering site seismicity and seismotectonics of the region along with specific site conditions. If there is an evidence of a capable fault within a distance of 5 km from the reactor centre or other geotechnical hazards with no practical engineering solutions, the site is deemed unacceptable.

ii. Design basis meteorological parameters such as wind, precipitation, temperature and storm surges including potential missile hazard associated with tropical cyclones.

iii. Design basis flood considering natural causes such as run-off from precipitation, high tide, storm surge or from earthquake induced water waves (tsunamis and seiches) or failure of upstream dams/barrages, as applicable. Possibility of loss of heat sink functions is also an important consideration. Evaluated for possible erosion of river banks and/or change of river course in case of inland sites and shoreline erosion for coastal sites.

iv. Considerations for aircraft crash, chemical explosions or missile generation in plants in the site region and impact of other activities in the site vicinity such as blasting operations, mining, drilling and sub-surface exploration. If no practical solution is available to mitigate these hazards, the site is rejected.

17.2 ASSESSMENT OF IMPACT OF NPP ON PUBLIC AND THE ENVIRONMENT

Siting consent by AERB and siting clearance from Ministry of Environment and Forests (MoEF) are given after detailed assessment of the impact of NPP on the environment.

17.2.1 Assessment by environmental impact by MoEF

Environmental clearance from the Ministry of Environment and Forests (MoEF) is a precondition for issue of siting consent by AERB. For obtaining environmental clearance from MoEF, Environment Impact Assessment (EIA) Report in a prescribed format is prepared by the utility. The Expert Appraisal Committee (EAC) constituted by MoEF carries out a preliminary review of the EIA report and determines the terms of reference on the basis of the information furnished, site visit if needed and other information that may be available with it. Based on the evolved terms of reference, the utility has to revise the report addressing all the concerns raised by the EAC.

Public Consultation is an essential pre-requisite for obtaining MoEF clearance in the formulation of a project. This process has two components (i) a public hearing at the site or in its close proximity to be carried out in the prescribed manner and (ii) obtaining response in writing from other concerned persons having a plausible stake in the environmental aspects of the project. Public hearing is conducted as per the 'procedure for conduct of public hearing' given in the gazette notification from MoEF. After completion of the public consultation, the project proponent addresses the environmental concerns expressed during this process and makes appropriate changes in the draft EIA and Environment Management Plans.

The EAC carries out the detailed scrutiny of the application and other documents like the final EIA report, outcome of the public consultations including public hearing proceedings, submitted by the applicant to MoEF for grant of environmental clearance. This appraisal is made by the EAC in a transparent manner at a proceeding to which the applicant is invited for furnishing necessary clarifications. On conclusion of this proceeding, the EAC makes recommendations to MoEF for grant of prior environmental clearance on stipulated terms and conditions, or rejection of the application, together with reasons for the same.

17.2.2 Safety Assessment by AERB

The effects of the plant on the environment that could warrant specific design or operational requirements are radioactive effluents (liquid and gaseous), radiation exposure of the public from these effluents and other environmental pollutants. This should be assessed for normal operation, anticipated operational occurrences and accident conditions, taking into account dispersion patterns, present and prospective population distribution, public water supply, milk and food consumption, and radioecology. The acceptable doses to the public are given in chapter on Article-15 (Radiation Protection).

For each proposed site the potential radiological impact on people in the region during operational states and accident conditions is assessed. Base line data required for assessment of radiological impact are collected for various environmental components, viz., air, water, land and biological etc. These include physio-chemical, biological characteristics & activity of ground water and surface water, soil characteristics, composition of vegetation cover, meteorological parameters etc.

The above criteria are implemented as follows:

i. It is mandatory that an exclusion zone, as specified by AERB is established around the plant and this area is kept under the exclusive control of the Plant Management. The public habitation in this area is prohibited. Further, a natural growth zone around the exclusion zone is established and influx of population to this zone is controlled by administrative measures.

ii. The site is required to have good atmospheric dispersion characteristics. An emergency planning zone area is established within 16 km radius of the site. Information on population distribution, land and water use, dietary habits, critical exposure pathways is collected and an appropriate radiological model is established for assessment of dose to members of public.

iii. The Environmental Survey Laboratory is established at every NPP site much before the commencement of operation for conducting the pre-operational studies, generating baseline data and meteorological surveillance during operational phase of NPP.

17.3 RE-EVALUATION OF SITE RELATED FACTORS

During the operating period of the plant, an environmental monitoring programme is established and implemented in accordance with the AERB requirements specified in code of practice in operation and safety guide AERB/SG/O-5, “Radiation protection during operation of nuclear power plants”. At each site, the Environmental Survey Laboratory (ESL) implements the programme. This programme includes comprehensive monitoring of radionuclide contents from various environments to obtain the activity distribution pattern. The samples are collected routinely from specified locations and analysed. Based on the survey and radioactivity data, the public exposure to radionuclide through different routes is estimated. AERB formally reviews the report of ESL with specified periodicity as part of its safety supervision.

As mentioned above, the planned expansion of activities in the natural growth area is regulated by legislative measures or administrative measures by the state government/local authorities etc.

At the time of PSR, following elements are comprehensively reviewed to determine the continued safety acceptability of the nuclear installation, taking account of changes, if any, in site-related factors given below:

i. Changes in use of land areas around the site
ii. Local population distribution
iii. Off-site population distribution
iv. Site characteristics, particularly flood and seismic
v. Local meteorological conditions.

In addition, the external events taking place at the site are reviewed to check that these are within the design basis of the nuclear installation. Based on the review, the need for providing any additional features is also identified.

17.4 REVISION OF SITING REQUIREMENTS BASED ON OPERATING EXPERIENCE

The requirements for siting assessment of nuclear facilities as given in the AERB code on Siting (AERB/SC/S:1990) are being re-drafted taking into account operating experience feedback, lessons learned from Fukushima accident, review methodologies and regulatory requirements worldwide. The IAEA safety standard “Site evaluation for nuclear

facilities: safety requirements" No NS-R-3, is extensively used in revising the AERB code The major aspects being considered for inclusion as part of revision of this code are as follows:

i. Higher return periods of external events for derivation of design basis including consideration for climate change.

ii. Uncertainty analysis during evaluation of hazard due to external events.

iii. External flood protection requirements for sites located along estuary.

iv. Additional safety margins beyond the parameters considered for design basis events including assessment for cliff edge effects due to external events.

v. For a multi unit/multi facility site, consideration of common cause failures impacting all facilities and emergency preparedness program to include assessment of scenarios involving simultaneous accidents in multiple facilities, possible isolation of site, etc.

vi. Continuous monitoring and periodic assessment of hazards including review of site characteristics and emergency measures during operational phase of NPP as part of periodic safety review.

17.5 CONSULTATION WITH OTHER CONTRACTING PARTIES

As per the Indian regulation, the planning for emergency preparedness is carried out for the Emergency Planning Zone (EPZ), which is designated up to a radial distance of 16 km from the NPP. The populations in this zone are kept informed on emergency planning and response. The neighbouring countries are at very large distances from the location of operating NPPs and those under construction. Hence there are no trans-boundary implications. India is party to Convention on Early Notification of a Nuclear Accident (1986), and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1986) and complies with the obligations under these conventions.

