FOURTH REPORT

STANDING COMMITTEE ON ENERGY (1993-94)

(TENTH LOK SABHA)

NUCLEAR PLANT SAFETY AND SPENT FUEL MANAGEMENT (Department of Atomic Energy)

सत्यमेव जयते

Presented to Lok Sabha on 18th March, 1994
Laid in Rajya Sabha on 18th March, 1994

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1	1.1	13	protection	Protection
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INTRODUCTION

I, the Chairman, Standing Committee on Energy having been authorised by the Committee to present the report on its behalf present this Fourth Report on "Nuclear Plant Safety and Spent Fuel Management." The task of examining this subject and preparing a report on it was entrusted to a Sub-Committee headed by the Chairman of the Standing Committee.

2. The Chairman held discussions with the representatives of the Department of Atomic Energy on 9th February, 1994.

3. The Committee considered and adopted the report at its sitting held on 15th March, 1994.

4. The Committee wishes to express its thanks to the Department of Atomic Energy for placing before it the material and information it wanted in connection with the examination of the subject. It also wishes to thank in particular the representatives of the Department of Atomic Energy who placed their considered views before the Chairman.

NEW DELHI,
March 16, 1994
Phalguna 25, 1915 (Saka)

JASWANT SINGH,
Chairman
Standing Committee on Energy.

I

NUCLEAR PLANT SAFETY AND SPENT FUEL MANAGEMENT

1. Overview

1.1 The Committee having examined the subject "Nuclear Plant Safety and Spent Fuel Management" in detail holds that the commitment of the Department of Atomic Energy to safety is total. This encompasses all activities in the nuclear fuel cycle and includes industrial safety and environmental protection. While installing nuclear facilities, safety is engineered into the design, maintained through fabrication and construction phases and implemented during the operation of the plant through appropriate procedures. Since the nuclear plants handle radioactive substances, the radiation exposure to employees and the public is continuously monitored and ensured to be within permissible limits as stipulated by the independent Atomic Energy Regulatory Board (AERB). The AERB limits are based on recommendations of the International Commission on Radiological protection (ICRP) as embodies in the basic safety standards of radiation protection adopted jointly by the International Atomic Energy Agency (IAEA), World Health Organisation (WHO) and International Labour Organisation (ILO). These health physics and environmental surveillance programmes for all the nuclear fuel cycle operations in the DAE units are implemented by the Bhabha Atomic Research Centre (BARC).

1.2 The Committee has found that care for protection of environment is built into the regular procedures for siting design and operation of all plants. An environmental impact assessment study is a pre-requisite. Environmental protection is ensured by monitoring and analysing all pathways for transport of radioactivity. A few years before the commencement of operation of the plant, an Environmental Survey Laboratory is at the plant site to collect baseline data around the site. These Laboratories continue to monitor radioactivity in samples of water, vegetation and food products in the entire area within a radius of 30 Kilometers, throughout the life of the Nuclear Power Station, to check any variation in the radioactivity levels. It also sends regular reports to AERB and other environment protection authorities. A micrometerological tower, to study the weather pattern, is established at each site.

1.3 The Committee observe that while choosing the site it is ensured that normal life in the area is not affected. An exclusion zone of 1.6 kilometers around the nuclear power plant is maintained. Surrounding this is a sterilisation zone (1.6-5 kms), where there is control on new expansion or setting up of industry that may lead to population expansion.

1.4 It has been observed that DAE adheres to site safety features including protection against earthquakes and associated phenomena, extreme metereological phenomena (such as cyclones, floods etc.) and man induced events (such as air craft crash, fire, explosions, toxic chemical handling etc.). In considering the effects of the plant on the site, population distributions, probable path ways of dispersion of radioactivity in air and water and hydrological features are studied in detail.

1.5 The Committee also finds that the philosophy of defence-in-depth is adopted in the design. The design is reviewed at various levels and the licence is authorised by the regulatory body. Quality assurance is the key element in the safety concept and begins at the design stages itself. The safety aspects are constantly reviewed during construction, with emphasis on surveillance for quality assurance.

1.6 The Committee notes that safety is also implemented during operation by taking steps as follows: Licensing of operating personnel after providing a suitable training programme; Formulating technical specification of operation and implementation of compliance with it; Constant vigil by monitoring of radiation levels in and around the associated environment and all streams of effluents. Safety surveillance is maintained by well trained safety teams. Regular safety reviews are conducted at different levels.

1.7 The Committee further notes that safety of occupational staff is continuously monitored. Necessary medical check-ups including bioassays are conducted, and continuous record of relevant health parameters are maintained. Employees are provided with all necessary personnel protective equipment for all conditions of operation. These aspects of management of safety govern the contract and temporary employees also. As part of the international GERMON programme a model station with an integrated radiation monitoring system was commissioned in BARC.

1.8 It has been observed that radiation awareness programme for the public is also conducted an almost all the sites. It is explained to them that radiation is already present in the environment and that people living in the neighbourhood of nuclear power plants receive from them just a tiny fraction of the radiation they receive from natural sources. These programmes dispel unnecessary fear and place radiation in proper perspective in their minds.

1.9 The Committee finds that while upholding best concepts in design, and operations, the Department holds and unique position in its concern for preparedness for emergencies at various levels. Not only plants for emergency preparedness, related to on-site and off-site are imperative, but also their approval by AERB followed by conduction of satisfactory mockup drills periodically, are necessary for the issue of licence for operation. Constant updating of the plans and conducting drills based on them and reviewing them during the phase of operation are also mandatory. To make emergency preparedness effective, public education and awareness programmes are undertaken.

1.10 The Committee further finds that research is also conducted in various areas relating to safety and, based on the findings, practices are reviewed and modified by the competent authority. R & D also extends to the following area: Development of computer codes for modelling for risk assessment; simulator development for operator training; and development of robotics for remote operations and maintenance to reduce the manrem budget and to minimise the outage of equipment. All sites are provided with well equipped fire stations managed by trained fire brigades.

1.11 The Committee examination reveals that nuclear industry in India has established a good record of safety. There have been no fatalities caused by radiation, nor any significant occupational radiation injuries of any kind detrimental to the public or the environment at any of the Indian Nuclear Facilities. The reports of the Three Mile Island (TMI-2) and Chernobyl accidents were thoroughly reviewed to learn generic lessons about these events. It has been found that our design have better safety strengths. It is observed that however improvements wherever necessary have been made.

2. Engineered Safety in Pressurised Heavy Water Reactors

1.12 The Committee notes that during the design of nuclear reactor, the following three basic safety considerations are given prime importance over and above a number of other design considerations.

1. Ability to shutdown the reactor and capability to maintain it in shutdown state at any point of time.
2. Ensuring decay heat removal from the core, and
3. Preventing escape of radioactivity.

1.13 The Committee have noted that reactor safety is assured through realisation of the above three requirements. The concept of defence-in-depth is built in the design which requires multiple echelons of defence to be available whenever there is a challenge to any of the safety functions. There are several ways through which such defence-in-depth is engineered. First of all there are several barriers between the fuels, where the fission reaction takes place, and the surroundings such as fuel sheath, primary heat transport system boundary, containment boundary etc. Indian PHWRs, in particular, have two containment buildings, one surrounding the other, thus adding an extra barrier and virtually eliminating any ground release. Defence-in-depth is also realised through incorporation of several redundancies and diversities in different systems that are provided for carrying out various safety functions. These systems are in addition to the systems required for normal operation of the nuclear power plant which itself is designed and build to a specified level of reliability and which provides primary defence by ensuring that the chances of drifting beyond the normal operational domain are minimised.

1.14 The Committee observes that one of the important aspects of the design of a nuclear power plant is the requirement on designer to postulate a series of design basis accident situation irrespective of their low probability of occurence and to provide systems to mitigate the effects of such postulated accident conditions. The postulates of failures within the plant and also external events are considered for this purpose. Loss of coolant accident, station blackout etc. are some typical examples of postulates that are made in the first category. This is mandatory inpsite of the very low probability of occurance of such events because of high qulaity engineering and construction as well as built-in design features to minimise the probability. Postulates of design basis earthquakes, design basis floods, are typical examples of external events that are considered in design. The probability of occurence of such external events and their consequences is also minimised at the siting stage itself through adherence to prelaid siting criteria such as specification of minimum distance from source of hazards such as a nearby air field, hazardous installation, active fault etc.

The design ensures provisions of adequate safety systems with built-in redundancies for each of such postulated design basis events. Indian PHWR design incorporates two diverse fast acting shutdown systems, each with some additional redundant capability. Similarly there are diverse heat transfer paths for removal of decay heat from the core. Additional core cooling provisions are available in the form of emergency core cooling system which can remove the decay heat from the core even in the event of a loss of coolant accident involving a break in primary heat transport system of the reactor.

1.15 It is observed that seismic design considerations have formed one of the most important design basis in the design of Pressurised Heavy Water Reactors (PHWR) that has been evolved in the country. The first of such units are the reactors at Narora. The seismic design process starts with siting considerations which require certain screening criteria to be met and seismicity related issues at the around the site to be evaluated in detail to generated a set of design inputs. The design of reactor systems is then checked for its adequacy against the design inputs to satisfy that the stresses and displacements at all locations are within the permissible limits.

1.16 The Committee finds that the entire process of nuclear power plant design, construction, commissioning and operation is covered by a systematic quality assurance programme to provide assurances about meeting of all safety requirements.

1.17 The Committee further finds that PHWRs have several important safety characteristics which provides superior safety strengths in these reactor systems as compared to other power reactor types. Existence of low temperature moderator inside the calandria (reactor vessel) provides an inherent heat sink which would prevent melting of fuel even under conditions of a low probability loss of coolant accident co-incident with a postulated failure of emergency core cooling system which itself has several in-built redundancies. Similarly the much longer neutron life time in heavy water moderated reactor systems helps in keeping the power excursion to a relatively lower magnitude. At the same time this feature also enable reactor operation with minimum amount of excess reactivity in the core, which also contributes to keeping the power excursion to relatively lower magnitudes. The limitation in temperature of fuel also means limitation on the metal water reaction that can occur in an accident involving core heat up. Thus the hydrogen released in the containment is lower and this in conjuction with larger containment volume that we have in our PHWR means a such lower threat to containment integrity.

1.18 The Committee is satisfied that the design of PHWRs is backed by an ongoing safety research programme that is being pursued by us. As a part of this programme several experiments and sophisticated computer calculations are made to understand the system behaviour under various conditions in greater detail. A number of advanced computer codes are available for different types of safety analysis activities. Many of these computers codes are validated through international benchmark calculations. Apart from the experiments carried out in the laboratory, tests are also carried out during the commissioning stages of a reactor to prove the safety characteristics of the reactor design. For examples, a test to demonstrate heat removal through thermosyphon was carried out at low power during the commissioning stage of Narora reactor. Such tests, apart from providing validation of design also provide sufficient confidence about the safety of our reactors.

1.19 The Committee, after investigation has found that during the Turbogenerator fire in the Turbine Building-I incident at Narora, the reactor operators and the safety systems of the reactor acted as intended and even though the incident led to failure of electrical power supply that is needed for pumping cooling water, alternate cooling provisions came into play and core cooling function was maintained unaffected. Similarly the reactor shutdown function and integrity of all barriers to prevent escape of radioactivity remained unaffected. The incident has been investigated in detail and lessons for improvements in power supply arrangements have been learnt and incorporated wherever necessary. Inspection of turbine has also been strengthened.

1.20 The Committee is satisfied that systematic probabilistic safety assessment studies are also carried out to assess the overall safety of the reactor system. It has been possible to demonstrate through such studies that our PHWRs are comparable to some of the best reactors in the world from the safety stand point, also.

3. Spent Fuel Management

1.21 The Committee observed that India's nuclear power programme envisages reprocessing of spent nuclear fuel discharged from the nuclear power reactors with the objective of separating and recovering reusable fissile and fertile components (Plutonium and Uranium) using sophisticated chemical separation processes and the conditioning and disposal of radioactive wastes. The separated fissile and fertile materials are recycled in thermal or fast reactors as considered appropriate. Besides enabling the extraction of fission energy from these elements, the process also reduces very significantly the quantity of long-lived Plutonium present in the waste to be disposed of. Reprocessing, rather that storage which is not visualized in the India nuclear power programme, therefore, achieves the twin objectives of augmenting fuel for nuclear power as well as simplifying the waste management procedures by reducing the associated radiological hazards.

1.22 The Committee notes that spent fuel management in the Indian context, therefore, involves only interim storage of spent fuel in a safe manner for periods generally not exceeding 10—15 years, prior to reprocessing. The technology developed in India for this purpose involves wet storage of spent fuel in specially designed stainless steel lined concrete waste pools of high integrity built to meet stringent criteria.

1.23 The Committee observes that three stages are involved in spent fuel management as outlined below:—

(1) Interim storage of spent fuel at the reactor site for a period not exceeding 5 years.

(2) Transport of the spent fuel to the reprocessing plant.

(3) Fuel Reprocessing and water management.

In step (1) above the spent fuel is automatically transferred under water to the spent fuel storage pool which is contiguous with the reactor. The operations are carried out remotely and there is no rediation hazard to personnel. The main purpose of interim storage of spent fuel at the reactor site is to (i) allow the 'decay heat' generated by spent fuel to reduce sufficiently and (ii) allow the radioactivity content in the spent fuel to drop significantly by natural radioactive decay, especially the short-lived and volatile radio-nuclide, I-131. This makes the subsequent step of transporting the spent fuel to the reprocessing plant simpler and safer in view of the fact that:

(i) Cooling requirements are reduced considerable e.g. for CANDU fuel, with a decay period of approximately 2 years, natural convention cooling is adequate and no forced cooling is required and the spent fuel can be shipped dry.

(ii) Inventory of radioactive material present in the fuel is considerably reduced.

1.24 This results in reduced radiation shielding requirements and weight of the transport container in relation to the quantity of fuel to the transported. The spent fuel shipping casks have to meet stringent criteria for them to qualify for transportation of spent fuel. The Committee has found that the recommendations of the International Atomic Energy Agency and the Atomic Energy Regulatory Board, Government of India are compulsorily in this regard.

Radiological Safety in Spent Fuel Management

1.25 The safety of interim storage of spent fuel in water filled storage pool have been well demonstrated in several countries including India which has accumulated sufficient experience in this area. The Committees examination of this question brings out the following observation:

Water filled pools have excellent features for the safe interim storage of spent nuclear fuel:—

(i) high thermal capacity for heat removal;

(ii) transparent medium with good visibility for operators to remotely handle fuel elements under water; and

(iii) excellent radiation shielding, both against gammas and neutron radiations, for reducing radiation exposures to operating personnel.

1.26 Water is also cheap, easily recycled through heat exchangers for removal of heat and through clean-up systems such as filters and ion-exchange resin column for the removal of any radioactive material that may be present in the water as contaminants.

1.27 In order to provide containment integrity, the related structures are designed for severe conditions and the pond is lined with stainless steel to prevent corrosion. The pools have a depth of 10 meters or more and with this depth of water acting as shield, the radiation levels at the water surface and the consequent radiation exposures to workers are negligible.

1.28 Control of any radioactive contamination that may be present in the pool water is achieved by continuously passing this water through special filters and non-exchange resins. This also enables water chemistry to be maintained for minimizing corrosion problems and maintaining fuel integrity.