17.6 REGULATORY REVIEW AND CONTROL ACTIVITIES

AERB safety guide AERB/NPP-RR/SG/G-1:2007 on "Consenting Process for Nuclear Power Plant and Research Reactor" give the guidelines on the contents of the site evaluation report. A detailed description on these requirements is given in Code of Practice on Safety in Siting of Nuclear Power Plants, AERB/SC/S, and safety guides issued under the Code. AERB requires that site evaluation report should be submitted for siting consent. Regulatory review of application for siting consent is carried out by multi-tier review system of AERB (section 14.1.1.2 (ii)). Staff of AERB carries out regulatory inspections during siting stage and provide inputs to the safety committees for review of the application for siting consent. Also, while making submissions for issue of consent/clearance from the second stage, viz. construction onwards, the applicant should invariably include a status report on compliance with AERB's stipulations if any, made during the issue of the earlier consent/clearance. The siting consent is issued for a limited period.

During Periodic Safety Review, utility is required to carry out review of the site related factors and submit it to AERB as part of PSR.

17.7 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

The Site Selection for locating an NPP is carried out by the Central Government. The utility carries out detailed site investigations and prepares Site Evaluation Report and

Environmental Impact Assessment Report for independent evaluation by AERB and MoEF respectively. The comprehensive review and assessment of site related factors ensure that setting up of the NPP will not cause undue risk to the public and the environment. The periodic safety review for renewal of license for operation ensures that important site related factors are periodically reviewed to determine the continued safety acceptability of the nuclear installation. As all the NPPs operating and under construction are located sufficiently away from the national border, formal agreement with the neighbouring countries for sharing of information has not been considered necessary. Hence, India complies with the obligations of Article 17 of the Convention.

ARTICLE 18: DESIGN AND CONSTRUCTION

Each Contracting Party shall take the appropriate steps to ensure that:

i. **the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence-in-depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;**
ii. **the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;**
iii. **the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.**

18.0 GENERAL

National laws, regulations and requirements for setting up a NPP are summarised in chapter on Article 7: Legislative and Regulatory Framework. AERB safety code on 'Regulation of Nuclear and Radiation Facilities' AERB/SC/G; 2000 and Safety Guide AERB/NPP&RR/SG/G-1: 2007 on Consenting Process for Nuclear Power Plant and Research Reactor identifies various consenting stages. The consenting process for locating and operating NPP in India is summarised in the chapter on Article 14: Assessment and Verification of Safety.

AERB safety code on 'Design of Pressurised Heavy Water Reactor Based Nuclear Power Plants', AERB/NPP-PHWR/SC/D (Rev.1); 2009, describes the design approaches and minimum requirements to be met during design of structures, systems and components (SSC) of PHWRs for assuring safety. This safety code is aligned with IAEA Safety Standard (NS-R-1, 2009- Safety of Nuclear Power Plants: Design) and includes high level requirements which are independent of NPP design. Therefore this code is applicable to all NPPs design under consideration in India. Various safety guides issued under the Code provide guidance for achieving these requirements to assure safety in PHWRs. For design review of PFBR, in addition to this code, AERB document on Design Criteria for Fast Reactors (1990) has been used. Design review of VVER units has been carried out with applicable AERB and IAEA requirements and safety guides. Notwithstanding with applicability of this Safety Code to all types of reactors, AERB has taken up preparation of a regulatory document on Safety Criteria for advanced LWRs, in view of the proposal for setting up several new NPPs based on advanced LWR technology. This document will take into account the Specific Safety Requirements as specified in IAEA safety Standard (SS-R-2/1, 2012 - Safety of Nuclear Power Plant: Design).

AERB safety code on 'Quality Assurance in Nuclear Power Plants, AERB/SC/QA(Rev.1): 2009, provides the principles and objectives for ensuring safety of public and site personnel when establishing an overall quality assurance programme for constituent phases, viz. design, manufacturing, construction, commissioning, operation and decommissioning of NPPs in the country. Various safety guides issued under these Codes provide guidance for achieving the requirements specified in them.

The details on the utility's safety management system for ensuring quality requirements during design, fabrication, construction etc are brought out in chapter on Article 13: Quality Assurance.

18.1 IMPLEMENTATION OF DEFENCE IN DEPTH

AERB Code of Practice on 'Design for Safety in PHWR based NPPs, AERB/SC/D Rev 1): 2009, Design Criteria for Fast Reactors:1990 (under revision) and Safety Criteria for advanced LWRs (under development) establish requirements for defence-in-depth in design of NPPs' The documents require that the design shall meet the acceptance criteria during normal operation and during accident conditions. To ensure that the overall concept of defence-in-depth is maintained, the design shall be such as to prevent-

i. challenges to the integrity of physical barriers,
ii. failure of barrier when challenged and
iii. failure of a barrier as a consequence of failure of another barrier.

The design shall be such that the first level of defence-in-depth (prevention of deviation from normal operation and prevent system failure) and at the most the second level (detect and intercept deviations from normal operating conditions in order to prevent anticipated operational occurrences) are capable of preventing accident conditions for all but the most improbable PIEs.

The concept is implemented in the reactor design by means of a series of layers of physical barriers and defence-in-depth levels of protection. Each layer acts as a barrier against breach of safety. Safety systems are also provided with redundancy so as to meet the single failure criteria. Diversity and physical separation of redundant systems is provided to avoid common mode failures. The concept of defence-in-depth is implemented for each system, which has a role in maintaining or ensuring the three fundamental safety functions of Safe Shut-down, Heat removal from core and Confinement of radioactivity to limit release to the environment.

The confinement of radioactivity is achieved by a series of independent barriers, namely, fuel pellet, fuel cladding, primary system boundary, and containment. Each of these barriers is designed for the environmental conditions and service loading to which it is subjected to, while performing the respective function. The exclusion zone and a natural growth zone around the plant are additional layers of defence-in-depth.

During normal operation, safety related process systems maintain the relevant plant parameters within set limits. The design of equipment takes care of all normal operating conditions and postulated abnormal transients. The design of these process systems incorporates appropriate detection and control measures to ensure these objectives. Measures such as controlled reduction in power and trips are provided whenever deviations from normal operating conditions are detected. The active components in safety systems and related control and instrumentation systems incorporate appropriate redundancy so that single failure criteria are met.

It is ensured that the structures, systems and components having a bearing on reactor safety are designed to meet stringent performance and reliability requirements. These requirements are met by adopting the following principles:

i. The quality requirements for design, fabrication, construction and inspection for these systems are of high order, commensurate with their importance to safety.
ii. The safety related equipment inside the containment building are designed to perform the desired function under the environment conditions expected in the event postulated design basis accident.
iii. Physical and functional separation is ensured between process systems and safety systems to the extent practicable. This separation is also provided between different safety systems and between redundant components of a safety system. These features ensure that a single local event viz. fire, missile, pipe failure, will not result in

multiple component/system failures and the functions required for safety of the reactor are not impaired due to common cause failures.

iv. Adequate redundancy is provided in the system such that the minimum safety function can be performed even in the event of failure of single active component in the system. In addition to 'single failure criteria' requirement, safety systems are also required to meet specified unavailability targets, evaluation of which takes into account permissible down time of the equipment specified in the 'Technical Specification for Operation'. Each channel in Reactor Control & Protection Systems is independent of other channels, with separate detectors, power supplies, amplifiers and relays. This arrangement ensures that safety function will be performed reliably by allowing testing and maintenance of a control or protection channel without affecting reactor operation.

v. To minimise the probability of unsafe failures, wherever possible, the logics and instrumentation circuits are designed to fail in the safe direction.

vi. Provisions are incorporated in the design to ensure that active components in safety systems are periodically testable.

vii. All support systems viz. electrical power supply, pneumatic power supply & cooling water supply, necessary for the satisfactory functioning of the safety systems are from reliable sources such that single component failure does not jeopardize the minimum supply requirements.

viii. Level-1 PSA is carried out to identify any weak links and to achieve a balanced design in terms of risk from various event sequences.