1.29 The Committee finds that radiological safety during the wet storage of spent fuel is achieved by measures to reduce radiation exposures of operators, control of contamination in the working environment, and minimizing and sage management of any waste arising as a result of these operations. Since the spent fuel is stored under sufficient depth of water and the fuel when removed is carried only in shielded casks, radiation exposures to workers are extremely small.

1.30 Area contamination is controlled by:

(i) minimizing and controlling the radioactivity level in the storage pool water by the provision of on-line continuous clean-up systems and fresh water make up.

(ii) provision of once-through ventilation system with filtered exhaust for controlling any likely airborne contamination.

1.31 It is observed that different types of radiological monitoring instrumentation are provided, in addition to process safety instrumentation. The instrumentation includes:

(i) Continuous area gamma monitors with read out and alarm devices.

(ii) Continuous air monitor for measurement of radioactive aerosol concentrations in air.

(iii) Contamination monitors for checking area and personal contamination.

1.32 The Committee finds that in addition, the areas are periodically surveyed for radiation levels, contamination levels if any, and air-activity levels using portable survey instruments and laboratory measurement by trained radiation protection technicians. Design of the pool and water recirculation system ensures that, under no conditions, water will be lost and the fuel uncovered. Specially safety interlocks are provided in the remote handling tools that will prevent the operator from lifting the fuel above a particular level. Radiation monitors are also installed near the pool side.

1.33 The Committee notes that operators receive training in different aspects of radiation safety including radiation protection procedures. Besides, as appropriate workers are provided with exclusive plant clothing, hand gloves, aprons respiratory protective equipments, etc. Workers are given personnel dosimetry devices for measurement of their individual doses. Workers pass through change rooms and monitoring stations.

1.34 The Committee further notes radioactive levels in the storage pool, where water is continuously circulated through the clean up system, is periodically determined by drawing water samples and analyzing these samples for radioactivity content.

1.35 The Committee has found that special precautions are taken during spend fuel transport. Spent fuel is transported in specially designed shielded containers which meet the criteria of Type B packages as stipulated by the International atomic Energy Agency. The procedures are governed by the IAEA regulations for the safe transport of radioactive materials as adopted by the Atomic Energy Regulatory Board. These aim to ensure the following principles:

(i) Containment of the radioactive materials.

(ii) Protection against radiation emitted.

(iii) Safe dissipation of heat generated as 'decay heat' in the spent fuel.

(iv) Preventing any accident criticality as applicable. One of the main features of the IAEA regulations is to specify a design for the shipping cask that will ensure integrity of the contents under various conditions.

1.36 Radiation levels at the surface of the casks should be less than 2mSv/hr and at 1 meter distance, it should be less than 100uSv/hr. Contamination levels should be less than 37 mega Bq/cm^2 (beta) and 37 kBq/cm^2 (alpha).

1.37 The Committee observes that the transport containers and the procedures are approved by the Atomic Energy Regulatory Board and where shipment by rail is involved by the Commissioner of Railway Safety. Rail shipments are special desicated shipments involving special trains and the shipments are accompanied by trained professional engineers and technicians.

1.38 The Committee further observes that the spent fuel after transport and interim storage is subjected to chemical decladding and solvent extraction technique know as PUREX process is adopted to separate Plutonium and Uranium. The process equipment is installed in concrete cells of wall thickness 90-150 cm. to prevent radiation exposures to workers maintained under vacuum. The ventillation of the plant is designed to provide comfortable working conditions and control the concentration of airborne activity with the stipulated limits. The reprocessing plant has eleborate radiation monitoring systems. Signals from all the installed instruments are brought to a Central Radiation Protection Console and are continuously recorded. The special work permit system ensures that no unauthorized person enters a radiactive area without proper protective wears and personnel monitoring devices, and that all necessary precautions are followed.

1.39 It is observed that provisions are available for the decontamination of equipment such as casks, containers and other under water fixtures for the removal of any radioactivity that may be adhering to the surfaces in special decontamination areas before they are taken out of the building. Effluents arising out of the water treatment process, such as ion exchange regeneration effluents are sent for treatment to the Effluent Treatment Plant.

4. Nuclear Waste Management

1.40 The Committee wishes to record that India has accorded topmost priority for management of radioactive wastes right from the beginning of Indian nuclear programme. The radioactive wastes arise at all stages of nuclear fuel cycle starting from mining and milling of uranium ores to reprocessing of spent fuel from the reactors. Radioactive wastes are also generated from other nuclear applications such as agriculture, medicine and industries. Minimising the generation of radioactive wastes, and to contain and confine them, thus preventing from reaching the biosphere, is the basic philosophy adopted in the entire waste management programme. Towards this objective, the wastes generated at all sources are segregated and collected, and they are categorised depending on the chemical and physical form as well as the nuclide contentradiation level for the purpose of treatment and disposal.

1.41 The Committee notes that the wastes are generated in all three physical forms like gas, liquid and solid. The air borne radioactivity emanating from nuclear facilities, though low in nuclide content, is always suitable treated and filtered through high efficiency particulate absolute filters forming part of the ventilation exhaust system before it is discharged through tall stack. The monitoring system also ensures that activity discharged to the environment through this route is well within the permissible limit specified by AERB and the international standards.

1.42 The Committee finds that the liquid waste generated at power stations and other nuclear research laboratories is mostly of low and intermediate level. The low level waste undergoes appropriate treatment like chemical precipitation, evaporation, ion exchange etc. and the activity is concentrated to a very low volume and the bulk of the volume discharged is almost free of activity. Concentrated low level liquid waste and the intermediate level liquid wastes are suitably immobilized in polymer or cementitious matrix and the same is put in earth trenches or tile holes with multiple engineered barriers.

1.43 It is observed that the high level liquid waste contains most of the radioactivity generated in the entire fuel cycle and this waste arises mostly in reprocessing operations. High active liquid waste is generally concentrated and immobilized in vitrified form in borosilicate glasses. The canisters containing vitrified glass is kept under survelliance for a period of 25 to 30 years before it is finally disposed off in deep geological repository, to be in isolation from biosphere for several thousands of years. Reprocessing and removing the long-lived actinides like plutonium from the spent fuel, have several advantages in the management of spent fuel.

1.44 The Committee wishes to record that solid radioactive wastes generated at various nuclear facilities are classified into different categories based on the nature and the radiation level. They are given appropriate treatment for volume reduction by incineration, baling etc. and depending on the radiation level, they are disposed in earth trenches or tile holes with multiple engineered barriers after suitable conditioning.

1.45 The Committee's examination reveals that India has developed the technologies and has set up waste management facilities at various reactor sites to meet the above objectives. In addition, India has set up adequate institutional control to regulate the disposal of waste and carry out surveillance of all these sites. As nuclides can enter the biosphere only through migration, R&D studies are being carried out for determining the parameters that influence such migration of nuclides. Suitable modelling is carried out before setting up such repositories. India also participated in various coordinated research programmes conducted by IAEA in this area and is thus one of the few countries having expertise in all facets of nuclear waste management.

5. Atomic Energy Regulatory Board (AERB)

1.46 The Atomic Energy Regulatory Board was constituted on November 15, 1983 by the President of India by exercising the powers conferred by Section 27 of the Atomic Energy Act 1962 (33 of 1962) to carry out safety-related regulatory functions under the Act. The regulatory authority of AERB is derived from rules and notifications promulgated under the Atomic Energy Act 1962 and Environmental Protection Act 1986.

1.47 The Committee notes that the mission of the Board is to ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to health, safety and the environment. Currently the Board consists of a full time Chairman, an ex-officio Member, two part-time Members and a Secretary. The AERB Secretariat has eight divisions and one section. The Board is independent of the Department of Atomic Energy (DAE) and reports to the Atomic Energy Commission.

1.48 The Committee further notes that AERB is supported by the Safety Review Committee for Operating Plants (SARCOP), Safety Review Committee for Applications of Radiation (SARCAR) and the Advisory Committees for Project Safety Review (ACPSRs, one for the nuclear power projects and the other for heavy water projects). ACPSR advises AERB on the issuance of authorisations at different stages to a plant of the DAE, after reviewing the submissions from the plant authorities, based on the recommendations of the associated Design Safety Committees. SARCOP enforces safety stipulations in the operating units of the Department of Atomic Energy. The SARCAR recommends procedures to enforce radiation safety in medical, industrial and research institutions using radiation and radioactive sources.

1.49 It is observed that AERB receives advice from two independent Committees — the Advisory Committee on Radiological Protection and the Advisory Committee on Nuclear Safety. These Committees are composed of experts from AERB, DAE and institutions outside the DAE. These Committees advise the Board on generic issues and are not involved in the day-to-day functions such as issuing authorisations, carrying out inpsections, etc. The administrative and regulatory mechanisms which are in place ensure multi-tier review by the best experts available nationwide. These experts come from reputed academic institutions and governmental agencies.

II

ADDITION ISSUES RAISED BY CHAIRMAN

The Chairman in addition held detailed discussion and evidence with the representatives of DAE on 9th February, 1994. The issues raised during the discussion are brought out below:

1. Safety standards in nuclear reactors

2.1 The Committee examined the aspect of adherance to international norms and standards. The Committee finds that India enjoys international reputation as a "Developed" country in the field of nuclear science and technology. Safety Standards in Indian nuclear reactors follow international standards and their safety is constantly monitored by the Atomic Energy Regulatory Board which follows current international regulatory norms. Inspite of not signing NPT, India continues to be playing a prominent role among the nuclear community. Units of DAE have dynamic links with some of the leading professional international organisations dealing with peaceful applications of nuclear energy by following means:

(a) members of technical and advisory committees,
(b) professional society memberships,
(c) offering consultancy services,
(d) exchange of visits,
(e) exchange of information,
(f) current communications through newsletters, bulletins, and other documents,
(g) consultancy for preparation of standards,
(h) conduct of regional seminars,
(i) offer training and services, and above all
(j) election to key positons of offices in them.

A. few illustration are given below:

	Name of organisation	Link unit	Method of service/ interaction	Remarks
1.	World Association of Nuclear Operators (WANO)	NPC	Almost all (b to h)	Member since inception Member of WANO Nuclear network for exchange of information. Annual report of performance indication regularly received. Team from Japan & Ukraine visited Indian Power Stations.

	Name of organisation	Link unit	Method of service/ interaction	Remarks
2.	Candu Owners Group (COG)	NPC	b to g	Canadian (Member of COG) team visited RAPS and its surroundings & appreciated the safety menagement.
3.	International Atomic Energy Agency (IAEA)	India	(a to i)	Associated with the formation Member of the Board of Governors since its inception.
4.				
a.		BARC	a, c	Members of Standing Advisory Committee for Safeguard implementation.
b.		BARC	a, c	Standing Advisory Committee for Rad. Waste Management
c.		AERB	a, c	Internationl Nuclear Safety Advisory Committee
d.		IGCAR	a, c, d	International Working Group for Fast Breeding Reactors.
e.		BARC	a, c	Radioactive Waste Safety Standards Committee.
f.		BARC AERB	a, c, d	Standing Committee for Transport of Radioactive Material
g.		AERB	a, c, d	International Nuclear Events Scale Committee.
h.		AERB	a, c,	International Reporting System Committee.
i.		NPC	a, c, d	International Working Group on life Management of Nuclear Power Plants.

	Name of organisation	Link unit	Method of service/ interaction	Remarks
j.		NPC	a, e,	International Group on Plant life Management
k.		BARC	a, e	International Consultants' Group on Food Irradiation.
l.		NPC	a, e	International Working Group on Water Reactor Fuel Performance and Technology.
m.		AERB	a, e,	Nuclear Safety Standards Advisory Group.
n.		BARC	a, e	United Nations Scientific Committee on the effects of Atomic Radiation.
o.				Several Technical and Standards Committees. The numbers of about 170 in 1991, 180 in 1992, 180 in 1993.
5.	International Commission on Radiological Protection (CRP)	AERB	a, c, e, f	This is an internationally renowned body on radiological safety.

2.2 India has been a Member of the Board of Governors of the IAEA, since its inception. We are one of the ten members considered most advanced in the technology of Atomic Energy in the world, and therefore get nominated to the Board every year alongwith other countries such as US, UK, France, Russia, China, Japan, Germany, Canada, Argentina/ Brazil. We are an active member of the IAEA contributing in a significant manner to the programme and shaping of the policies of IAEA.

2.3 The Committee observes that recently India hosted the third IAEA technical committee meeting on "Exchange of operation safety experience of Pressurised Heavy Water Reactors" (PHWRs) in which a large number of delegates from the Candu Owners Group (COG) attended. There were almost 44 delegates from 6 countries, in addition to a large number of delegates of India. During the seminar, presentation regarding the various safety aspects in the India nuclear reactors were made by Indian experts. Dr. M. Rosen Assistant Director General for Nuclear Safety International Atomic Energy Agency (IAEA) Vienna paid tributes to safety standards followed in the Indian Reactors and to the Monitoring of safety aspects by AERB in strict conformity with current IAEA standards. He also praised the safety culture and the morale prevailing among the operating staff in Kakrapar Atomic Power Station (KAPS) noticed during the visit. The copies of the press release issued by him to the Indian news media, along with the other information reported by the press on the proceedings of the meeting, are enclosed.

2.4 The Committee would like to record that India even though a non-signatory to NPT has not isolated itself from the other nuclear countries of the world, even though technology control regimes are imposed by most of the developed countries. In addition, it clearly shows how India holds the status of a developed country in the field of nuclear science and technology. Further its willingness to share in experience with others bears testimony to the transparency programme. It often keeps reminding IAEA that promotion of peaceful applications of atomic energy is its primary goal.

2. Safety — Prime Concern

2.5 The Committee has also found that safety is engineered during design by following the latest international standards on the subject followed by a quality assurance programme. It includes several concepts such as defence-in-depth, redundancy of safety systems, with diverse-principle fail-safe design, maintainability, multiple barriers, physical separation, consideration for natural events such as earthquakes, cyclone, etc. in the design.

Evaluation of design from safety angle is done at three levels by committees at different stages and finally by AERB.

Fabrication of equipment, systems and construction of plants is executed with a good quality control programme.

The operators undergo well structured and systematic training and these personnel are licensed by AERB for operations.

There are several levels of inspection before the plant is commissioned for operations.

During the operation the occupational health of staff is continuously monitored and also their adherence to safety practices and procedures is continuously under surveillance. In addition the compliance of operation to technical specification is monitored by special committee of AERB.

The environmental quality is monitored by environmental survey laboratory set-up about 2 years in advance of commissioning of the plant. They monitor ambient environmental radiations on a continuous basis to detect increase, if any, due to plant operation. In addition, formulation of emergency preparedness plants and keeping alert by repeated emergency drills, are enforced by AERB.

2.6 The Committee wishes to observe that the safety of Indian nuclear industry is in no way less than that of a developed country. This aspect has been well recognised by IAEA as brought out by the press release of Dr. M. Rosen, Assistant Director General for Nuclear Safety, IAEA, on safe operation of India Nuclear Reactors (copy attached).

3. Emergency Preparedness

2.7 The Committee finds that guidelines in respect of safety measures to be taken in the event of a sudden increase in background radiation levels above levels of natural radiation, have been jointly discussed and worked out by DEA and the district officials in each State where a nuclear facility is operating. They are in the form of manuals/guides. These contain action plans for the various agencies. These action plans are also regularly tested by way of drills. The capability to evacuate the public in the Emergency Planning Zone is also checked and demonstrated as a part of the offsite emergency drills.