The design of the plant also takes into consideration external events specific to a site. The external events are grouped into natural events and man-induced events. Natural events considered in the design are possible seismic events at the site and extreme meteorological phenomena such as heavy precipitation, floods, high winds, cyclones, tsunami etc. Man-induced events include hazards from toxic and explosive materials, blasting etc. For each of the events whose potential at the given site is known to exist, a design basis event is established.

The seismic design of the plant considers two different intensities of earthquakes viz. operation basis earthquake (OBE) and safe shutdown earthquake (SSE). The OBE represents the intensity of earthquake for which the plant is designed to remain functional during and after the event. The SSE considers the maximum earthquakes potential of the site and its intensity is decided on the basis of geological and seismo-tectonic data. The structures, systems, and components whose failure could directly or indirectly cause accident conditions, which are required for shutting down the reactor, monitoring critical parameters, maintaining reactor in a safe shutdown condition and removing decay heat on a long term basis, and which are required to prevent radioactive release or to maintain release below limits established by AERB for accident conditions are designed for SSE.

Flooding in inland sites could be caused by heavy precipitation or by the release of large volumes of water due to failure of upstream dams under seismic disturbance or any other cause. The plants are designed for a design basis flood resulting from probable maximum precipitation with a mean recurrence interval of 1000 years. Flooding due to failures of upstream dam is also considered. Failures of dams located downstream may also affect availability of ultimate heat sink and is therefore considered in the design. For coastal sites, flooding due to cyclones, tsunami and wind waves are considered in the design.

Over the years, through operational feedback available from all around, the insights gained through deterministic supplemented by probabilistic safety analysis certain selected plant conditions/event sequences involving multiple failures have become part of regulatory review. One such example in Indian context is Station Blackout condition for a relatively long

period included traditionally in the regulatory review of standardised Indian PHWRs. AERB Safety Guide (AERB/SG/D-5) covers such Plant conditions.

Thus selected situations of multiple failures have been included in the design of recent plants to meet regulatory requirement of assessing Severe Accident conditions as per (AERB/SC/D:2009). Design Safety provisions in 1000 MWe VVER units at Kudankulam, 700 MWe PHWRs now under construction and the 500 MWe PFBR units described in the national reports submitted to the fourth and fifth Review Meetings of the convention.

The safety upgrades done or proposed in Indian NPPs as a result of PSR and special safety reviews subsequent to major nuclear events take into account such plant conditions for implementing backfits. It is evident therefore that Defence in Depth (DID) framework has included extended requirements emphasizing on design of plants as well as for old plants upgrades to better handle beyond-design-basis and severe accident conditions.

The regulatory document on Safety Criteria for advanced LWRs at present under preparation proposes to include the category of Design Extension Conditions (DEC) in line with IAEA Safety Standard- Safety of Nuclear Power Plants Design (No SS-R-2/1). This document will reflect updated understanding of the Defence in Depth, in particular the DEC category which includes selected plant conditions/event sequences involving multiple failures which have become part of regulatory review over time as well as include the lessons evolving from understanding of the Fukushima event. Also, the document on safety requirement will solicit for implementation of specific provisions designed to meet the target like avoidance of long term off site contamination in case of a severe accident.

18.2 ADOPTING PROVEN OR QUALIFIED TECHNOLOGY

It is ensured that the quality standards followed for design, fabrication, construction and inspection of SSCs are commensurate with their importance to safety, as required in AERB safety guide AERB/SG/D-1 on Safety classification and Seismic Categorization of components in PHWR based NPPs. All the regulatory requirements specified in the different AERB Codes and other regulatory documents are complied with. If the design, construction, manufacture, inspection and maintenance of civil structures, mechanical, electrical, Instrumentation & Control equipment and systems are done by using the international codes & standards, it should be acceptable to AERB.

As a general principle use of proven equipment and systems is preferred. However, if first of a kind (FOAK) systems are introduced, safety and system performance are demonstrated by appropriate analysis and supporting R&D programmes or by review of operational experience from other similar applications. All these systems are adequately tested during commissioning to verify that the expected behaviour is achieved. These systems are critically monitored during service to ensure their intended performance.

The equipment important to safety are qualified to operate in the environment expected under accident conditions. All civil structures and mechanical, electrical & instrumentation equipment which are required to perform during earthquake loading are qualified by analysis to demonstrate their pressure boundary integrity or structural integrity for two levels of earthquake i.e. OBE & SSE, depending on the seismic categorisation of the equipment. Equipment which have moving components viz, relays, valves, actuators, starters, push buttons etc. are tested on a shake-table for their functional performance for the two levels of earthquake.

For structural analysis, state of the art codes are used, which are validated with both benchmark classical problems and experimental tests and results.

Computer codes which deal with safety analysis during normal operation and accident conditions such as Thermal hydraulics, Core physics, Neutronics, High temperature phenomena and Core concrete interaction during severe accidents, fuel behaviour and radioactivity release, containment behaviour, etc. have been developed. These codes are developed in-house and are benchmarked with results of experiments conducted at national and international laboratories, by participating in standard problem exercises of IAEA, coordinated research programmes of IAEA and technical exchange programmes.

The primary containment for PHWRs is tested for pressure expected under postulated MSLB and LOCA conditions and that of FBR for the pressure expected due to postulated sodium fire inside the containment subsequent to a core disruptive accident.

Digital I & C technologies have matured over the last several years and this has led to their use in nuclear power plants for carrying out functions important to safety. Since several analogue equipment have become obsolete, digital technologies offer a practical replacement for the same. The digital instrumentation and control equipment have been extensively used in the newly built reactors in India. For qualification of this technology for use in NPPs, an elaborate process of Independent Verification & Validation (IV&V) has been implemented in NPCIL and IGCAR (for PFBR design).

18.3 R&D CAPABILITY FOR ASSURING SAFETY IN DESIGN

BARC and IGCAR provide R&D support for the nuclear power programme. The overall program is aimed to enhance the safety margins of the current reactors and establishment of improved safety features of the proposed reactor designs. The overall safety goal is to ensure that there are no cliff edge effects and sufficient margin is available for all the internal and external events.

BARC is presently involved in the following key activities as a part of R&D efforts related to NPP safety:

- AHWR Criticality Facility at BARC for validation of the analytical models and nuclear data used in design of AHWR. The facility is used for validation of reactor physics analytical models for loosely coupled reactor cores of 540 MWe and 700 MWe NPPs
- AHWR Thermal-Hydraulic Test Facility (ATTF), Tarapur for validation of safety analyses for different postulated initiating events
- Validation of Fuelling machine and study of refuelling strategies to maximise channel power at Integrated Test Facility Tarapur (ITFT)
- Experimentation and analysis to establish the first of a kind features of the reactor under different accident scenarios.

IGCAR is involved in R&D activities related to fast reactor technology. Some of the key test facilities set up by IGCAR are:

- Sodium circuits to study the properties of sodium and sodium fire test facilities to study the various types of sodium fire in case of sodium leak in Fast Breeder Reactors (FBRs).
- Large component test rig to test various equipment including the fuel handling machines in sodium
- Test loop to validate the decay heat removal system in PFBR by natural circulation.
- Facility to validate the design of once through type steam generators, with sodium in shell side and water in the tube side, used in FBRs

18.4 DESIGN FOR RELIABLE, STABLE AND EASILY MANAGEABLE OPERATION

The governing documents establish the requirement for design for optimised operator performance. These include:

- Redundancy, diversity and fail safe approach for safety critical systems
- Man-machine interface is designed to provide the operators with comprehensive & easily manageable information
- Providing interlocks & automatic actions. Design provides adequate time for operator to take necessary action.
- Ergonomically designed control panels
- Layout to facilitate operability and maintainability
- Working areas and working environment are given due consideration to personnel comfort.

The implementation of the requirements for human factors / human machine interface is addressed in chapter on Article 12: Human Factors.

18.5 REGULATORY REVIEW AND CONTROL ACTIVITIES

The prerequisite for issue of consent for construction is the review of the design safety of the proposed NPP. For this, the utilities are required to submit Preliminary Safety Analysis Report (PSAR) in a prescribed format. Through the PSAR, the utilities

i. provide safety evaluation of the proposed facility and demonstrates that the facility can be built and operated at the proposed site without undue risk to the health and safety of the general public. The evaluation should take into account experience feedback from similar NPPs and experimental results.
ii. provide information such as design bases, site and plant characteristics, safety analyses and conduct of operations, in such a way that the AERB may evaluate the safety of the plant.

Consideration of postulated initiating events (PIEs) strongly influence the design limits for the safety systems and for most structures, systems and components (SSCs) needed for operation of the plant. The potential radiological consequences for workers, the public and the environment for design basis accidents may be much more severe than those during routine operation. For this reason, a large part of the review and assessment effort is directed to the safety analysis of such low frequency PIEs.

The review and assessment of the safety analysis by the AERB is carried out to ensure that

a. the list of PIEs and their frequency is acceptable as the basis for the safety analysis (AERB/SG/D-5 provides the list of PIEs to be considered for PHWR of current design),
b. the overall plant design is capable of meeting the prescribed limits for normal operation and acceptable limits for accident conditions for radiation doses set by AERB,
c. the design provisions made on SSC are consistent with safety requirements derived from the safety analysis.

The regulatory review and assessment includes a check that any data, modelling or computer codes used in the analysis are based on sufficiently well founded knowledge and understanding, and that an adequate degree of conservatism has been built in. The computer codes are validated against experience or experiment. It is ensured that the coding

has been done accurately, the input data have been correctly assigned, and that the checks have also been made to ensure that the code has not been corrupted by modifications and is being used in an appropriate manner.

To supplement the PSAR, the utilities are also required to provide among other submissions, the following documents to AERB in the prescribed format in a progressive manner for review and approval for the purpose of consent for construction:

i. Quality assurance program for design and fabrication
ii. Applicant's site construction Quality Assurance manual
iii. Construction schedule (major milestones including regulatory clearances)
iv. Construction methodology document for the proposed NPP
v. Design Reports' (DR) of items important to safety
vi. Documents on Industrial Safety during Construction
vii. Qualification and organisation of the applicant and his vendors
viii. Emergency preparedness plan covering the project construction personnel and their colony (for existing sites)
ix. Security aspects relevant to the construction phase

18.5.1 Design

The review and assessment areas of particular significance for design as specified in the AERB Safety Guide AERB/NPP&RR/SG/G-1 on "Consenting Process for Nuclear Power Plants and Research Reactors" include the following topics:

i. Safety approach of the applicant (objectives and principles) especially the importance given to such topics as accident prevention, surveillance and means of intervention and mitigation, defence in depth, redundancy, physical separation, diversity
ii. Safety classification of systems, structures and components
iii. Compatibility of the design with the site
iv. Design basis ground motion, geo-technical investigations and foundation parameter, meteorological parameter (Hydrology and Hydro-geology)
v. Layout of the nuclear power plant buildings and equipment, in particular, physical separation, easy accessibility to equipment for maintenance and routine surveillance, shielding and protection against explosions, missiles, fire and other natural and man-induced events.
vi. Nuclear Security giving emphasis on Physical Protection System Design.

In carrying out its review and assessment of design prior to issue of licence for construction, AERB determines that the proposed design of NPP meets the safety requirements as specified in the AERB Safety Guide AERB/SG/G-1 on "Consenting Process for Nuclear Power Plant and Research Reactor'. These safety requirements include the following:

i. Implementation of defence in depth principle
ii. Emphasis on prevention of DBAs rather than on mitigation of their consequences
iii. Technologies incorporated in the design and construction of a nuclear installation have been proven by experience or qualified by testing or analysis
iv. Implementation of good practices related to human factors and human machine interface

18.5.2 Construction

The review and assessment by AERB includes consideration of the applicant's organization and management to ensure that the proposed construction will meet the quality requirements envisaged in the design. The applicant is required to demonstrate that the safety management system put in place is comprehensive and it would ensure that the relevant activities are carried out in a planned and systematic manner and that the quality of work is in accordance with the approved procedures and nuclear industry practices. For this, AERB reviews the QA manuals of the utilities for design, procurement, fabrication, construction, commissioning and operation. It is the responsibility of the utilities to ensure that the vendors employed by it for carrying out different activities, follow a QA programme commensurate with the safety requirements.

Any change in the approved design of systems, structures and components important to safety due to site related constraints or otherwise requires regulatory approval.

In order to ensure industrial safety during construction, AERB requires that the utilities should establish a construction safety management system. For this, AERB reviews various documents related to industrial safety such as Job Hazard Analysis Report, Construction Safety Management Manual, etc and monitors their compliance.

The regulatory inspections of NPPs are normally carried out at a frequency of four inspections in a year during construction. In addition to normal regulatory inspection, AERB also identifies certain critical activities during construction as hold points for which the utilities are required to inform AERB in advance for deputing its representative to witness or carry out inspection or tests, as may be necessary.

The availability of system completion certificates and system transfer documents form one of the prerequisite for considering consent for commissioning.

In the last three years, based on the experience feedback, new regulatory and technological developments, international practices, etc. following regulatory documents on construction were published:

i. AERB safety guide on Materials of Construction for Civil Engineering Structures

The safety guide 'Materials of Construction for Civil Engineering Structures Important to Safety of Nuclear Facilities' (AERB/NF/SG/CSE-4) was published in 2011. In addition to specifications prescribed by Indian Standards for Testing Materials (ISTM), the document also draws inputs from relevant international standards and specifications such as ASTM and BS.

AERB standard AERB/SS/CSE, 'Civil Engineering Structures Important to Safety of Nuclear Facilities' provides broad guidance on materials of construction. Unlike the shop manufactured components, the materials of construction for civil structures could have diverse origins owing to location of NPP site as well as the location of the sourced material. In addition, certain ingredients like concrete admixture need to meet stringent specifications. Taking these requirements into account, this safety guide provides detailed guidance on use of major construction materials for civil engineering construction for structures important to safety of nuclear facilities as well as for preparation of specifications of major construction materials.

ii. AERB safety Manual on Quality Assurance during Construction

The safety manual on 'Quality Assurance during Construction of Civil Engineering Structures Important to Safety of Nuclear Facilities' (AERB/NF/SM/CSE-3) was published in 2011.