2.8 There are no proper link roads in certain interior villages near Rawatbhata as the population density is very low in these areas. The District Magistrate has agreed pursuant to the decision in the State Level Emergency Response Committee, to develop the roads under "Apana Gaon — Apna Kam" and "Jawahar Yojana Development Programme" which the State Government is already undertaking as its normal development activities, and has agreed to give priority Rawatbhata area.

4. Assistance to Local People

2.9 The Committee observes that for the Referral Hospital which the villagers were demanding, an unused building of the old Welfare Centre belonging to RAPS has been temporarily made available to the District Administration. This has been recently inaugurated by the Health Minister of the Rajasthan Government and facilities are to be provided by the State Government. Both RAPS and RAPP 3 & 4 are giving preference to local people in employment in group C & D categories during the last three years. All these measures are apart from many incidental benefits due to development of colonies and works taken by contractors who in turn employ local youths.

5. Interface with Public

2.10 The Committee notes that workshop and exhibitions are arranged every year at Rawatbhata addressed to the public and in particular functionaries such as Sarpanches, Panches, Pradhans, Patwaris, Block Development Officers and Gram Sevaks, regarding the safety of nuclear power, presentation of actual radioactivity release data, radiation dose attributable to RAPS in comparison to everpresent natural background radiation in the area. Every year, stalls in Udyog Mela Exhibitions organised at Kota are put up and public responses to both these exhibitions have been very good.

2.11 The Committee observes that with regard to alleged illness in the neighbouring areas RAPS gave all necessary assistance to State Government in its investigation. The disease in these villages were of common nature and mainly attributable to poor hygienic conditions and use of untreated water and were not radiation induced.

2.12 The Committee notes that an expert group constituted by the Ministry of Environment and Forests carried out investigations in the impact zone around RAPS. The Committee concluded that radiation exposure to public arising from situation related effluents is negligible when compared with average radiation exposure received by an individual in India from naturally occurring sources. The matter of releasing this information to public has been addressed to the Ministry of Environment & Forests.

2.13 The Committee also notes that four one-day workshops were arranged in villages Jherjani, Tamlao, Mandesra, Bensror Garh in the last one year to remove apprehensions in the villages about radiation. About 800 villages participated in deliberations shows and exhibitions.

6. Public Awareness Education

2.14 It is observed that for creating an awareness about nuclear power in an organised manner, the Directorate of Environment and Public Awareness in the Nuclear Power Corporation was constituted in March 1989. Public Awareness functions assigned to the Directorate have been:—

Organising Public Awareness Programmes and activities at Corporate level and co-ordinating these programmes with those conducted by Project Director/Chief Project Engineers/Chief Superintendents at various nuclear power plant sites for integrating them into the overall policy frame work.

Communication with the public on various aspects of nuclear power, responding to articles for publication, preparation of publicity literature/ brochures and co-ordinating the publication of literature prepared by sites for ensuring consistency of approach are regularly carried out by this Directorate.

Letters to the Editors of newspaper were written from time to time on various articles that appeared in the newspapers. Special supplements were brought out in leading newspapers on the occasion of dedication of power plant to the nation. Brochures were made for distribution to public during off-site emergency drills.

A special public information compaign on "Nuclear Power and You" was conducted through publication of 10 serials covering all aspects of nuclear power in newspaper and magazines in English, Hindi and other regional languages various questions raised by the public were answered.

2.15 The Committee notes that the work disseminating information on nuclear power through video cassettes, seminars, visit to sites were carried out and are being continued.

Public information centres are being established at various project sites. Various publications as handouts, brochures & audio facilities are being planned. Topical video films on radiation, nuclear power have been made for screening to the public.

Assistance is extended to villagers as far as possible by way of assisting local schools providing books and note books, some basic infrastructure etc.

2.16 The Committee further notes that at Kalpakkam, opportunity for some residents of every village around the station and within 16 km zone to visit the power station, is provided. They are taken around the station and allowed to witness the safety measures. They also talk to the staff who are working there. This provides them a good occasion to clear their doubts and fears if any. The green site and the clean environment dcfinitely impress them. The composition of the visitors is netrogenous ranging from school children to teachers and the general public. The impression recordcd by them in the visitor book indicates a certain amount of pride regarding indigenous development of nuclear technology.

7. Narora Fire Incident

2.17 The Chairman examined the Narora Fire Incident in detail. The facts of the case are as under:—

A fire incident took place in Narora Atomic Power Station at about 0330 hours on 31st March, 1993. As per the findings of the two committees, one constituted by the Nuclear Power Corporation, another by Atomic Energy Regulatory Board, the failure of two blades in the 5th stage of the low pressure turbine due to fatigue and detachment at the root has been the initiating event for the fire. These blades caused damages to other blades of the turbine which was rotating at high speed. The resulting imbalance of the machine led to the failure of the oil seals and the hydrogen seals of the generator which caused the fire. The operating staff responded exceedingly well to the situation.

2.18 This event was reported by India to the IAEA as a member of the international Nuclear Event Scale (INES) System. The INES was established over three years ago to promote gathering of information regarding incidents and accidents in the world's nuclear installations. India has been a member of the INES system and has been contributing the data ever since the inception of INES. Even a developed country like the United States did not join this open international reporting system till two years ago.

2.19 As per the INES system, the fire event that occurred in Narora is an incident and the incident took place in a turbine building physically separated from the reactor. There has no physical injury or death in this incident. There was also no spread of radioactive contamination whatsoever or radiation injury. This incident of fire due to the failure of the turbine blades at root in the turbine is not unique to India. Similar incidents have occurred in other countries also. The functioning of the termo-siphon system provided the necessary cooling, offering protection to the core. It is worth mentioning that this aspect was studied during the time of safety evaluation of the particular reactor and thermo-siphon capability was demonstrated as a part of commissioning experiment. It is gratifying to note that the system behaved as intended during the incident.

2.20 It is observed that the Committee after studying the incident, made recommendations which relate to improvement of design of blades, segregation and better lay-out of cables, strengthening of in-service inspection activities and quality assurance among other things. These recommendations are being implemented by the station authorities.

8. Plant Aging and Decommissioning

2.21 The Chairman also examined the question of plant aging and decommissioning. The observations of the Committee are as under:—

The economic life of nuclear power plants is normally assumed for the purpose of calculation of tarriff as twenty five years. However, with the development of life extension measures, this period could be extended to forty years or even more. Among various alternatives for decommissioning at the end of life, mothballing appears to be appropriate for the nuclear power plants. The process of decommissioning consists of the following steps: Removal of spent fuel for further processing (reprocessing/storage away from the reactor)—drain of coolant and other circuits. Disconnecting the operating systems—sealing all openings in the containment and keeping under surveillance. The next phase consists of dismantalling and decontaminating all equipment and buildings except reactor core and its shielding. Final stage consists of removal of reactor core and its shield, clearing the site for other uses. As mentioned earlier once the spent fuel is removed the bulk of the radioactivity is removed before the decommissioning begins, there is no uncontrolled safety hazard in this operation. Technology for decommissioning is essentially an assembly of skills, expertise and procedures developed during repair and maintenance of components and equipment in the operational phase of the reactor, to be supplemented by further development work on the robotics and remote handling techniques. The procedure for treatment of wastes arising from decommissioning nuclear power plants are similar to the ones during operation except that the quantity of low level waste to be dealt with are relatively large. India has gained valuable experience in decommissioning the fuel reprocessing plant at Trombay and the small Zerlina research reactor. Also experience in the Madras plant and replacement of feed water sparger at Tarapur plant have demostrated the inherent capabilities to take up the decommissioning work, Development work on the robotics at the Bhabha Atomic Research Centre (BARC) is in advanced stage. Therefore, there is enough confidence with regard to technology for decommissioning and it will be available in time to take up the job when required.

2.22 The Committee observes that as life extension measures are at present contemplated for the reactors that are in operation, there is no likehood of decommissioning of any reactor in this decade.

9. Implication of Delay of PHWRs

2.23 The Chairman further examined the implications of delay of PHWRS. The Committee findings are as under:—

Indian long term nuclear power programmes is a three stage programme. The first stage is based on Pressurised Heavy Water Reactors (PHWRs) using indigenously available natural uranium as fuel. Indigenous natural uranium fuel resources would sustain a nuclear power programme of 10000 MWe in the first stage. The second stage of the programme is based on Fast Breeder Reactors (FBRs) using plutonium as fuel reprocessed from the spent fuel of the first stage. During this stage with blanket material of depleted uranium, more plutonium will be bred to set up additional FBRs. Also at a later part of the second stage therium as blanket material will breed U-233 from thorium. The third stage of the programme is based on U-233 thorium based reactor systems by which U-233 can be bred to set up a number of reactors.

2.24 It is observed that the first stage programme is not an end in itself but it is route to the second stage programme of FBRs and for ultimately utilising the thorium resources. India has moderate reserves of uranium whereas thorium reserves are vast. Under the circumstances, and if a long term view of energy resources is taken, it is important push through the PHWR programme at a fast pace.

2.25 The Committee finds that for funding of nuclear power, there are no avenues for resources from overseas financial institutions, unlike in the conventional power sector. Therefore it is important to have Government support until the operating base grows to a sizable level to generate adequate internal resources.

2.26 The Committee has also found that the development and commercialisation of any technology takes considerable time. Nuclear power technology is no exception. In fact the time and efforts that have gone into development of this technology are significant having regard to the demanding nature of this technology. Development of nuclear power technology cannot be a stop-go programme working in fits and starts. A number of indigenous industries who have developed capabilities will lose interest and diversify to other areas. Indian Companies like M/s. Bharat Heavy Electricals Limited (BHEL), Larsen & Toubro, Walchand Nagar Industries, Kirloskar Bros, or and several others have developed expertise in critical areas. Spin off benefits in terms of improvement of quality level in Indian industries due to nuclear power programme is significant. If the programme slows down the turnover of scientists and engineers will progressively increase. Later when we need to revive the programme, it will be stupendous task to assemble this infrastructure. Therefore it is important to maintain atleast a minimum level of sustained growth if we have to rctain the cxpertise already developed.

10. Fuel for Tarapur

The Chairman examined and held evidence on this vexed question. The Committee wishes to record its findings as below:

2.27 A cooperation agreement was signed between the Governments of India and USA in August 1963 for setting up of Tarapur Atomic Station (TAPS). This agreement envisaged IAEA safeguards on any material, equipment or devices supplied by US. Accordingly a trilatera safeguards agreement was concluded between India, USA and IAEA in 1971. TAPS has been operating on Low Enriched Uranium (LEU) supplied by US till 1980 and subsequently by France from 83 till the expiry of the Co-operation Agreement.

2.28 The Committee set up by the Department of Atomic Energy to review the life of TAPS has recommended that it can be safely operated for another 15 years beyond 1993. Accordingly it is proposed to continue operation of TAPS. For this purpose a mixture of MOX and LEU fuel will be used. For fabrication of MOX fuel we need to reprocess the TAPS spent fuel.

2.29 On 24th October, 1993, the 1963 Cooperation Agreement with USA and the 1971 trilateral safeguards agreement expired. As we need to reprocess TAPS spent fuel to obtain the plutonium required for the MOX fuel, as a confidence building measure, Government of India made a voluntary offer to IAEA in August this year to apply safeguards on the nuclear material used in TAPS on a bilateral basis between India and the IAEA. This offer is to take effect after the expiry of the bilateral safeguards agreement on 24.10.93. Pending finalisation of this bilateral safeguards agreement (we are presently negotiating this with IAEA), India and the IAEA agreed to continue to be bound by the provisions of the expired trilateral safeguards agreement. In so far as they relate to the bilateral relationship between India and the IAEA from 25.10.1993 till 1.3.1994. The bilateral safeguards agreement based on our voluntary offer has been approved by the Board of Governors of IAEA and would be effective from 1st March, 1994.

2.30 TAPS has two reactors with a designed capacity of 2.10 MWe each. From 1969, when it was commissioned till 1985, TAPS operated at this level. In 1985, due to certain difficulties encountered in the secondary steam generators, which are on the non-nuclear side, it was decided to keep these steam generators, isolated and TAPS was derated to 160 MWe from 1985 onwards. All along (since 1969) TAPS has been operating on a nuclear fuel core of LEU. Our proposal to operate TAPS on a mixture of MOX fuel and LEU, will maintain the present generation capacity.

11. Safety of Spent Fuel Storage in the Water Pool and During Transportation

2.31 The Committee having examined this important aspect find that spent fuel is stored under water after its receipt from the reactor, as an interim measure, before being reprocessed. The storage pool has been built to the latest international codes under strict quality control. The pool is lined with stainless steel and undergoes severe qualifying procedure. The water is continuously monitored to keep its optical and chemical qualities and recirculated through ion exchange resins. The areas around the pool are monitored for radioactivity. The pool has a separate once-through ventilation system. Monitors are provided to check air for any activity. Spent fuel transportation has been well managed as per current international standards and in addition, the transport containers undergo regular inspection as per the relevant safety code classification.

III

REPLIES RECEIVED FROM DAE

Replies received from DAE to a detailed questionnaire sent to them by the Committee are reproduced below:

1. Organisational Set-Up

What is the organisational set-up of Atomic Energy Commission (AEC)/ Department of Atomic Energy (DAE) and what is the objective and area of work entrusted to this Department and role of its subsidiaries?

India embarked on its atomic energy programme over 4 decades ago. The Atomic Energy Commission (AEC) set up in 1948 laid down policies on use of atomic energy for peaceful applications. To execute these policies, the Dept. of Atomic Energy (DAE) was formed in 1945, direcetly under the charge of the Prime Minister. Today the DAE comprises of over 35 major units/sub-units. Various units are grouped based on their function under a broad classification such as Research and Development units, Public Sector Undertakings, Industrial units etc. Bhabha Atomic Research Centre (BARC) is the premier national centre not only in nuclear technology, but also in several areas of high technology and basic research and development in nuclear science and disciplines. It is the cradle of research and development in nuclear science and technology and allied areas. It has played a key role in acquiring self sufficiency and reliance in technology related to reactor and its fuel cycle. It has done pioneering work in developing technology for application of nuclear energy for medicine, agriculture and industry. The second largest research centre *viz.* Indira Gandhi Centre for Atomic Resarch (IGCAR) is located at Kalpakkam and it is devoted for development of technology of Fast Breeder Reacter (FBR) and its full cycle. The Centre for Advanced Technology (CAT), Indore is devoted to development of high technology in the areas of accelerator, lasers, fusion etc. The Variable Energy Cyclotron Centre (VECC) is a national facility for basic and applied research in the area of nuclear physics, nuclear chemistry, studies related to radiation damage, etc. Among the public sector undertakings, Nuclear Power Corporation of India Ltd., (NPCIL) is the largest one and is devoted to commercial generation of power and is responsible for design, construction and operation of nuclear power reactors in the country. The Electronics Corporation of India Ltd. (ECIL) is set up to manufacture electronic systems, instruments and has produced a wide range of sophisticated electronic systems primarily needed for the nuclear programme based on the indigenous technology developed in BARC. Uranium Corporation of India Ltd. (UCIL) and Indian Rare Earths Ltd. (IREL) are other public sector undertakings. UCIL supports the nuclear power programme by operating mines at Jaduguda and Bhatin and mill at Jaduguda for supplying uranium are concentrates needed for the pressurised Heavy Water Reactors (PHWR) while Atomic Mineral Division (AMD) is engaged in R&D activities pertaining to radiometric and geological surveys, exploration, prospecting and development of various mineral resources needed for the nuclear power programme. IRE produces various minerals and value added products. It also separates thorium from the monazite sands available in the country.

Heavy Water Board (HWB), Nuclear Fuel Complex (NFC), Board of Radiation and Isotope Technology (BRIT) are the industrial units of the Department. Heavy Water Board is primarily responsible for production of heavy water needed for the PHWRs and operates several plants set up indigenously. The NFC produces finished fuel and blanket bundles needed for the PHWRs and the FBRs in the country. In addition, the Department supports aided institutions such as the Tata Institute of Fundamental Research (TIFR), Tata Memorial Centre (TMC) at Bombay, Saha Institute of Nuclear Physics, Calcutta and Institute of Physics, Bhubaneswar. The structure of DAE is given separately in Annexure I where the functions of the various units have also been explained.

The prime objective of the atomic energy programme as defined in the Atomic Energy Act of 1948 was development, control and use of atomic energy for peaceful purposes, *viz.* generation of electricity and the development of nuclear applications in medicine, agriculture, industry and research other areas. The functions of Atomic Energy Commission (AEC) as defined in the Atomic Energy Act are given in Annexure II.

2. Historical Background

A note giving the historical background regarding Nuclear Programme.

In regard to organisational history for setting up and operating the nuclear power stations TAPS-1&2 was set up by a separate project group of DAE. Construction of Rajasthan Atomic Power project (RAPP) also commenced in 1960s under a project group. In June 1967, DAE constituted Power Projects Engineering Division (PPED) with headquarters in Bombay with responsibility for design, engineering procurement, construction, commissioning, operation & maintenance of atomic power projects. In July 1970, Atomic Power Authority was created as a separate constituent unit of DAE for operation of atomic power station on a commercial basis. On July 1, 1979, the responsibilities of Atomic Power Authority were transferred to PPED. With the proposed expansion of nuclear power programme a Nuclear Power Board (NPB) was constituted under DAE in

August 17, 1984 to implement the programme. The NPB was subsequently converted into Nuclear Power Corporation of India Limited, (NPCIL) as a Govt. owned Public Ltd Company in September 1987. This company is now responsible for setting up and operating nuclear power stations.

Nuclear power was ushered in India in 1969 with the Tarapur Atomic Power Station (TAPS) comprising of two boiling water reactors (BWRs) going into commercial operation. Though Indian nuclear power programme is essentially based on PHWRs using natural uranium as fuel and heavy water as moderator and coolant, the Tarapur station was set up essentially to prove the technical viability of operating such units which were, at that time, considered largest in the Indian grids. This station has seen a safe and reliable operating record of about 25 years providing the much needed electricity to the States in the Western Region. The work on the next power station near Kota in Rajasthan having two units each with the original installed capacity of 220 MWe started about the same time. Indigenisation of about 55% in the construction of RAPS—1 was achieved. It was only when work on RAPS-2 with a capacity of 220 MWe commenced that a major effort on indigenisation was launched. Indian industries were inducted in the manufacture of sophisticated nuclear components. This required active interaction between Indian industry and PPED to achieve the quality levels warranted by these sophisticated components. The indigenous content of RAPS-2 increased to about 75%.

Madras Atomic Power Station with 2×220 MWe units was taken up in 1967 (first unit), 1971 (second unit) as a totally indigenous effort including design and engineering responsibility for the plants. A number of site related changes in the design of the plant and also improvements in safety related systems such as containment were implemented in this station. While nuclear designs were taken up by PPED/NPB, the engineering work in conventional systems was entrusted to indigenous consulting engineering firms who had experience with the thermal power plants. Most of the components in nuclear and conventional systems were manufactured in India. The foreign exchange content of this project was only about 10%.

When designs of the next project at Narora with a 2×220 MWe capacity PHWRs was taken up, efforts were directed towards evolving a standardised version of 220 MWe units to suit the moderately seismic conditions at the site, taking into account the trends in the safety standards of nuclear power reactors and feedback from operating stations in the country. The subsequent projects *i.e.* Kakrapar Atomic Power Project (KAPP-1&2) Rajasthan Atomic Power Project (RAPP-3&4) and Kaiga Project (KAIGA-1&2), each with 2×220 MWe units, taken up by PPED/NPB/NPCIL have seen further improvements in design based on the feed back from construction and operating experience.

Present installed capacity of nuclear power stations in commercial operation is 1720 MWe. (TAPS-1&2 with 2×160 MWe, RA-1&2 with

1×100 & 1×200 MWe, MAPS-1&2 with 2×220 MWe, NAPS-1&2 with 2×220 MWe and KAPS-1 with 220 MWe). The second unit (220 MWe) of Kakrapar (KAPS-2) is scheduled for achieving criticality in the second quarter of 1994. At Kaiga, 2×220 MWe units presently under construction are scheduled for achieving criticality in June/December, 1996. At Rajasthan units 3&4 (2×220 MWe) are scheduled for achieving criticality in November, 1996 and May, 1997 respectively. The total nuclear installed capacity is expected to reach 2820 MWe by 1997.

DAE's 8th Five Year Plan proposals envisaged commencement of work on 2×500 MWe units at Tarapur, 4×220 MWe Units at Kaiga and 2×500 MWe units at Rajasthan to reach an installed capacity of 5700 MWe by 2002 A.D. However, due to significant reduction in nuclear power plan outlays, reduction in budgetary support to NPCIL from Government and difficulty in mobilising resources through market borrowings, it has not been possible to commence work on these projects. However, it is planned to start work on one/two units at Tarapur (TAPP 3&4) on the totally indigenous 500MWe, PHWR reactor design. In parallel, possibility of joint sector with beneficiary States is also being explored for other projects. Further programme will depend on resources. In regard to 2×1000 MWe plant at Kudankulam proposed to be set up in terms of the Inter Governmental Agreement (IGA) on November, 1988 between India and USSR, due to developments in the erstwhile USSR discussions are in progress with Russian Federation on the proposed project and a clear picture would emerge in due course.

3. Nuclear Power Generation

3 (i) A detailed note on account of the performance of atomic power stations generating power - unitwise and yearwise, also indicate the installed capacity, target, actual generation and capacity utilisation and the reasons for shortfalls, if any, in power generation. The information may be given for the Seventh Five Year Plan, Annual plans and for the year 1992-93.

Following Tables-1 to 4 provide the required information

Table-1

Generating Performance of Nuclear Power Stations of NPCIL during 7th Plan (1.4.1985 to 31.3.1990)

Unit	Rated Capacity MWe	Target Generation MUs	Actual Generation MUs	Availability factor (%)**	Capacity factor (%)	Remarks
TAPS-1	160	4696	4519	70	64	The unit achieved capacity factor of 64% which is above normative level.
TAPS-2	160	4754	4491	71	64	The unit achieved capacity factor of 64% which is above normative level.
RAPS-2	220	5636	6680	78	69	The unit achieved capacity factor of 69% which is above normative level.
MAPS-1	235	6150	5027	62	49	The performance of the unit was affected due to failure of generator transformer, turbine HP rotor replacement and damage to calandria inlet manifold and consequent power limitation.
MAPS-2	235	5056	3938*	57	41	The performance of the unit was affected due to a problem of spent fuel getting stuck M fuel handling system and retreiving the same, turbine blade failure and calandria in 'et manifold failure and con- q'ent power limitation.

(1) *w.e.f. March '86 the date of commencement of commercial 'eration.

(2) RAPS-1 (220 MWe) generated 1428 MUs during the plan peri with an availability factor 35% and capacity factor of 15%. The performance was mainly affected due to the light water leak in south endshield, the efforts on sealing the same and subsequent maximum power limitation to around 100 MWe. This first PHWR unit is retained by the Govt. and was not transfered along with other assets to NPCIL when the company was formed.

(3) **Availability Factor : The availability factor is the ratio between th ber of hours the unit was on-line and the total number of hours in the reporting pe Capacity Factor : The capacity factor of an unit is the ratio of the energy that it duced during the reporting period to the energy that it could have produced at ximum capacity under continuous operation during the whole of the reporting period

Table-2

Generating Performance of Nuclear Power Stations of NPCIL during 1990-91

Unit	Rated Capaci-ty MWe	Target Genera-tion MUs	Actual Genera-tion MUs	Availa-bility factor (%)	Capaci-ty factor (%)	Remarks
TAPS-1	160	1186	943	77	67	The unit achieved 67% capacity factor which is above normative level.
TAPS-2	160	790	961	88	69	The unit achieved 69% capacity factor which is above normative ' vel.
RAPS-2	220	1585	1310	83	68	The unit achieved 68% capacity factor which is above normative level.
MAPS-1	235	835	911	75	44	The unit experienced the problems of generator transformer failure strike, and PHT pump seal-failures. Further the unit's power level was restricted to a max. of 175 MWe as compared to 235 MWe based on which capacity factor is calculated.
MAPS-2	235	975	1163	84	56	The unit's maximum power level was restricted to 175 MWe as compared to 235 MWe based on which capacity factor has been calculated.
NAPS-1	235	1213	568* 286**	80**	56**	The unit's commenced commercial power generation from 1.1.1991.

(1) *w.e.f. 1.4.90 including infirm power.

(2) **w.e.f. 1.1.91 the date of commercial operation.

(3) RAPS-1 generated 471 MUs with an availability factor of 68% and capacity factor of 24%. The unit's power level was limited to around 100 MWe.

Table-3

Generating Performance of Nuclear Power Stations of NPCIL during 1991-92

Unit	Rated Capacity MWe	Target Generation in MUs	Actual Generation MUs	Availability factor (%)	Capacity factor (%)	Remarks
TAPS-1	160	915	745	63	53	The unit had its refuelliung & planned maintenance outage. It also experienced a few forced outages.
TAPS-2	160	915	965	72	69	The unit achieved capacity factor of 69% which is above the normative level.
RAPS-2	200 w.e.f. 1.4.91	1160	1062	65	60	The unit achieved capacity factor of 60% which is around the normative level.
MAPS-1	220 w.e.f. 1.1.92	930	869	59	43	The outage arising out of failure of Generator Transformer continued in this year in addition to a few forced outages. The unit's maximum operating power level was restricted to 175 MWe consequent on the implementation of interim solution to overcome the failure of moderator inlet manifolds. The capacity factor indicated are based on 235 MWe upto 1.1.92 and thereafter 220 MWe.
MAPS-2	220 w.e.f. 1.1.92	900	1292	89	64	Inspite of operational power limitation of 175 MWe. The unit achieved 64% capacity factor.
NAPS-1	220 w.e.f. 1.1.92	970	532	47	26	A number of safety related modifications like installing additional Diesel Generator and system improvements were carried out. A number of maintenance jobs were also carried out.

Unit	Rated Capacity MWe	Target Generation in MUs	Actual Generation MUs	Availability factor (%)	Capacity factor (%)	Remarks
NAPS-2	220	220	(35*) infirm power			

* Unit commenced commercial power generation from 1.7.92.

(2) RAPS-1 generated only 123 MUs during the year due to a long planned maintenance outage.

Table-4

Generating Performance of Nuclear Power Stations of NPCIL during 1992-93

Unit	Rated Capacity MWe	Target Generation in MUs	Actual Generation MUs	Availability factor (%)	Capacity factor (%)	Remarks
TAPS-1	160	1156	1146	86	82	Achieved a capacity factor of 82%
TAAPS-2	160	916	788	62	56	The unit had its planned refuelling and maintenance outage. Emergency condenser tubeleak and low condenser vacuum problems were solved.
RAPS-2	200	1061	925	59	53	The unit had its planned maintenance outage. Inservice Inspection of coolant channels and chemical decontamination were carried out.
MAPS-1	220	900	1191	83	62	The unit achieved capacity factor of 62% based on rated capacity of 220 MWe even though its max. operating power level was restricted to 175 MWe.
MAPS-2	220	870	787	56	41	The unit had its planned annual shutdown. The max. operating power level was restricted to 175 MWe as compared to rated 220 MWe based on which capacity factor has been worked out.

Unit	Rated Capacity MWe	Target Generation in MUs	Actual Generation MUs	Availability factor (%)	Capacity factor (%)	Remarks
NAPS-1	220	1060	1031	69	54	The performance is an improvement over 1991-92. Problems on TG, condenser tube leak were solved and certain other maintenance jobs were carried out.
NAPS-2	220	881	737 (648*)	54	45	The problem of turbine lacing rod failure and generator rotor replacement called for a long outage.

Note - RAPS-1 generated 133 MUs during the year. The unit's availability was affected due to a minor but difficult leak of heavy water from the Over Pressure Relief Device mounted over Calandria.

* w.e.f. 1.7.92, the date of commencement of commercial operation.

3(ii) Projections, estimates, targets and priorities during the 8th Plan in respect of (i) above may be given.

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3(iii) What goals have been set by Department of Atomic Energy for the 8th Five Year Plan.

During the 8th Plan, Narora Atomic, Power Station Unit-2 (220 MWe) achieved commercial operation w.e.f. 1st July, 1992. Subsequently Kakrapar Atomic Power Station Unit-1 (220 MWe) achieved criticality in September 1992, synchronised to grid in November 1992 and Commenced Commercial hower generation from 6th May 1993. Kakrapar Atomic Power Project Unit-2 is expected to achieve criticality during the second quarter of 1994 and thereafter commence power generation. Construction activities on the ongoing projects Kaiga-1&2 (2×220 MWe) and RAPP-324 (2×220 MWe) are progressing for achieving criticality in June/December 1996 (Kaiga-1&2) and November 1996/May 1997 (RAPP-3&4.) This will enable these units contributing to sizable generation in the 9th plan.

The other priorities are rehabilitation of Narora Unit-1 consequent to the fire incident. Narora Unit-2 which also continued to be shut down after the fire incident came back on line in November 1993. Narora Unit-1 is expected to be back on line by May 1994. The other important priorities are to fund the ongoing projects for meeting the schedule and expediting the activities. Efforts are also in progress to commence work on the 500 MWe units at TAPP-3&4. Consequent to the Narora fire incident, a series of inservice inspections of turbines in the units have been taken and it is intended to complete them and make necessary modifications with a view to improving the performance.

During the first year (1992-93) of the 8th plan, against a total target nuclear generation of 6844 MUs actual generation of 6606 MUs was a cheereed including 133 MUs of generation from RAPS-1. In 1993-94 though a total nuclear generation of 8100 MUs was inititally envisaged, after the Narora fire incident this was revised to 6500 MUs. A generation of 5500 to 5700 MUs is anticipated during this year.

4. Nucler Power Generation Cost

4(i) What is the estimated per MWe power generation cost for rated capacity of nuclear power generation at point of use, along with the cost of network required for transmission?

The estimated capital costs of 2×220 MWe units at Kaiga (Kaiga-1&2) and 2×220 MWe units at Rajasthan (RAPP-3&4), for completion in 1966 & 1997, are in the range of Rs. 3.5 crores per MWe base plus Rs. 1.5

crores per MWe towards interest during construction. As Department of Atomic Energy is responsible only for generation, the transmission network cost is not included in the above.

4(ii) What steps have been taken by the Ministry or propose to take to make nuclear power generation competitive with other thermal and hydro power generation etc.