This manual was developed to elaborate the provisions for civil engineering construction of structures and buildings which are stipulated in the AERB safety code on 'Quality Assurance in Nuclear Power Plants' [AERB/NPP/SC/QA (Rev. 1)] and AERB safety guide on 'Quality Assurance during Site Construction of Nuclear Power Plants' (AERB/SG/QA-4). This manual provides detailed quality assurance aspects during construction of Civil engineering structures and detailed guidelines to develop QA plans specific to various activities of civil engineering construction.

iii. AERB safety manual on Regulatory Inspection during Construction of Civil Engineering Structures

The safety manual on Regulatory Inspection during Construction of Civil Engineering Structures Important to Safety of Nuclear Facilities (AERB/NF/SM/CSE-4)–was published in 2011.

This safety manual describes in detail various aspects related to inspection by AERB during construction of Civil engineering buildings and structures important to safety. Specific lists of items (i.e., activities and associated records) to be checked during various stages of construction of NPPs are also covered in this manual. Provisions of this manual are applicable to NPPs, research reactors and nuclear fuel cycle facilities.

18.6 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

The stage wise consenting process of AERB ensures that the safety in design is comprehensively reviewed prior to issuance of consent for construction. The regulatory review and assessment determines that in the design of NPP, proper emphasis is placed on prevention of accident as well as on its mitigation. The defence in depth principle is as per the intent elaborated in the regulatory documents. All NPPs including those under design and construction have undergone a special review following Fukushima accident and enhancements as required to cater to natural events have been incorporated in the design. Technologies used in the design and construction of the NPPs, are either proven by experience or otherwise qualified by testing or analysis. Human factors and man machine interface have been given important considerations among others in the design of NPPs. The objective of design has been to ensure reliable, stable, safe and easily manageable operation of the plant. Therefore India complies with the obligations of Article 18 of the Convention.

ARTICLE 19 : OPERATION

Each Contracting Party shall take the appropriate steps to ensure that:

i. the initial authorisation to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;
ii. operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;
iii. operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;
iv. procedures are established for responding to anticipated operational occurrences and to accidents;
v. necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;
vi. incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;
vii. programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies;
viii. the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.

19.0 GENERAL

The requirements for licensing of NPPs for operation emanate from the Atomic Energy Act 1962 and rules framed there under. National laws pertaining to NPP are given in detail in Chapter on Article 7: Legislative and Regulatory Framework. Based on these requirements, the system of licensing, inspection and enforcement has been established. AERB code of practice on regulation of Nuclear and Radiation Facilities, AERB/SC/G and AERB Safety Guide AERB/SG/G-1 on “Consenting Process for Nuclear Power Plant and Research Reactor” establishes the entire licensing process for NPPs. The licensing process is summarised in Chapter on Article 14: Assessment and Verification of Safety. Further, AERB safety code “Nuclear Power Plant Operation”, AERB/NPP/SC/O (Rev. 1) establishes requirements related to operation of NPPs and several safety guides issued under this Code describe and make available methods to implement specific requirements of the Code.

19.1 INITIAL AUTHORIZATION

Prior to issuance of consent for construction, AERB completes the review of Preliminary Safety Analysis Report (PSAR). At this stage, a large part of the review and assessment effort is directed to the safety analysis of design basis events provided by the applicant. The review and assessment process considers whether the applicant’s list of Postulated Initiating Events (PIEs) is complete and acceptable as the basis for the safety analysis. AERB determines that the PIEs, type of analytical considerations and assumptions are in conformance with applicable safety guides. Further, the engineering systems are

qualified to meet the functional requirement for which they were designed, under all situations considering environmental conditions, ageing etc. Aspects of review of safety analysis are given in detail in the Chapter on article 18: Design and Construction.

On completion of construction, a Regulatory clearance for commissioning of NPP is sought by the licensee. For a typical PHWR, such stages are indicated in the table below:

Phase	Stages of Commissioning	
	No.	Activity
A	i.	Hot conditioning or passivation of the primary system and light water commissioning
	ii.	Fuel loading of the reactor core, and borated heavy water addition to moderator systems for flushing in specified limited quantity
	iii.	Addition of heavy water to primary heat transport system
	iv.	Bulk addition of heavy water to moderator system with minimum specified boron level in heavy water to prevent criticality
B	i.	Initial approach to criticality
	ii.	Low power reactor physics tests and experiments.
C	i.	Initial system performance tests at low, medium and rated power levels as determined by the stable operation of the turbine.
	ii.	System performance at rated power.

Before start of commissioning activities, NPCIL prepares a comprehensive programme for the commissioning of plant components and submits the same for review and acceptance by AERB.

The commencement of operation of an NPP begins with approach to the first criticality. This is a major step in the licensing process. At this stage NPCIL demonstrates to AERB its preparedness to commence operation of the NPP. This requires completion of all activities with requisite approvals, pertaining to the following:

a. Final as built drawings for the plant components and systems and Final Safety Analysis Report.
b. Evaluation of safety analyses in view of changes in design, if any.
c. Quality records (such as construction completion certificate, history dockets etc.) after construction of the plant components and systems, and the program for their operation.
d. Report on Pre-Service Inspection (PSI).
e. Establishment of organization for plant operation, training, qualification & licensing of the operating personnel, as per AERB requirement.
f. Technical Specification for Operation specifying operational limits and conditions.
g. Operating instructions and procedures for commissioning and operation of the plant including emergency operating procedure.
h. Establishment of physical protection system.
i. Radiation protection program.
j. Emergency Preparedness and Response Plans.
k. Waste management programme.
l. Nuclear Security Aspects.

AERB carries out review and assessment of preparedness of NPPs to satisfy itself that the plant has been built in accordance with the accepted design, and meets all the regulatory requirements.

Before licensing regular operation, AERB carries out review and assessment of the results of commissioning tests for their consistency with design information and with the prescribed operational limits and conditions. Any inconsistency at this stage has to be resolved to the satisfaction of AERB. At this stage, the utility revises the PSAR taking into account all the changes that have been carried out and submits Final Safety Analysis Report (FSAR), which forms one of the licensing documents for operation of the unit.

The review and assessment by AERB also includes consideration of the applicant's organization, management, procedures and safety & security culture, which have a bearing on the safety of the operation of the plant. The applicant should demonstrate with the necessary documentation that there is an effective safety management system in place, which gives the highest priority to nuclear safety and security. The typical organisation for plant operation established at an Indian NPP is given in Annex 19-1.

19.2 OPERATIONAL LIMITS AND CONDITIONS

The licensee prepares the Technical Specifications for operation before approach to first criticality, based on the inputs from the design and safety analysis. AERB safety Guide AERB/SG/O-3: Operational Limits and Conditions for Nuclear Power Plants provide guidelines for preparation of this document, which is submitted to AERB for review and approval. Adherence to Technical Specifications during operation is mandatory.

The Technical Specification document is issued in two parts. Part A contains the technical specifications and station policy clauses, bringing out the mandatory requirements to be adhered to during operation. Part-B is explanatory in nature and outlines the bases for arriving at different conditions/requirements in technical specifications for operation.

Technical Specifications (Part-A) consists of following sections:

i. Safety Limits
ii. Limiting Safety System Settings (LSSS)
iii. Limiting Conditions for Operation (LCO)
iv. Surveillance Requirements
v. Administrative Requirements

If a change in any section of the Technical Specification becomes necessary, based either on operating experience or new findings consequent to changes in safety analysis, the same is submitted to AERB for review and approval. A general review of the document is carried out once in five years.