The cost of generation of nuclear power stations is generally comparable with coal fired thermal power stations located about 1000 km away from coal mines. Over a period of time due to evolving safety standards and additional design provisions the capital costs have shown an increasing trend. This is also due to higher debt equity ratio, high interest, relatively longer gestation periods. However having regard to energy resource scenario and long term angle, the economics of nuclear power falls into an acceptable domain for electricity generation.

One of the important factors for reducing capital cost is the gestation period. Increased level of mechanisation, paralleling of construction activities, packaging of works between defined terminal points and strengthening project management are some of the measures being adopted/planned for reducing the gestation periods. The other important factor is improving the capacity factor. Efforts on strengthening preventive and predictive maintenance, better outage planning, and equipment condition monitoring are continuing for improvement of capacity utilisation.

5. Safety Performance

5(i) A note on the safety performance of atomic power plants bringing out inter-alia, the details of accidents occured (national and international) so far and their impact on human lives and environment case-wise.

Nuclear power plants in India have establised a good record of safety during their operation. Safety is given utmost importance in the operation of all the atomic power plants in the country. It is continuously reviewed by the Atomic Energy Regulatory Board (AERB), constituted by Government of India.

There has been no nuclear accident in any of the nuclear power plants in the country which could result in any adverse impact to the environment or human life. There has been no case of injury or casualty due to radiation. Gaseous and liquid releases from the nuclear power stations have been small percentage of the authorized limits specified by Atomic Energy Regulatory Board (AERB).

Occupational radiation exposure is controlled as per the individual limits stipulated by AERB. Efforts are continuing to reduce the collective dose to occupational workers.

Survey by Environment Survey Laboratories located in each operating stations has revealed no perceivable adverse environmental impact.

India follows International system of reporting as per International Nuclear Even Scale (INES). As per this scale no nuclear accidents have taken place and only incidents have occured which are reported to IAEA. No lives have been lost due to nuclear incidents in more than 100 reactor years of operation.

In regard to industrial accidents frequency and severity rates of the same in the nuclear power stations in operation and construction are far below prevalent national levels.

All the limits and standards followed by AERB are in line with international standards including that of International Atomic Energy Agency (IAEA) and International Commission on Radiation Protection (ICRP).

There have been two major reactor accidents in atomic power plants in the world, the Three Mile Island accident in the United States of America in the year 1979 and the Chernobyl accident in the Soviet Union in the year 1986. In the case of the Three Mile Island accident, there was no casualty among the workers and environmental consequences were insignificant. There were 31 casualties among workers of the plant in the case of Chernobyl accident. Most of these were firemen who were involved in the immediate fire-fighting operations. A total of 300 workers surffered radiation sickness but recovered. There was no casualty or any radiation sickness among the public. Long term effects such as cancer are estimated to be insignificant in relation to natural incidences.

5(ii) A note on the adequacy of existing safeguards in the nuclear power plants in regard to safety during normal operations and to meet emergency situations.

Adequate modifications are made in the design of nuclear power plants to ensure safety to operationg personnel/public and environment during normal operations as well as during emergency situations. During the design of the nuclear reactor, the following three basic safety considerations are given prime importance over and above a number of other design features.

1. Ability to shut down the reactor and capability to maintain it in shutdown state at any point of time,
2. Ensuring decay heat removal from the core, and
3. Preventing escape of radioactivity.

The reactor safety is assured through realisation of the above three requirements. The concept of defence-in-depth is built into the design which requires multiple echelons of defence to be available whenever there is a challenge to any of the safety functions. There are several ways through which such defence-in-depth is engineered. First of all there are several barriers between the fuel, where the fission reaction takes place, and the surroundings such as fuel sheath, primary heat transport system boundary, containment boundary etc. Indian PHWRs, in particular, have two containment buildings, one surrounding the other, thus adding an extra barrier and virtually eliminating any ground release. Defence-in-depth is also realised through incorporation of several redundancies and diversities in different systems that are provided for carrying out various safety functions. These systems are in addition to the systems required for normal operation of the nuclear power plant which itself is designed and built to a specified level of reliability and which provides primary defence by ensuring that the chances of drifting beyond the normal operational domain are minimised.

One of the important aspects of the design of a nuclear power plant is the requirement on the designer to postulate a series of design basis accident situations irrespective of their low probability of occurrence and to provide systems to mitigate the effects of such postulated accident conditions. The postulates of failures within the plant and also external events are considered for this purpose. Loss of coolant accident, station blackout etc. are some typical examples of postulates that are made in the first category. This is mandatory in spite of the very low probability of occurrence of such events because of high quality engineering and construction as well as built in design features to minimise the probability. Postulates of design basis earthquakes, design basis floods, are typical examiples of external events that are considered in design. The probability of occurrence of such external events and thir consequences is also minimised at the siting stage itself through adherence to prelaid siting criteria such as specifications of minimum distance from source of hazards such as a nearby air field, hazardous installation, active fault etc. The design ensures provisions of adequate safety systems with built-in redundancies for each of such postulated design basis events. Indian PHWR design incorporates two diverse fast acting shutdown systems, each with some additional redundant capability. Similarly there are diverse heat transfer paths for removal of decay heat from the core. Additional core cooling provisions are available in the form of emergency core cooling system which can remove the decay heat from the core even in the event of a loss of coolant accident involving a break in primary heat transport system of the reactor.

Seismic design considerations have formed one of the most important factors in the design of PHWR that has been evolved in the country. The first of such units, where significant upgradation in seismic design has been carried out are the reactors at Narora. The seismic design process starts with siting considerations which require cortain screening cricteria to be met and scismicity related issues at the around the site to be evaluated in detail to generate a set of design inputs. The design of reactor systems is then checked for its adequacy against the design inputs to satisfy that the stresses and displacements at all locations are within the permissible limits.

The entire process of nuclear power plant design, construction, commissioning and operation is covered by a systematic quality assurance programme to provide assurances about meeting of all safety requirements.

PHWRs have several important safety features which provide superior safety strengths in these reactor systems as compared to other power reactor types. Existence of low temperature moderator inside the calandria (reactor vessel) provides an inherent heat sink which would prevent melting of fuel even under conditions of a low probability loss of coolant accident co-incident with a postulated failure of emergency core cooling system which itself has several in-built redundancies. Similarly the much longer neutron life time in heavy water moderated reactor systems helps in keeping the power excursion to a relatively lower magnitude. At the same time this feature also enables reactor operation with minimum amount of excess reactivity in the core, which also contributes to keeping the power excursion to relatively lower magnitudes. The limitation in temperature of fuel also means limitation on the metal water reaction that can occur in an accident involving core heat up. Thus the hydrogen released in the containment is lower. We have large containment volume in our PHWRs, and this accounts for much lower threat to containment integrity.

The design of PHWRs is backed by an ongoing safety research programme that is being pursued by DAE. As a part of this programme several experiments and sophisticated computer calculations are made to understand the system behaviour undervarious conditions in greater detail. A number of advanced computer codes are available for different types of safety analysis activities. Many of these computer codes are validated through international benchmark calculations. Apart from the experiments carried out in the laboratory, tests are also carried out during the commissioning stages of a reactor to prove the safety characteristics of the reactor design. For example, a test to demonstrate heat removal through thermosyphon was carried out at low power during the commissioning stage of Narora reactor. Such tests, apart from providing validation of design also provide sufficient confidence about the safety of our reactors.

During the turbogenerator fire in the turbine building I, incident at Narora, the reactor operators and the safety systems of the reactor acted as intended and even though the incident led to failure of electrical power supply that is needed for pumping cooling water, alternate cooling provisions came in to play and core cooling function was maintained unaffected. Similarly the reactor shutdown function and integrity of all barriers to prevent escape of radioactivity were unaffected. The incident has been investigated in detail and lessons for improvements in power supply arrangements have been learnt and incorporated where ever necessary. Inspection of turbine has also been strenghened.

Systematic probabilistic safety assessment studies are also carried out to assess the overall safety of the reactor system. It has been possible to demonstrate through such studies that Indian PHWRs are comparable to some of the best reactors in the world from the safely stand point.

A nuclear power plant is designed such that in the event of a Design Basis Accident, no harm can occur to plant personnel or members of the public. Such an approach is unique to nuclear power plants. As a further precaution, a nuclear power plant has an exclusion zone of about 1.6 km around it where permanent residence by the public is not allowed. This is surrounded by a sterilised zone in the annulus between 1.6 Km & 5 Km radius where activities that may lead to enhanced population growth or influx of new population are regulated. A combination of probability-limiting and consequence-limiting steps are thus systematically applied and represent the "Defence-in-depth" philosphy that underlies the safety approach for containment of radioactivity in nuclear plants.

The radiological safety of the plant personnel is ensured by radiological assessement of plants areas, personnel monitoring and by implementing appropriate approved radiation protection procedures-in conformity with the guidelines of IAEA.

The Department holds a unique position in its concern for preparedness for emergencies at various levels. Not only plans for emergency preparedness, related to on-site and off-site are imperative, but also their approval by AERB followed by conducting satisfactory mock drills periodically, are necessary for the issue of licence for operation. Constant updating of the plans and conducting drills based on them and reviewing them during the phase of operation are also mandatory. To make emergency preparedness effective, public education and awareness programmes are undertaken.

5(iii) Whether technologies available in India are sufficient to check nuclear hazards or some outside help is being taken to make our Nuclear Programme safe.

Yes. India has acquired sufficient allround expertise in all areas related to design, construction and safe operation of PHWRs. Hence the need for seeking assistance from outside the country does not arise, but we keep in touch with the latest trends through participation in international conferences and in meetings organise by the Intenational Atomic Energy Agency (IAEA). We are the member in almost all the important committees set-up by IAEA. (Annexure III).

For example, the third IAEA Technical Meeting on the exchange of operational safety experience of PHWR has been hosted by India in which the members of the CANDU owners group participated. This was attended by a large number of delegates from six countries. This also included the World Association of Nuclear Power Plant Operatars. During the seminar, presentations regarding various safety aspects pursued by the India were presented by Indian experts which received all round admiration. In a press release Dr. Moris Rosen, Assistant Director General of IAEA for Nuclear Safety paid tributes to the safety standards regulated by the

AERB in the Indian reactors which are comparable to International standards. He also expressed his appreciation of the safety culture and high morale observed among the staff of Kakrapar Atomic Power Station, which, he witnessed during his visit to the site. Copies relating to the press conference are enclosed as Annexure IV.

5(iv) Whether we are lacking in technology in making our nuclear programme safe. Whether we are facing any types of constraints in importing nuclear safety technologies from other countries? If so, give details.

India has competence to deal with the safety issues with the indigenours expertise and technology. This has been possible because of the strong safety research programme and scientific and technical support fom the different DAE units, Indian academic institutions and industry. The country's nuclear technology has reached a mature state to ensure safety in all related activities. It is worth mentioning that today India is denied access to technology by the discriminatory and restrictive technology control regimes exercised by the developed countries because of the fact that India has not signed the NPT. However, this has not in anyway been a constraint as India is capable of finding solutions to safety related problems on her own. Exchange with other nations is however, achieved by international conferences and meetings organised by India or by Indian participation in these when arranged outside.

5(v) In view of Three Mile Island and Chernobyl incidents, whether the Department of Atomic Energy have reviewed the safety measures of nuclear plant. What steps have been taken in case of eventuality.

Following the two major accidents in nuclear power plants i.e. at TMI-2 (1979) and at Chernobyl (1986), detailed reviews were conducted taking into account the International inputs to draw lessons from these accidents, and to improve designs and operating practices where required.

The review following the TMI accident resulted in recommendations for several improvements including design, emergency preparedness, and training and qualification. The design related improvements implemented include enhancement in reliability of auxiliary boiler feedwater supply by adding a standby auxiliary boiler feed pump (BFP) and other changes; upgradation of emergency core cooling system by incorporating high pressure accumulators, and incorporation of additional redundancy to improve the reliability of on-site emergency power supply. The review also indicated the need for improved training of operators to handle emergency/accident conditions. Detailed procedures to meet this objectives were prepared.

The Chernobyl accident which happended because of the features of the RBMK type of reactor (very different from PHWR) and non adherence to following the laid down procedures, also pointed to the need for well-coordinated plants and organisation for on-site and off-site emergencies, that may arise from nuclear accidents.

The Three Mile Island (TMI) resulted mainly from operators' errors, which led to the partial melt-down of the reactor fuel. Despite this, various safety systems functioned as designed. The radioactivity was contained with practically no release to the environment. There was no loss of life or injury. At Chernobyl, the accident occurred when safety precedures were violated while carrying out the experiment on turbo-generators. This experiment itself was not authorised from safety considerations. No less than six such specific violations took place, which by-passed safety mechanisms that could otherwise had shut-down the reactor and prevented the accident. Further, the reactor was of earlier generation of RMBK type, whose safety features were marginal.

Steps have been taken to further strengthen our plans and preparedness for on-site and off-site emergencies. On-site and off-site drills are conducted for the purpose.

5 (vi) In view of the above (v) what was the reason of recent fire in the Narora Atomic Power Station. Whether any Committee/Commission had been appointed to investigate the cause of fire at the NAPS. If so, the findings of the Commission/Committee thereon.

In both Chernobyl and TMI events the core of the reactor was affected. However, in TMI the spread of radioactivity was prevented and radioactivity was contained. There was no radiation injury or death. In case of Chernobyl as mentioned earlier there was spread of radioactivity and casualities as well. TMI and Chernobyl are ranked seven and five respectively in the INES classification and both are accidents, whereas the fire event in Narora was an incident as per the INES. The incident took place in the turbine building and there was no spread of radioactivity or any radiation injury. Hence at the outset the two cannot be compared. Two committees were constituted to investigate the fire incident, one by the Nuclear Power Corporation under the Chairmanship of the Director, Health and Safety of the Corporation and the other by the Atomic Energy Regulatory Board under the Chairmanship of the Director, Reactor Group, Bhabha Atomic Research Centre, to inquire into the cause of fire. Both the Committees have identified the failure of two blades in the 5th stage of the low pressure turbine due to fatigue and detachment at the root as the initiating event for the fire. The detached 5th stage blades caused damage to the other blades of the turbine which was rotating at high speed. The resulting imbalance of the machine led to the failure of the oil seals and hydrogen seals of the generator which caused the fire. Both committees gave their recommendations for improvement of fire protection such as better layout of cables improved design of turbine blade and provision of fire bariers among other things. The station authorities are implementing the recommendations.

6. Radiation Exposure

6(i) A note on safety measures undertaken for preventing exposure to radiation. Are these steps considered adequate?

Radiation exposures are of two types (i) external exposure (ii) internal exposure. External exposure refers to exposure received from sources external to the body. Exposure to cosmic rays, a chest X-ray examination, or exposure from an industrial radiography source are examples of external exposure. Internal exposure refers to the exposure from radioactive materials present within the human body. Exposure received from Potassium-40 present naturally in the human body as a small fraction of body potassium and exposure received by the human thyroid when a doctor administers radioactive I-131 for diagnostic or therapeutic purposes for thyroid disorders are examples of internal exposure. Internal exposure can occur in the work place when a worker gets radioactive material inside the body by inhalation of air-borne radioactive contaminants as aerosols, ingestion of contaminated food or water, (this is not normally relevant in the work place), radioactive contamination of skin or skin abrasions or wounds.

Control of external exposure is achieved by shielding the radiation sources, increasing the distance of the worker from the sources and by regulating the time spent near the same. Areas and buildings where human occupancy is more are located sufficiently far from "active" buildings, remote handling tools such as master slave manipulators are used for reducing radiation levels. The above three approaches constitute the Time-Distance-Shielding techniques for controlling the external exposures. Lead, concrete, steel and water are commonly used as shielding materials against penetrating gamma and neutron radiations. Special lead glasses are used as window materials where viewing through the shield is required.

The main objective of the control adopted to avoid the internal exposures is to "contain" the source. This is known as "containment". Besides, an elaborate ventilation and air-cleaning system forms part of the "containment" philosophy adopted for the operation of such plants. The main features of such a ventilation system are (i) adequate air changes in areas occupied by personnel (ii) air flow pattern from inactive to increasingly active areas (iii) properly controlled pressure differentials to ensure the same (iv) no recirculation of air i.e. once-through system (v) elaborate cleaning and filtration systems before the air is discharged through a tall stack (vi) redundancy in equipment such as fans and auxiliary power for continued operation in the event of power failure and (vii) adequate instrumentation to monitor the proper performance of the ventilation system.

For control of contamination, the work areas are classified into different zones, depending upon the contamination potential. Instrumentation is provided at inter-zone barrier locations where personnel can monitor their body and clothing for radioactivity.

In order to ensure that exposure of workers to radiation and radioactive contamination is effectively controlled and to comply with statutory guidelines, a number of radiological measurements using a variety of portable and installed radiation measuring instruments and laboratory systems are carried out.

Further, jobs involving high radiation levels or potential for contamination are regulated through a system of "Special Work Permits" which ensures a numbers of stipulations to be followed. The stipulations will specify personnel dosimetry devices to be used, time limit for the work, dress regulations including special type of "frog suits" while working in high active areas, respiratory protection equipment to be used etc.

These and other related steps taken to control the exposure of plant personnel have been considered adequate on the basis of operating experience and guidelines issued by regulatory authorities.

6 (ii) Has there ever been any damageable dose of radiation exposure among workers and local population? If so, please give details unit wise indicating the permissible limit and actual extent of radiation exposure, duration of plant closure, if any.

There has been no "damageable" dose of radiation exposure among workers and local population due to the operations of the atomic power plants in the country. There has been no instance of plant closure on account of any radiation injury.

6(iii) Is it true that leakage of radiation have been reported from two research reactors-Dhruva and Cirus as also from Rawatbhata Atomic Power Plant? If so, has any investigation been made of such occurrence of radiation? What are the findings of such investigations, what action has been taken so far to contain in the light of investigation? Has any future action plan been prepared to prevent any mishaps in future.

In December 1991, radioactive contamination was observed in the sub-soil in CIRUS reactor complex at one location. This was investigated in detail and was found to be due to a leak in an underground stoneware pipeline used for transferring low level active effluents. The excavated soil was safely disposed off as active waste. The area was back-filled after making provisions for preventing migration of any residual activity. Bore holes were also provided around the area and water samples from these are being analysed every month. No migration of radioactivity has been observed.

To prevent recurrence of such incidents, monitoring of all pipelines carrying radioactive fluids is being carried periodically. Results of analysis of bore hole water samples and checking of pipelines are being regularly submitted to safety authorities.

6(iv) Has any assessment been made about the impact of radiation on public health residing near the nuclear power plants? If so, what steps have been taken by the Department to improve the situation in close coordination with the Ministry of Health. Is there any Inter-Ministerial Group/Committee to oversee this aspects? If yes, furnish a detailed note on the functioning of such Group/Committee.

Environmental Monitoring Programmes around the atomic power plants are conducted by the Environmental Survey Laboratories located at the plant sites. The results indicate that doses received by the members of the public residing near the power plants are only a small fraction of the stipulated dose limits. These are only a small fraction of the variation in natural background observed in the different areas of the country. No health effects are attributable to such insignificant radiation exposures. This conclusion has been arrived at after a careful study. The possible level of exposure of the public residing near the nuclear plants to radiation is compared with the level of exposure they would have received any way due to natural background radiation in the absence of power station. The contribution from the station to radiation exposure turns out to be a very small fraction of exposure due to natural background radiation. An expert committee constituted by the Ministry of Environment and Forests to collect relevant data including field measurements of radioactivity in the impact zone of Rajasthan Atomic Power Plant (RAPP). In order to study the adverse effect of radiation after its investigations came to the conclusion that radiation exposure to public arising from station related effluents is negligible as compared to average radiation exposure received by an individual in India from naturally occurring sources with in the country. The composition of the committee and the summary and conclusion of its report are provided in the Annexure. This has been supported by detailed epidemiological studies carried out in our country as well as in some other advanced countries. In view of the absence of evidence of damage to the general population from the operating plants, the steps taken by the DAE have been limited to keeping a watch on the environmental radiation levels and sharing this information with the Ministries who evince interest in it.

6(v) In what the radiation is responsible for environmental degradation?

Radiation is part and parcel of natural environment. There always exists a background radiation level. Normally, the contribution of nuclear plants to the already existing levels has been insignificant. This has been confirmed by studies carried out by various Environment Survey Laboratories installed near the nuclear power stations. The comparison of radiation levels during the operation stages with that of pre-commissioning data does not indicate any marked increase.

Our prevailing understanding of radiation effects point out that radiation levels in the environment during the normal plant operations do not contribute to any environmental degradation.

6(vi) Has any case been reported about the environmental degradation due to radiation?

No case of environmental degradation has been reported in India due to nuclear power plant operation. The only known case of environmental degradation due to radiation from a nuclear power station in the world is that of Chernobyl when an accident occurred in April 1986.

6(vii) Is there any mechanism to check environmental degradation caused in India due to emanation of radiation from atomic power plants of other countries/neighbouring countries. A detailed note may be furnished in this regard?

The Environmental Survey Laboratories located at the sites of different nuclear power plants in the country conduct a comprehensive & continuous environmental monitoring programme to assess radioactivity content in various environmental samples such as soil, water, air, vegetation and the food items. These laboratories are also capable of detecting any significant radiation emanating from neighbouring countries. Besides a countrywide radiation monitoring network is being established by Department of Atomic Energy.

But, there has been no significant impact of any of these in the country.

6 (viii) Has the Department of Atomic Energy issued guidelines to State/ dist.adm. in respect of radiation. If so, what are those guidelines?

Guidelines in respect of safety measures to be taken in the event of sudden increase in background radiation levels above naturally present values have been jointly worked out by DAE and State/district authorities in each state where there is a nuclear facility operating. These are in the form of Manual of Emergency Procedures and they contain procedures to cope up with emergency situations in the atomic power plants. They describe the measures to be taken by the district administration/State officials under such circumstances and appropriate guidelines have been issued by AERB. On the basis of these guidelines the district/State officials have participated in the off-site emergency exercises conducted at the sites to demonstrate the emergency preparedness. There are also regular training programmes for public authorities to enable them to discharge their function effectively during such enventualities.

7. Radioactive Waste Disposal

A note on the management of radioactive waste generated from atomic power indicating *inter-alia*, the extent of nuclear waste disposed off so far, effectiveness of the waste containment, impact eco-system, the effectiveness of the method followed in this regard in comparison to those adopted internationally, details regarding cases of radiation from disposed wastes, if any and the likely magnitude of nuclear waste by the year 2000.

Radioactive wastes in different physical forms viz., solid, liquid and gaseous, are generated during operation and maintenance of nuclear reactors. The objective of waste management is to ensure protection of man and his environment from the potential hazards associated with radioactivity. The basic philosophy adopted in waste management is to concentrate the waste to a small volume and contain it safely out of contact with our eco-system until the radioactivity in the waste comes down to harmless levels by natural decay process. Management of radioactive waste is carried out in conformity with the stipulation of the regulatory authorities based on Internationally accepted guidelines. The gaseous and liquid effluents are decontaminated by suitable treatment processes to ensure that the radioactive contents of the treated effluent are well within the permissible specified limits for discharge into environment and the radioactivity is concentrated in small volume. Various techniques such as filtration, chemical treatment, evaporation, ion exchange etc. are employed for this purpose. The solid wastes are also subjected to volume reduction, as feasible, by techniques such as incineration and compaction. The concentrate from liquid wastes as well as the solid wastes are immobilised in solid matrices like cement, bitumen, polymer etc. so that the radioactivity will not leach out and re-enter our bio-sphere. This is known as conditioning of wastes. The conditioned wastes are packaged in suitable containers to facilitate handling, transport and storage/disposal. Such storage/disposal is carried out in specially constructed structures such as reinforced concrete trenches, tile holes and vaults. These are located both above and underground in access-controlled areas. These areas are kept in constant surveillance to monitor the effectiveness of the containment.

The total amount of solidified waste products disposed from the nuclear power stations at different sites is of the order of 15,000 cubic metres upto 1993.

The solidified waste products are disposed in specially engineered structures to ensure their confinement. The structures are designed based on multi-barrier principle for ensuring effective containment of the radioactivity to avoid its impact on the eco-system. The area where the disposal structures are located are kept under constant surveillance with the help of bore-wells laid out in a planned manner. The underground soil and water samples from these bore-wells are routinely monitored to confirm effective confinement of the radioactivity present in the disposed wastes.

While radioactive contents of high level wastes produced are very large, their volumes are relatively small. A 1000 MWe nuclear power plant and associated fuel cycle facilities will, for example, generate only about 2 cubic metres of vitrified waste per year. The waste produced by 220 MWe power plants are much lower.

Till date, the surveillance of the radioactive waste disposal areas at different sites has confirmed the very high effectiveness of the disposal systems adopted. There has been no incident of release of radioactivity from such disposed wastes. No adverse effect of radiation from the disposed wastes to the public or the environment has been observed.

AERB continuously monitors all waste management operations in the country. It authorises discharge of all effluents to the environment subject to their conformity with limits specified by ICRP.

The waste management practices of the Indian nuclear energy programme conform to international practices. India has accumulated a lot of experience in radioactive waste management and the Indian expertise in this field has been recognised by IAEA by inclusion of India as member in many of its technical and advisory committees.

The total quantity of radioactive wastes disposed will essentially depend upon the number of reactor units in operation. All efforts are being made to minimise waste generation. Taking into account the existing nuclear power stations and the additional ones expected to be in operation by the year 2000, it is estimated that the volume of wastes will be of the order of 23,000 cubic metres.

8. Decommissioning

A note giving background of plants age, decommissioning of atomic power projects and their impact on Environment indicating *inter alia*, the facilities decommissioned so far, their impact on eco-system. The plants which are due for decommissioning in the current decade and the expertise available to undertake the decommissioning activity.

The economic life of nuclear power plants is normally assumed for the purpose of calculation of tariff as twenty five years. However, with the development of life extension measures, this period could be extended to forty years or even more. Among various alternatives for decommissioning at the end of life, mothballing appears to be appropriate for the nuclear power plants. The process of decommissioning consists of the following steps: Removal of spent fuel for further processing (reprocessing/storage away from the reactor)—drain of coolant and other circuits. Disconnecting the operating systems sealing all openings in the containment and keeping under surveillance. The next phase consists of dismantalling and decontaminating all equipment and buildings except reactor core and its sheilding. Final stage consists of removal of reactor core and its shield, clearing the site for other uses. As mentioned earlier once the spent fuel is removed, the bulk of the radioactivity is removed, before the decommissioning begins, there is no uncontrolled safety hazard in this operation. Technology for decommissioning is essentially an assembly of skills, expertise and procedures developed during repair and maintenance of components and equipment in the operational phase of the reactor, to be supplemented by further development work on the robotics and remote handling techniques. The procedure for treatment of wastes arising from decommissioning nuclear power plants are similar to the ones during operation except that the quantity of low level waste to be dealt with are relatively large. India has gained valuable experience in decommissioning the fuel reprocessing plant at Trombay and the small Zerlina research reactor. Also experience in the Madras plant and replacement of feed water sparger at Tarapur plant have demonstrated the inherent capabilities to take up the decommissioning work. Development work on the robotics at the Bhabha Atomic Research Center (BARC) is in advanced stage. Therefore, there is enough confidence with regard to technology for decommissioning and it will be available in time to take up the job when required.

As life extension measures are at present contemplated for the reactors that are in operation, there is no likelihood of decommissioning of any reactor in this decade.

9. A.E.R.B.

What are the functions, powers of AERB? Please also give details about organisational set up and inadequacy, if any, which affects its efficient functioning.

The Atomic Energy Regulatory Board was constituted on November 15, 1983 by the President of India exercising the powers conferred by Section 27 of the Atomic Energy Act 1962 (33 of 1962) to carry out safety-related regulatory functions under the Act. The regulatory authority of AERB is derived from rules and notifications promulgated under the Atomic Energy Act 1962 and Environmental Protection Act 1986.

The mission of the Board is to ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to health, safety and the environment.

The detailed functions of AERB are as follows:

(i) develop Safety Codes, guides and Standards for siting, design, construction, commissioning, operation and decommissioning of the different types of plants, keeping in view the international recommendations and local requirement, and develop safety policies in both irradiation and industrial safety area;

(ii) Ensure compliance by DAE and non-DAE installations of safety codes and standards during construction/commissioning stages;

(iii) Advise AEC/DAE on technical matters that may specifically be referred to it in connection with the siting, design, construction, commissioning, operation and decommissioning of the plants under DAE;

(iv) Review from the safety angle, requests for authorising commissioning/operation of DAE projects/plants. Before authorisation of commissioning/operation of the plant/project is granted, the AERB will be satisfied by appropriate review of:

(a) Final Design Analysis Report prepared by the Project/Plant;

(b) Commissioning reports and results thereof; and

(c) Proposed operating procedures and operational limits and conditions. That the plant/project can be operated without undue risk to the operating personnel and the population. For this purpose, AERB may ask for relevant additional supporting information;

(v) Review health and safety aspects of modifications in design/operation involving changes in the technical specifications adopted in any of the DAE units;

(vi) Review operational experience in the light of the radiological and other safety criteria recommended by the International Commission on Radiological Protection, International Atomic Energy Agency and such other International bodies and adapted to suit Indian conditions, and thereby evolve major safety policies;

(vii) Prescribe acceptable limits of radiation exposure to occupational workers and members of the public and approve acceptable limits of environmental releases of radioactive substances. (in the DAE units, the AERB also prescribe limits of environmental release of conventional pollutants);

(viii) Review the emergency preparedness plans prepared by the different DAE units, similar plans for non-DAE installations and during transport of large radioactive sources (e.g. Irradiated fuel, kilo/mega curie sources, fissile materials);

(ix) Promote research and development efforts for fulfilling the above functions and responsibilities;

(x) Review the training programme, qualifications and licensing policies for personnel by the projects/plants;

(xi) Prescribe the syllabi for training of personnel in safety aspect at all levels;

(xii) Enforce rules and regulations promulgated under the Atomic Energy Act, 1962 for radiation safety in the country and under the Factories Act, 1948 for industrial safety in the units under the control of DAE.

(xiii) Maintain liaison with statutory bodies in the country as well as abroad regarding safety matters.

(xiv) Take such steps as necessary to keep the public informed on major issues of radiological safety significance.

(xv) Perform such other functions as may be assigned to it by the Atomic Energy Commission.

(xvi) Send reports periodically to Chairman, AEC on safety status including observance of safety regulations and standards and implementation of the recommendations in all DAE and non-DAE units. It will also submit an Annual Report of its activities to Chairman, AEC.