19.3 PROCEDURES FOR OPERATION, MAINTENANCE, INSPECTION & TESTING

The safety code on 'Nuclear Power Plant Operation', AERB/NPP/SC/O (Rev 1) requires that all the activities in the NPP be carried out as per the well laid down operating procedures. The procedures should be prepared, tested and approved as per the standard guidelines developed for the same. Based on these guidelines, the plant management prepares various procedures for commissioning and operation of all systems, maintenance, inspection, testing, and surveillance requirements. The procedures also include conditions dealing with plant under normal operation and anticipated operational occurrences as well as appropriate actions for accident conditions including design basis accidents. These documents are normally prepared by plant personnel in co-operation with the designers and

suppliers. The Plant Management ensures that the aspects of Quality assurance are duly considered in the preparation, review and approval of these procedures. All the approved procedures are available to the users on plant local area network and hardcopy is maintained in main and supplementary/back-up control room.

19.4 PROCEDURES FOR RESPONDING TO OPERATIONAL OCCURANCES & ACCIDENTS

At present, all NPPs have emergency operating procedures for various anticipated operation transients and accident conditions. These procedures are primarily event based and are also used extensively for training of the operating personnel.

NPCIL has completed the development of symptom-based procedures for accident management and these Emergency Operating Procedures (EOPs) have been validated on plant simulator. Development of system for deploying these procedures in NPPs has been completed and the system has been implemented at KGS-1 to 4 and RAPS-3 to 6.

In addition to the above, several plant specific administrative procedures are also prepared, which include shift change over procedure, station work permit procedure, radiation protection procedure, engineering change procedure, temporary change control procedure, etc. All the above procedures are periodically reviewed and revised, as necessary.

Development of Severe Accident Management guidelines

Generic document for Severe Accident Management Guidelines (SAMG) of PHWRs is under advanced stage of preparation. The document will also contain guidelines for dealing with postulated accident conditions in spent fuel storage pools. From this generic document, station specific accident management guidelines will be prepared.

The generic accident management document for PHWRs is a comprehensive technical document covering all aspects of IAEA Safety Guide (IAEA-NS-G 2.15): 'Severe Accident Management Programme for Nuclear Power Plant'. In addition, following documents have been referred in the preparation of this generic document:

- IAEA Safety Reports Series (No. 32): Implementation of Accident Management Programmes in Nuclear Power Plants
- IAEA-TECDOC-1594: Analysis of Severe Accidents in Pressurized Heavy Water Reactors
- IAEA-TECDOC (under preparation) on IAEA Coordinated Research Project on Benchmarking of Severe Accident Analysis computer codes for heavy water reactor applications.

The generic accident management document for PHWRs is designed to be a complete reference in itself and is the basis for accident management actions. This includes:

- Objectives and strategies for accident management
- Strengths and vulnerabilities of PHWRs against accident with inputs from probabilistic safety assessment
- Severe accident scenario for PHWRs
- Analysis for severe accident scenario without and with accident management measures
- Analysis for extended failure of cooling of spent fuel pool
- Description and design basis of accident management measures
- Organizational aspects of accident management and interaction of accident management programme with emergency plans

A graded approach for accident management guidelines is envisaged and accordingly, following guidelines covering preventive and mitigating domain are finalized.

- Severe accident prevention guidelines
  - injection into steam generators
  - injection into primary heat transport system
- Severe accident mitigation guidelines
  - maintain calandria heat sink
  - maintain calandria vault heat sink
  - controlling reactor building conditions
- Severe accident ultimate guidelines
  - Reduce containment pressure
  - Reduce containment atmosphere flammability/hydrogen
  - Mitigate fission products release

Various hardware provisions/additional equipment required by these accident management guidelines are under implementation at all Indian PHWRs. Actions to procure passive autocatalytic hydrogen recombiners have been initiated. In parallel testing of indigenous hydrogen recombiners is continuing at NPCIL R&D Centre. Containment Filtered Venting System design options are being tested.

For meeting accident management training needs, faculties are developed at each station. These faculty members have been trained by NPCIL corporate office. A programme is in place to maintain and sustain training on accident management. The training module on accident management also addresses human factors such as cognitive, emotional and behavioural under envisaged adverse environmental conditions. The training module is designed based on the concept of “systematic approach to training” and the mode of training primarily is classroom training with plant walkdown exercises. While finalizing this training module, IAEA-TECDOC-1440 “Overview of training methodology for accident management at nuclear power plants” and IAEA Technical Report Services (No. 380) “Nuclear power plant personnel training and its evaluation” were considered.

Once accident management guidelines and the required provisions are implemented, the qualified and licensed operating staff at all stations will undergo training. It is envisaged to have an initial training of all identified site personnel within a year of implementation of accident management programme and thereafter, regular re-training once every three years.

19.5 ENGINEERING AND TECHNICAL SUPPORT

NPCIL manages all the presently operating NPPs through the Directorate of Operation set up at its Head Quarters at Mumbai. This Directorate monitors the operational and safety performance of NPPs and provides the necessary engineering and technical support. The Directorate also acts as interface between plant management and AERB. For achieving these objectives, the Directorate of Operation also derives support from other technical groups at Headquarters, which include Directorates of Engineering, Safety, Quality Assurance and Procurement. These groups at headquarters also provide Design, Engineering and Technical support to units under construction and commissioning. NPCIL also enters into memoranda of understanding with Research and Development and academic institutions so as to avail additional engineering and technical support as and when required.

To initiate in-house Research & Development effort, NPCIL established Directorate of R&D in 2001 with specific focus on enhancement of nuclear safety and reduction in unit

energy cost of nuclear power plants. The thrust areas of development effort in NPCIL are nuclear systems and electronic systems. In the year 2010 Technology Development Group at NPCIL Head Quarter was formed and the activities relating to areas other than electronics and computer based systems were brought under its purview. This group undertakes application oriented projects to provide quick solutions to the problems emanating from operating stations/project under construction, assessing/extending life of plant systems, structures and components. It also undertakes experiment oriented projects for furthering plant nuclear safety, validating new designs and in-house developed computer models/codes at its R&D facility at Tarapur. In addition to the technology development activities reported in the Indian National report to the Fifth Review Meeting of CNS, some of the new activities undertaken in the reporting period are:

- Safety experiments for simulation of new system designs like Passive Decay Heat Removal System (PDHRS) and Containment Spray System (CSS). Full scale CSS test has been carried out to verify its design.
- Containment Filtered Vent System (CFVS) viz Scrubber tank design is considered for a full scale prototype evaluation towards design finalization.
- Hydrogen Recombiner Test Facility (Fig 19.1) has been commissioned. Initial tests with recombiners are completed upto 2% hydrogen concentration. The next phase will include tests in which performance of passive hydrogen recombiners will be evaluated, in steps, upto 4% of hydrogen concentration without steam and upto 10% of hydrogen concentration with steam in the test vessel.

Electronic systems R&D group concentrates mainly on development of electronics and computer based controls and instrumentation. The laboratory facilities for electronics and computer based systems are established at NPCIL headquarters, Mumbai.

At the plant level, the Technical Services Section, which provides support in monitoring and review of operational and safety performance, is also equipped to provide the necessary engineering and technical support. A Corporate Level Safety Review Committee for operation reviews all the issues pertaining to safety in NPPs. This committee reviews all the safety related proposals emanating from stations before being forwarded to AERB. Vendor support is taken for systems like turbine and other conventional systems as and when needed.