Responsibilities of AERB

1. Exercising the powers conferred by Section 27 of the Atomic Energy Act, 1962, the Central Government has constituted the AERB to carry out regulatory and safety functions under Sections 16, 17 and 23 of the Atomic Energy Act. AERB has jurisdiction over all the units of the Department of Atomic Energy and all radiation installations in the country.

2. Sections 16 and 17 refer while radioactive contents of high level wastes produced are very large, their volumes are relatively small. A 1000 MWe nuclear power plant and associated fuel cycle facilities will, for example, generate only about 2 cubic metres of vitrified waste per year. The waste produced by 220 MWe power plants are much lower to control over radioactive substances and special provisions of safety. Section 23 empowers the board with administration of Factories Act, 1948 including enforcement of its provisions, appointment of inspection staff and making of rules in the installations of DAE.

3. Chairman, AERB has been appointed as the Competent Authority under the following safety related rules:

(i) Radiation Protection Rules, 1971.
(ii) Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.
(iii) Atomic Energy (Factories) Rules, 1984.
(iv) Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules, 1984.

4. AERB is also empowered to perform the functions under Sections 10(1) (powers of entry) and 11(1) (powers to take samples) of Environmental Protection Act, 1986 and Rule 12 (agency to which information on excess discharge of pollutants to be given) of the Environmental Protection (Amendment) Rules, 1987.

5. Section 52 of Air (Prevention and Control of Pollution) Act, 1981 has specifically stated that in relation to radioactive air pollution the provisions of Atomic Energy Act, 1962 (33 of 1962) will apply.

6. Hazardous Wastes (Management and Handling) Rules, 1989 state that these rules will not apply to radioactive wastes (Rule 2(e). The radioactive wastes are covered under the provisions of Atomic Energy Act, 1962 and rules made thereunder.

7. Manufacture, storage and import of Hazardous Chemicals Rules (1989) under the Environmental Protection Act, 1986 notified AERB as the

authority to enforce directions and procedures as per Atomic Energy Act, 1962 (Rules 2(b) and 3).

Organisational Structure of AERB:

Currently the Board consists of a full time Chairman, an ex-officio Member, two part-time Members and a Secretary. The AERB Secretariat has eight divisions and one section. The Board is functionally independent of the Department of Atomic Energy (DAE) and reports to the Atomic Energy Commission.

AERB is supported by the Safety Review Committee for Operating Plants (SARCOP), Safety Review Committee for Applications of Radiation (SARCAR) and the Advisory Committees for Project Safety Review (ACPSRs, one for the nuclear power projects and the other for heavy water projects). ACPSR advises AERB on the issuance of authorisations at different stages to a plant of the DAE, after reviewing the submissions from the plant authorities, based on the recommendations of the associated Design Safety Committees. SARCOP enforces safety stipulations in the operating units of Department of Atomic Energy. The SARCAR recommends procedures to enforce radiation safety in medical, industrial and research institutions using radiation and radioactive sources.

AERB receives advice from two independent Committees—the Advisory Committee on Radiological Protection and the Advisory Committee on Nuclear Safety. These Committees are composed of experts from AERB, DAE and institutions outside the DAE. These Committees advise the board on generic issues and are not involved in the day-to-day functions such as issuing authorisations, carrying out inspections, etc.

The administrative and regulatory mechanisms which are in place, ensure multi-tier review by the best experts available nationwide. These experts come from reputed academic institutions and Governmental agencies.

10. IAEA on Safety

10 (i) Are there any guidelines of IAEA in regard to nuclear safety? If so, whether these are being followed strictly?

Yes. There are codes of practices and guides on nuclear safety provided by IAEA and AERB codes & guides are in conformity with the same.

10 (ii) Is there any arrangement for exchange of information with IAEA on happenings in the nuclear power plants around the world in regard to safety related aspects? If so, what measures have been taken on gaining such information to improve safeguards in our plants?

India is a member of IAEA from the very beginning. It also participates in various Committees which are entrusted with the responsibility of developing safety guides and standards. Thus there are good channels of communication on safety related matters. In addition IAEA has developed an International nuclear events scale for expressing the severity of accidents. This system has been established by the IAEA over three years ago to promote the gathering of information regarding incidents and accidents which have been occurring in the world's nuclear installations. India has been a member of the INES system and has been contributing data ever since the inception of INES.

Under the INES system, events are rated in a scale of 0 to 7, with ascending degree of severity. Level-0 is an event which has no safety signficance at all. Level-1 event is an anomaly beyond the authorized operating regime. This may be due to equipment failure, human error or procedural inadequacies. On the other hand, Level-7 incident will signify a major event like the Chernobyl accident.

By putting events in proper perspective, the scale can facilitate a common understanding between the nuclear community, the media and the public. The Incident Reporting System (IRS) of IAEA is an information on all safety related events, excluding both failures and errors in the technical, human and man-machine interface areas and the root causes of the events.

Since India is a member of both INES and IRS, there is an effective exchange of information with other countries. This information is passed on to all plants and safety Committees. Based on the lessons learned in this exchange of information, corrective actions if necessary are taken in Indian plants to improve safety. Similarly selective reports on events in the Indian Nuclear Power Plants are sent to IAEA.

11. Public Awareness/Education

11 (i) What steps have been taken to educate the people living in the vicinity of the nuclear plants regarding the safety and benefit of nuclear power?

11 (ii) What steps are being taken to build confidence among the people regarding nuclear safety and an instinct of pride being resident near the nuclear power plants as symbol of advancement?

The Department has laid emphasis on the public awareness programme related to the safe operations of the atomic power plants. This is a continuing activity.

The Health Safety and Environment Group, BARC has participated in these programmes extensively. Examples are given below. In November 1992, the Environmental Survey Laboratory, RAPs and the Rajasthan Atomic Power Station conducted four one-day camps in four villages around RAPS in association with the Indian Association for Radiation Protection. About 800 villagers particiapted.

In the year 1993, more than 2000 members of the public comprising district officials (Medical, Agriculture, Transport, Revenue and Police Departments), school children, students from colleges and others visited the Environmental Survey Laboratories (ESL) at different sites. Lectures on nuclear energy and its impact on the environment and visits to the power stations were also arranged. Special lectures on natural radiation exposure and application of radiations were given to college students and staff.

In September 1993, the Indian Association for Radiation Protection in collaboration with Defence Laboratory, Jodhpur conducted a 3-day Public Awareness Programme comprising of lectures and exhibition at the Defence Laboratory, Jodhpur, local schools and the Jodhpur University Campus.

Environment Survey Laboratories (ESLs) took part in a DAE organised 4 day exhibition held at Shimoga during November 1993 on the "Progress of Nuclear Energy for Peaceful Purposes" which attracted a large number of students from the nearby schools and colleges. Similarly during December 1993, a "Jana Vignana Mela" was organised at Mangalore in which more than one lakh people from different walks of life participated. For creating an awareness on nuclear power in an organised manner, the Directorate of Environment and Public Awareness in the Nuclear Power Corporation was constituted in March 1989. Public Awareness functions assigned to the Directorate were:

— Organising Public Awareness Programmes and activities at Corporate level and co-ordinating these programmes with those conducted by Project Director/Chief Project Engineers/Chief Superintendents at various nuclear power plant sites for integrating them into the overall policy framework.

— Communication with the public on various aspects of nuclear power, responding to articles for publication, preparation of publicity literature/brochures and co-ordinating the publication of literature prepared by sites for ensuring consistency of approach are regularly carried out by this Directorate.

Letters to the Editors of Newspaper were written from time to time on various articles that appeared in the newspapers. Special supplements were brought out in leading newspapers on the occasion of dedication of power plant to the nation. Brochures were made for distribution to public during off-site emergency drills.

A special public information campaign on "Nuclear Power and You" was conducted through publication of 10 serials covering all aspects of nuclear power in newspaper and magazines in English, Hindi and other regional languages, questions raised by the public were answered.

The work of disseminating information on nuclear power through video cassettes, seminars, visit to sites was carried out and is being continued.

Public information centres are being established at various project sites. Various publications as hand-outs brochures & audio facilities are being planned. Topical video films on radiation, nuclear power have been made for screening to the public.

Nuclear Power Corporation also encourages various universities, school, colleges through financial assistance in holding seminars and also for carrying out research in ecology and environment in areas around nuclear power stations. For the benefit of the young school children, a coloured comic book on "Power of the Atom" has been published and widely distributed to the schools around the power plants.

A number of seminars/workshops/exhibitions were organised as part of Public Information Programme.

The steps taken to educate the people living in the vicinity of a nuclear power station, Kalpakkam, for instance consist primarily of providing an opportunity for some residents of every village around the station and within the 16 km zone, to actually visit the power station and learn, from discussions with plant personnel and direct observation, about the safety measures employed and the environmental survey activities carried out. This also helps them to form their own impressions after seeing the clean and green conditions in the site. This is a continuing programme undertaken every year and covers the general public, the school teachers and students and the district officials. Again the Kalpakkam experience shows that the visitors from the vicinity express, through their impressions recorded in the visitor's register, a certain pride about the power station having been set up entirely by indigenous expertise. Their only appeal is for an uninterrupted supply of electricity to them to pursue their agricultural opeations without hindrance.

12. Nuclear Fuel Recycling

12 (i) What is the nuclear fuel capacity of India at present?

The present nuclear power consists of following reactors in operation. Two reactors of boiling water type (BWRs) of installed capacity 160 MW each located at Tarapur and Seven Pressured Heavy Water Reactors (PHWRs) with a capacity of 1560 MWe totalling to 1720 MWe. The first two BWRs operating in Tarapur have been built and commissioned in 1969 under a 1963 bilateral agreement between India and USA provided with IAEA safeguards. As per the Agreement the fuel for these reactors which happen to be low enriched uranium (LEU) was to be supplied by USA, the utilisation of the fuel being under the survelliance of IAEA. In 1980, USA stopped supplying the fuel. A bilateral agreement was signed with France for the supply of LEU fuel and it supplied fuel for a period of ten years. This agreement expired on 24.10.93. France has expressed its inability to supply the fuel without the provision of full-scope safeguards. Since the Government is not accepting the full-scope safeguards, it is proposed to continue the operation with fuel consisting of mixed uranium and plutonium oxide fuel and low enriched uranium fuel. For this, TAPS spent fuel has to be reprocessed to obtain the plutonium required for the MOX fuel. As a confidence building measure, the Government of India made a voluntary offer to IAEA in August 1993 to apply safeguards on the nuclear material used in TAPS based on a bilateral agreement between India and IAEA. This offer is to take effect after the expiry of the trilateral safeguard agreement on 24.10.93. An adhoc arrangement valid till 1st March, 1994 providing for continued application of safeguards has been entered into between the Govt. of India and IAEA. The bilateral safeguards agreement based on our voluntary offer has been approved by the Board of Governors of IAEA and would be effective from 1st March, 1994. The fuel required for the PHWRs are fabricated from the Nuclear Fuel Complex using the uranium oxide concentrate, mined in Jaduguda and processed in the mill located there. The mixed carbide fuel of uranium and plutonium used in the fast breeder test reactor (FBTR) in India is fabricated in BARC utilising the plutonium obtained from reprocessing spent fuel discharged by our reactors.

12 (ii) Whether India is having self-sufficiency in nuclear fuel for existing nuclear plants? If not, how the nuclear fuel demand is met.

Except for the Tarapur all other requirements of fuel are met indigenously. The arrangements for Tarapur has been mentioned above in 12(i).

12 (iii) Is it true that nuclear fuel could be recycled and processed? What percent of nuclear fuel is available by recycling and processing? Please give the break-up of nuclear fuel, recycle and processed fuel and disposal of waste.

Barring the two reactors at Tarapur, all the remaining Indian nuclear power reactors are fuelled with natural uranium. Only about 0.7% of the natural uranium is U-235 which is fissile and is responsible for power generation by undergoing fission. The burn-up of this fuel in PHWRs is in the range of 6000 MWD/tonne which corresponds to about 45% depletion of fissile content. Beyond this burn up, the efficiency of power generation comes down drastically due to the effect of the fission products generated. The spent fuel taken out from the nuclear reactor contains unburnt uranium, plutonium (produced in the nuclear reactor) and highly radioactive fission products. This spent fuel, after cooling for the decay of short lived fission products, is further processed in a reprocessing plant to recover the plutonium besides separating uranium and fission product wastes. The plutonium thus recovered can be recycled as fuel in the fast breeder reactors. The plutonium requirement for fuelling FBTR at IGCAR Kalpakkam has been met in this manner only. Besides, plutonium can also be recycled in the thermal reactors in the form of mixed oxide (MOX) fuel where plutonium is substituted for the fissile uranium.

The resultant spent fuel from one tonne of natural uranium (containing 0.7% of fissile U-235) after burning in PHWRs to a level of approx. 6000 MWD/tonne will have about 3-3.5 kg. of plutonium which can be recovered by reprocessing and recycled. The uranium recovered in the reprocessing plant is Uranium-238 and it is depleted in U-235 content and cannot be recycled as fuel in thermal reactors. However, they can be used as blanket or otherwise in fast breeders to produce plutonium. The fission products seperated are in the form of highly radioactive solutions. About 800 litres of high level radioactive wastes are generated per tonne of spent fuel reprocessed.

13. A note on technology development, renovation and modernisation and other programmes in the area of nuclear energy and bottlenecks in achieving the targets.

BARC pursues R&D programmes necessary to support nuclear programme. Technology development activities related to nuclear power programme are being pursued as part of this broader programme.

In the early stages of development, the emphasis was on proving of components for reliable performance under stimulated reactor conditions. Progressively the systems and components in a number of key areas have been upgraded for improved performance and safety characteristics. Some of the important systems/sub-systems that have been developed are reactor shut down system, fuel handling and control system, coolant channel components, reactor components such as calandria and end shield, channel temperature monitoring systems, programmable digital comparator systems, visitor recording systems etc.

Currently the emphasis in technology development is related to improved inservice inspection techniques, remote repair capability, plant life extension and safety augmentation. Greater usage of computers in Instruments & Control systems is also one of the important thrusts in technology development. To realise these objectives, BARC is pursuing a number of R & D schemes in :

- Heat Transfer and Fluid Flow Studies,
- Failure Assessment & Repair Technology Development,
- Development of Comprehensive Diagnostic System,
- Development of Tribology & Fluid Power Laboratories,
- Fuel & Materials Irradiation Programme, and
- Modernisation of Reactor Control Systems.

Design study for an Advanced Heavy Water Reactor, which would incorporate a number of new passive safety features, is also in progress.

14. A note analysing environment impact of projects and safeguards required.

(NB-The word 'safeguard' is interpreted by DAE as 'safety')

The first nuclear power reactor in India was built at Tarapur. The second unit was also built at the same site. Both units started supplying power in 1969. These reactors were of the Boiling Water Type. All subsequent reactors are of the Pressurised Heavy Water Reactors (PHWR). The first eight PHWR units are located at Rawatbhata in Rajasthan, Kaplakkam in Tamilnadu, Narora in Uttar Pradesh, and

Kakrapar in Gujarat. Four more power reactor of this type are already under different stages of construction.

The nuclear power reactors in India are sited, designed, constructed, commissioned and operated on the basis of clearly defined guidelines. From consideration of radiation, safety and protection of environment, the site selected for locating a nuclear power station has to satisfy several stipulations of AERB. A site may be rejected or accepted even at the preliminary stage of site selection itself. An area of radius 1.6 Km. around the reactor is designated as an Exclusion zone which is under the ownership of the station authorities.