19.6 REPORTING OF INCIDENTS SIGNIFICANT TO SAFETY

AERB safety code on ‘Regulation of Nuclear and Radiation Facilities’, AERB/SC/G specifies the reporting obligations of the Plant Management. AERB/SG/O-13 on Operational Safety Experience Feedback on Nuclear Power Plants issued under the Code of Operation provides guidance for reporting events to regulatory body. The detailed reporting criteria for the events are provided in the Technical Specifications for Operation.

Events of relatively lower safety significance (limited consequences from safety point of view) are reported as ‘Event Report’ to AERB in a prescribed format as part of the minutes of the Station Operation Review Committee (SORC). However, Events with relatively higher significance for safety are required to be reported as Significant Event Reports (SER) as per the reporting criteria specified in Technical Specification for Operations. These events are reported to AERB in following three stages:

i. Prompt Notification
   Prompt Notification in the prescribed format is sent within 24 hours of the occurrence of the event.

ii. Significant Event Report
A detailed significant event report (SER) in a prescribed format for SER is submitted within a period of 20 days from the date of occurrence of the event.

iii. Event Closing Notification Report
Event Closing Notification Report (ECNR) in a prescribed format is submitted for those significant events for which root cause could not be established within 20 days (reporting time for significant event report). ECNR indicates completion of all investigations pertaining to the event.

Number of SERs reported during the years 2010, 2011 and 2012 were 34, 38 and 32 respectively.

All the SERs are reviewed by AERB and recommendations arising out of the multi-tier review process are addressed in a time bound manner. A system for reporting of low level and near miss events is established at each NPP. A report on trend analysis and corrective actions taken for such events is submitted periodically to utility headquarters.

19.7 OPERATING EXPERIENCE FEEDBACK SYSTEM

AERB safety code on operation (AERB/SC/O) specifies the requirement for establishing operation experience feedback system at NPPs. AERB Safety Guide AERB/SG/O-13 on 'Operational Safety Experience Feedback on Nuclear Power Plants' provides guidance and procedure for establishing an Operating Safety Experience Feedback (OSEF) system based on national / international experience on management of safety related operational experience in NPPs. The OSEF system at NPPs and at NPCIL complies with the guidelines given in the safety guide.

NPCIL obtains reports of international events through IAEA-IRS, WANO, COG etc. These reports (both national and international) are reviewed by the experts in the relevant fields like operation, design and safety. The expert comments are reviewed by the Corporate Level Safety Committee. NPCIL through its safety management system ensures the dissemination of relevant information amongst all senior management persons in NPPs and projects under construction.

The organizational structure at Plant Level ensures that both national and international events are systematically analyzed and appropriate actions are taken to prevent the occurrence of similar events in Indian NPPs. A committee comprising of members from Technical Services, Operation, Maintenance, Health Physics, Training and other relevant sections is responsible for the review of these events. The observations of this Committee are further reviewed in Station Operation Review Committee (SORC) for finalization of recommendations.

The system ensures that events taking place at one NPP are communicated to other NPPs in India. The system also ensures that the information on events and corrective actions at one NPP is disseminated to other NPPs. Further, management of various NPPs interacts with each other at different levels. At these meetings, the information on various modifications to equipment and procedures is exchanged. These exchange meetings are held periodically.

At corporate level a 'Flash Report' is issued by Directorate of operations at NPCIL headquarters to all the stations for quick dissemination of information pertaining to the occurrence of an event in any plant. In addition, an 'Operational Experience Feedback Report' is also issued by headquarters on those events which have significant learning points for all the other stations of NPCIL.

In addition, to the reporting of events significant to safety (refer section 19.6), the plant management is also required to submit routine reports such as periodic performance reports, inspection & testing reports, health physics reports, environmental surveillance reports, waste management reports, minutes of Station Operation Review Committee (SORC) and other miscellaneous reports to AERB. The functioning of the operating experience feedback setup at the plant and the corrective actions taken in response to internal and external operating experience is monitored by AERB through the reports received from licensee and during regulatory inspections carried out twice in a year. Actions taken by licensee based on internal and external operating experience are also reviewed during renewal of licence for operation every five years.

AERB reviews operational experience available from Indian NPPs, TSOs and also of external information available from NPPs abroad received through IAEA, IRS and other regulatory forums (like CANDU Senior Regulators Group, VVER Senior Regulators Forum). IAEA-IRS reports are made available to AERB staff who reviews these reports for further discussions in Operating Experience Review Group in AERB. The selected reports are further referred to the utility headquarters and the Licensees for checking applicability of the reports to their NPP and to submit response to AERB on the actions taken or proposed to be taken. Some reports involving specific technical issues are referred to Technical Support Organisations (TSO) also for obtaining their views. The responses received from utility, licensee and TSOs, are reviewed in AERB.

AERB is the national coordinator for all IAEA-IRS activities. Reporting of events to IAEA - IRS is done as per the guidelines of IAEA-IRS.

19.8 MANAGEMENT OF SPENT FUEL AND RADIOACTIVE WASTE ON THE SITE

19.8.1 Spent Fuel Storage

Spent fuel is stored in a water filled storage bay provided at each NPP. These storage bays are designed to accommodate spent fuel accumulated during 10 reactor years of operation. In addition, space is also reserved for storing one full core inventory of fuel in case of exigencies. For storage of spent fuel beyond this capacity, additional facilities in the form of Away From Reactor-Spent Fuel Storage Bay and Dry Storage Facilities are created. All such additional storage facilities are subject to regulatory review and clearance.

19.8.2 Radioactive Waste Management

Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 specifies the requirement for obtaining authorization for safe disposal of radioactive waste arising out of operation of NPP. Further, AERB Safety Code on Management of Radioactive Waste, AERB/NRF/SC/RW, 2007 establishes the requirements, which need to be fulfilled for safe management of solid, liquid and gaseous radioactive waste disposal. This safety code deals with the requirements for radiation protection aspects in design, construction and operation of waste management facilities and the responsibilities of different agencies involved. In addition, AERB/SG/O-11 on Management of Radioactive Wastes Arising during Operation of NPPs gives guidelines for radioactive waste management.

Based on the above requirements, NPCIL has to establish a facility for management of radioactive wastes (solid, liquid and gaseous) at each NPP site prior to the commencement of operation. NPCIL demonstrates that the facility has necessary engineered systems and administrative procedures to exercise control on release of activity into the environment, as per the regulatory requirements.

19.9 COMPLIANCE WITH OBLIGATIONS OF THE CONVENTION

The licensing process in India ensures that the initial authorisation for operation is given after a comprehensive review of the safety analysis and safety management system to ensure that the commissioning and operation of NPP is carried out in a safe and reliable manner. Operation of NPP is carried out within the operating limits and conditions specified in the Technical Specifications for Operations. In addition to the organisational set-up in accordance with the Technical specifications, an effective operating experience feedback mechanism has been set-up both at utility and AERB to ensure that both internal and external operating experience is reviewed and appropriate corrective actions as applicable are taken at Indian NPPs as well as the projects under construction. Therefore, India complies with the obligations of the Article 19 of the Convention.

Fig. 19.1 Hydrogen Recombiner Test Facility

Annex 19-1: Typical Organisation at NPP

NPCIL has established a well-defined functional organization for each station. A typical organization chart is annexed for reference. The functional responsibilities of various wings of the organization to conduct safe, orderly and efficient operation of the Station are described below:

STATION DIRECTOR (SD) is the Head of station management of NPP. He has the overall responsibility for the safe operation of the plant and implementation of all relevant policies, statutory requirements and radiation protection rules and other instructions and procedures laid down by the operating organization for plant management. He is also responsible for ensuring that the requirements of AERB are complied with. He is also responsible for training, qualification and licensing of operating personnel, in accordance with the approved laid down procedures.

The SD ensures compliance with the technical specifications for operation, which detail the operational limits and conditions. In addition to the overall responsibility for ensuring the safety of the Station and the public, his responsibilities also include:

- Prompt notification of deviations from established technical specification limits and conditions in accordance with procedures.
- Maintenance of quality assurance in all activities at the Station including in maintenance, testing, examination and inspection of structures, system and components.
- For ensuring that modifications to plant configuration are carried out only after due approval by AERB as per the laid down procedures.
- Assumes the role of site emergency director in case of an emergency.
- Liaison with HQ, AERB and other statutory bodies.

In discharge of his responsibilities, Station Director is assisted by a team of operations personnel, responsibilities of whom are described in detail in the Technical Specification and Station Policy documents for station operation. Some of these are summarized below:

CHIEF SUPERINTENDENT (CS) is responsible for coordinating the safe and orderly operation and maintenance of the station / systems in accordance with approved procedures. Operation, Maintenance, Technical Services and Quality Assurance Superintendents assist him in this regard.

TECHNICAL SERVICES SUPERINTENDENT (TSS) is responsible for:

(a) Engineering assistance required to efficiently operate the station/systems at optimum performance level.
(b) Performing engineering/technical studies and reviews.
(c) Issuing of work plans for specific jobs during operation and shutdowns.
(d) Reactor Physics and fuel management.
(e) Chemistry control of the systems.
(f) Upkeep and arranging updating of all technical documents including all design manuals and drawings.

OPERATION SUPERINTENDENT (OS) is responsible for:

(a) Safe operation of station / systems as per approved objectives, procedures, policies and within the limits and conditions laid down in the Technical Specifications.
(b) Bringing to notice of Station Operation Review Committee (SORC) members deviations / deficiencies in the operation of the systems.

(c) Ensuring that shifts are manned efficiently by providing adequate trained and licensed manpower.
(d) Bringing to the notice of SD/ CS/ TSS, promptly all deviations of Technical Specifications and all unusual occurrences with full information along with his comments and recommendations.
(e) Arrange to convene SORC meeting at least once in a month and also as and when necessary.
(f) Upkeep and updating of operating manuals.

MAINTENANCE SUPERINTENDENT (MS) is responsible for:
(a) Planned preventive / breakdown maintenance in respect of mechanical, electrical, control and fuel handling equipment / systems.
(b) Maintenance of adequate spares and consumables.
(c) Modifications to systems after approval by concerned authorities.
(d) Civil and Service maintenance.

TRAINING SUPERINTENDENT (TS) is responsible for coordinating arrangements for:

(a) Training of station staff in radiation protection, first aid and emergency procedures, industrial safety & fire protection.
(b) Training / Qualification / Re-qualification of operation staff.
(c) Training / Qualification / Re-qualification of maintenance staff.
(d) Training / Qualification / Re-qualification of fuel handling staff.

SUPERINTENDENT (QA) Heads the Quality Assurance group and is responsible for:

(a) Station Quality Assurance.
(b) Technical Audit.
(c) QA documentation.
(d) Monitoring the implementation status of recommendations of AERB.
(e) Pre-Service & In-service inspections.

Radiological Safety Officer (RSO) is responsible for advising station management and staff on radiation protection. This includes advice on personnel exposure, radiation monitoring and surveys and for liaison with Waste Management Plant regarding discharges and management of radioactive wastes, equipment for radiation protection and emergency arrangements and environmental surveys within the boundary of the unit. He is responsible for making measurements and observations during normal operations as well as during abnormal occurrences in the area of radiation safety.

SHIFT CHARGE ENGINEER (SCE) is responsible for authorizing all operation and maintenance activities of the station on shift basis. He is delegated all powers given to the SD / CS to maintain reactor systems under safe condition during operation and shutdown of the reactor. He is responsible for safe start up, operation and shutdown of the reactor, turbo generator and auxiliaries. In the absence of SCE, Assistance Shift Charge Engineer (ASCE) discharges these responsibilities. Both SCE and ASCE hold licence granted by AERB for plant operation, including authorization for control panel operations.

REVIEW MECHANISM

TECHNICAL SERVICES SECTION at each station is entrusted with the responsibility of review of operational and safety performance of all the systems on a routine basis, identify areas for improvement and suggest necessary corrective actions. TSS, the head of the unit maintains liaison with unit safety committee and SARCOP. He also submits all safety related

proposals for multi-tier review to SORC, NPC-SRC, unit safety committee and SARCOP for obtaining necessary approvals.

STATION OPERATION REVIEW COMMITTEE (SORC), headed by Station Director / Chief Superintended and having TSS, MS, OS, Superintendent QA and Radiological Safety Officer as members is formed at each station. The committee,

- Reviews the station operations at regular intervals to detect potential safety issues at the station and recommends corrective actions.
- Reviews all proposed special / emergency operation, maintenance and test procedures and recommends revisions thereto as necessary.
- Reviews reactor shut downs initiated by safety system and recommends action to prevent recurrence of unwarranted shutdowns, where applicable.
- Reviews all proposed changes, Engineering Change Notices including modifications to approved procedures for plant systems / equipments and recommends action. The review includes an evaluation of the effect of the proposed change on the relevant technical specifications.
- Reviews all proposed changes to technical specifications / Station Policies and gives recommendation.
- Investigates promptly, all safety related unusual occurrences and instances involving deviations of technical specifications, station policies (as applicable).
- Investigates loss, misplacement or unauthorized use of radiation sources.
- Investigates incidents involving radioactive material during transportation within the controlled area of the station.
- Investigates incidents involving disabling injury preventing the person from working for a period of 24 hours or more. (Injuries of lesser significance are reviewed by Head. Fire & Industrial Safety).

TECHNICAL AUDIT ENGINEER is responsible for auditing and monitoring the compliance with the operating procedures, administrative procedures, surveillance test schedules, SORC recommendations, in-service inspection and Engineering Change Notices of all safety related systems. He also monitors deviations of the technical specifications & station policy, and follows up implementation of the decisions given by SORC / Unit Safety Committee / SARCOP from time to time.

OVER EXPOSURE INVESTIGATION COMMITTEE is constituted at each station to review all cases of radiation exposure above the investigation level, identify root causes and recommend remedial measures to prevent re-occurrence. The functions of the committee are:

- To investigate genuineness of the reported value in case of external exposure and measured value in case of internal exposure.
- To investigate fully, the causes of the over exposure and to prepare a factual report.
- To suggest remedial measures to prevent recurrence of such overexposures.
- To suggest further action in respect of work to be allocated to such over exposed persons.

Investigation by the committee is carried out within specified timeframe and the report is forwarded to Unit Safety Committee / SARCOP.

NPC-SRC (Operations) is the corporate level safety committee, with representation from design, safety, operation and quality assurance groups at NPCIL head quarter. All safety related proposals, including engineering changes, which require review and concurrence by regulatory body are first reviewed in NPC-SRC (operations). The recommendations made by this committee are incorporated before the proposal is forwarded to unit safety committee / Safety Review Committee for operating plants (SARCOP) at AERB.

Organization Chart of a Typical Indian Nuclear Power Plant