Another zone in the annulus upto a radius of 5 Km. around the reactor is designated as sterilised area where the growth of population will be regulated by state govt. for effective implementation of emergency measures, in the unlikely event of its necessity. Natural growth of population is allowed in this zone. Nuclear Power Plants are not associated with chemical pollutants. There is no combustion or emission of carbon dioxide, sulphur dioxide etc. The space utilised by a nuclear power plant is much less as compared to a hydel power plant. The volume of fuel which requires to be transported is also very small, thereby avoiding the need for an elaborate transportation arrangement which necessarily has an impact on the environment. Thus the nuclear power plant is environmentally benign.

The radioactive fission process which is the central activity in a nuclear power plant is well contained in multiple barriers. Several measures of safety are inbuilt into the design of the plant. The safety aspects are rigorously reviewed and monitored by regulatory body, at different levels.

Strict quality assurance procedures are in place during the construction, commissioning and operational phases of the reactors. Authorisations are given by the regulatory organisation at every stage to ensure that the standards and codes are complied with by the project authorities. All the nuclear power reactors in the country are operated as per the safety standards stipulated by AERB which are in line with international standards.

The traces of radioactivity released routinely from nuclear power reactors are well within the permissible limits. Records exist from the date on which the reactor becomes critical. Prior to this extensive environmental survey is carried out to collect the base line data on environmental background radiation.

Radiation surveys as well as collection and analysis of samples of water, soil, food, air and various other products, in an area of about 30 Km. radius around the plant, are systematically carried out by the respective Environmental Survey Laboratories located at each site. These Labs are established prior to operation and collect the base line data with respect to the above. The findings are analysed by the Atomic Energy Regulatory

Board. The results of the measurements from the very inception of the reactors indicate that the releases from the plant are very much well within the limits prescribed by AERB.

Control is exercised by a scheme of monitoring the releases at the source prior to their discharge to the environment by means of in-plant instrumentation supplemented by the environmental monitoring programme. Radiation and concentration of radionuclides in air, water or foodstuffs are accurately estimated. This ensures effective monitoring of the impact of radiation or radioactivity on the environment due to the operation of the reactors.

Measurement of the external radiation fields is also carried out by Environmental Survey Laboratories (ESL) using very sensitive instruments upto a distance of 30 Km. from the plant. The radiation levels have not shown any perceivable increase over the natural background radiation levels. The increase in radiation levels in the public domain during the normal operation of the reactor is found to be only a small fraction of the natural background radiation present everywhere. No adverse impact on the operating personnel or the environment including the plant, animal and human life, has been noticed in the operating nuclear power plants in the country.

Management of radioactive wastes

The nuclear power reactor generates low and intermediate level of radioactive wastes. Each nuclear power reactor site has been provided with a radioactive waste management facility to handle, treat, store and dispose of radioactive wastes safely. The solid wastes are collected, categorised and segregated at the site. After appropriate conditioning, the wastes are collected in steel drums and placed in reinforced cement concrete trenches in the solid waste management facility.

The radioactive liquid effluents generated at the station are received in tanks, categorised, treated appropriately to remove the bulk of the radioactivity and discharged at concentration levels, fixed by AERB to nearby aquatic bodies.

The airborne effluents containing traces of radioactive elements generated during the normal operation of the reactor is discharged into the environment through a tall stack after filtration through high efficiency filters to remove particulate activity. The gaseous effluents are diluted significantly before they are released through the stack. These releases are also within the technical specification limits.

Safety of Workers

The safety of personnel working in the nuclear power plants is ensured in a variety of ways. The radioactive exposure limits of workers are regularly monitored with reference to the norms stipulated by the AERB — Annual medical examination are also conducted over environmental effects:—

Environment clearances of site are also obtained from Union Ministry of Environment and Forests. This is apart from clearance from safety angle from AERB. Indepth review is carried out by environmental appraisal committees, constituted by Environmental Ministry before clearance. No objection certificate from state pollution control board is also obtained. As a matter of tradition, green belt development is also being taken as a means of environmental upgradation.

AERB reviews all the nuclear power plant projects especially with respect of environmental aspects by appointing a project design safety review committee which reports its findings to AERB. The various units of Department of Atomic Energy such as NPCIL, NFC and IRE also employ consultants like National Environmental Engineering Research Institute, Nagpur for the preparation of environmental impact assessment report. The assessments are comprehensive and cover aspects such as environmental utilisation, effects of local ecology if any, and other related items. These assessments are scrutinised by the Environmental Appraisal Committee of Ministry of Environment and Forests, Government of India.

15. A note on the present state R&D in the nuclear energy sector achievement so far and projections for the 8th Plan Period.

The nuclear power programme in the country is being developed with the objective of tapping our vast nuclear resources for electricity generation. This programme is planned as three stage programme. In the first stage, pressurised heavy water reactor system based on natural uranium have already been developed and are being deployed at various sites in the country. While current reactors are 220 MWe size, the larger 500 MWe reactors have been designed and developed. These also would be deployed soon.

The PHWR programme which is being pursued on fully commercial runs has seen large scale R&D inputs in all related areas. The programme supported through R&D inputs from BARC and also a number of other national laboratories and academic institutions. These have provided design features in special products areas such as reactor physics, stress analysis thermal hydraulics, component testing, manufacture of speciality product, fuel development, material development, non-destructive examination, seismic analysis and testing, instrumentation and control etc. BARC has also piloted development of other fuel cycle related activities for the PHWR programme. These relate to development of process for milling and refining of uranium, production of fuel bundles, production of reactor core structural parts made of zirconium alloys which is a special material used mainly in nuclear reactor, production of heavy water etc. The Centre has also developed process and technologies for the back end of fuel cycle. These include waste management activities at the reactor plants, reprocessing of spent fuel and immobilisation of waste. Today we have industrial scale plants operating in all these areas.

In addition to the R&D work being carried out within the Department, considerable R&D work has been carried out by the Indian industry to develop manufacturing technologies which enable production and fabrication of various reactor components like calandria, endshield, steam generators, fuelling machines, pumps etc. Today we have multiple industrial units capable of manufacturing nuclear components without any external help.

Research in area of safety is another imported component of our R&D programme. Safety research is an ongoing activity. Continuous efforts are being made to improve detailed understanding of various safety aspects related to India's nuclear power programme. Areas covered include study of efforts of radiation, environment surveillance, study of pathways for movement of radioactivity in the environment and also within the reactor, study of various possible postulated scenarios in our reactor systems and behaviour of reactors and systems under such conditions, development of reactor systems with improved safety characteristics etc. Several large facilities have been built and are being built to support safety research. The most notable ones being the 3 MW boiling water loop and the facility for integral systems behaviour experiments.

Another important aspect of R&D programme is development of technology in support of operating power plants. Work in this area includes in service inspection, remote repair, reduction of man-rem, updating instrumentation & control systems, decontamination etc. Extensive work is being done in these areas.

In the second stage of the programme the plutonium generated the first stage would be used to setup fast breeder reactors which will enable multiplication of plutonium inventory and also the installed power generation capacity. A fast breeder test reactor using plutonium-uranium carbide fuel developed indigenously is also operational. The design of 500 MWe prototype fast breeder reactor has been completed. Development of technology to build components for this reactor is currently in progress. In the later part of this second stage thorium would be introduced to generate uranium-233.

A comprehensive R&D infrastructure has been built at the Indira Gandhi Centre for Atomic Research (IGCAR) at Kalpakkam for supporting fast breeder reactor development. The Centre has piloted development of components and systems to work in liquid metal (Sodium), development of materials suitable for liquid metal fast breeder reactors, fast irradiation examination of fuel and materials irradiated in reactors, reprocessing of fuel discharged from fast reactors, radio chemistry studies etc. A strong researsch laboratory is also active at Kalpakkam. A facility for testing large components meant for 500 MWe Prototype Fast Breeder Reactor is getting ready.

In the third stage the emphasis would be on building reactor systems based on thorium-uranium 233 fuel systems. For this purpose a broad based programme in the area of thorium utilisation is also being pursued to cover all aspects related to thorium technology. A 30 KW uranium 233 based reactor is expected to be operational very soon. Apart from irradiation experiments in reactors at Trombay, thorium irradiation is being progressively augmented in our power reactors. Design of an Advanced Heavy Water Reactor, which will generate large fraction of its power from thorium, is also in progress.

16. A detailed note on the constitutional provisions regarding the jurisdiction of Control and State Govt. in the various activities relating to the nuclear energy sector.

A note on the constitutional provisions and the provisions of the Atomic Energy Act with regard to the jurisdiction of the Central Government and the State Governments in the various activities relating to Nuclear Power is enclosed.

It may be seen from the note that the responsibility with regard to the development of Atomic Energy vests with Central Government, either directly or through a Company or Corporation in which atleast 51% of the share holding is held by the Central Government. The provisions enable participation of the State Governments and the Public Sector in the generation of atomic energy provided the Central Government directly holds majority of the shares in such Companies.

NOTE

'Atomic Energy and mineral resources necessary for its production' form Item No. 6 of the 'List-I—Union List' under the Seventh Schedule of the Constitution of India, which indicates that in respect of this field, Parliament has the exclusive power to make laws under Article 246(1) thereof. 'Electricity' forms Item No. 38 of the 'List III — Concurrent List' under the Seventh Schedule. In respect of that field, Article 246(2) of the Constitution provides that notwithstanding anything in Clause (3) thereof the Parliament, and subject to Clause (1) the Legislature of any State, have the power to make laws.

(2) Accordingly, Parliament has enacted the Atomic Energy Act, 1962 (Act No. 33 of 1962—repealing the earlier Atomic Energy Act, 1948 passed by the Dominion Legislature) to provide as per the Preamble 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.

(3) An overview of the provisions of the Atomic Energy Act, 1962 [as

amended by the Atomic Energy (Amendment) Act, 1987 (Act No. 29 of 1987)] would show that the Act (see, Section 3) confers powers (jurisdiction) on the Central Government to produce, develop, use and dispose of atomic energy either by itself or through any authority or corporation established by it or a government company, and carry out research into matters connected therewith. Similar provisions are to be found regarding prescribed or radio active substances of other minerals or materials required for the production, development and use of atomic energy or research as aforesaid [see generally, Sections 4 to 16]. The Central Government can declare as "restricted information" any information not so far published or otherwise made public relating to prescribed substances, their acquisition, disposal, processing, extraction of fissile materials and separation of isotopes therefrom, besides the theory, design, construction and operation of nuclear reactors as well as research and development in respect of the same [Section 18 may also be referred to]. The Central Government can also declare as "prohibited area" any area or premises where work, including research and development is carried on, in the aforesaid fields [Section 19 may also be referred to]. Further, the Central Government has the power to provide for control over radio active substances or a radiation generating plant in order to: (i) prevent radiation hazards; (ii) secure public safety and safety of persons handling such substances or working in such a plant; (iii) ensure safe disposal of radioactive wastes [Section 17 & 23 may be usefully referred to in this context]. The contravention of certain Sections or Rules or Orders made thereunder, is penalised as per Section 24 of the Act.

(4) Moreover, the Central Government has the power to provide for the production and supply of electricity from atomic energy and for taking such measures as are conducive to the same and all matters incidental thereto, either by itself or through any authority or corporation established by it or a government company. Section 22 of the Act provides in this regard that notwithstanding anything contained in the Electricty (Supply) Act, 1948, the Central Government shall have authority : (a) to develop a sound and adequate national policy in regard to atomic power; to coordinate such policy with the Central Electricity Authority (CEA) and the state electricity boards (constituted under that Act of 1948) and other statutory corporatioons concerned with the control and utilisation of other power resources; to implement schemes for the generation of electricity in pursuance of such policy; and to operate either by itself or through any authority or Corporation established by it or a government company, atomic power stations in the manner determined by it in consultation with the C.E.A., the Boards or Corporations concerned with whom it shall enter into agreements regarding the supply of the electricity so produced; (b) to fix rates for and regulate the supply of electricity so produced from atomic power stations either by itself or through any authority or

corporation established by it or a government company consultation with the C.E.A.; (c) to enter into arrangements with the Electricity Boards of the State in which an atomic power station is situated either by itself or through any authority or corporation established by it or a government company, for the transmission of electricity to any other State; provided that in cases of differences of opinion between the aforesaid parties in regard to the construction of necessary transmission lines, the matter shall be referred to the C.E.A., whose decision shall be final and binding on the parties. It is further provided under that Section that no provisions of the Indian Electricity Act, 1910 or any rule or order made thereunder shall have effect in so far as it is inconsistent with the provisions of this Act. However, save as otherwise provided, the provisions of this Act shall be in addition to and not in derogation of the Indian Electricity Act, 1910 or the Electricity (Supply) Act, 1948.

(5) The other provisions of the Act are all enabling provisions in greater detail building upon these basic provisions conferring certain powers upon the Central Government which may act either by itself or through Government Companies, such as, Indian Rare Earths Ltd., Uranium Corporation of India Ltd., Nuclear Power Corporation of India Ltd., in this regard. Under the Government of India, Allocation of Business Rules, 1961 all matters relating to Atomic Energy in India including the administration of the Atomic Energy Act, 1962 are to be dealt with by the Department of Atomic Energy (DAE) which was established by the President under Article 77(3) of the Constitution, *vide* Notification dated 2nd August, 1954. Since the inception of the DAE, important strides have been made in the research and development of the peaceful uses of atomic energy. These developments called for setting up of a new Atomic Energy Commission (AEC) in the place of the earlier AEC set up under Section 13 of the (repealed) Atomic Energy Act, 1948, *vide* the then Department of Scientific Research's Notification dated 10th August, 1948. Hence, a new AEC with full executive and financial powers, modelled more or less on the lines of the Railway Board, was set up replacing the earlier Commission, *vide* Resolution dated 1st March, 1958. The business of the Commission is as under:

(i) To formulate the policy of the Department of Atomic Energy for the consideration of the Prime Minister;

(ii) To prepare the capital, revenue and foreign exchange budget of the Department for each year;

(iii) To ensure the implementation of the Central Government's policy in all matters concerning atomic energy and all others which might have been allotted to the Department by the G.O.I., Allocation of Business Rules, 1961.

(6) An Atomic Energy Regulatory Board (AERB) has also been constituted by the President of India in the exercise of powers conferred by

Section 27 and all other powers enabling him in that behalf, *vide* DAE Notification, S.O. 4772, dated 15th November, 1983, to carry out certain regulatory and safty functions as envisaged under Sections 16, 17 and 23 of the Act. As per its constitution, the AERB will have the powers of the Competent Authority to enforce rules and regulations framed under the Atomic Energy Act, 1962 for radiation safety in the country. The AERB shall also have authority to administer the provisions of the Factories Act, 1948 for industrial safety of the units of DAE as per Section 23 of the Act. The AERB has also been delegated certain powers to enforce some of the provisions of the Environment (Protection) Act, 1986 in respect of DAE installations.

(7) Also the DAE Project/Installations which have come into existence after coming into force of the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981 (as amended) have been complying with the provisions of those enactments.

(8) The Central Government through the Department of Atomic Energy has framed Rules under Section 30 and other enabling provisions of the Act, as for instance,

— The Radiation Protection Rules, 1971;

— The Atomic Energy (Working of the Mines, Minerals and Handling of the Prescribed Substances) Rules, 1984;

— The Atomic Energy (Factories) Rules, 1984;

— The Atomic Energy (Arbitration Procedure) Rules, 1984;

— The Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987; A number of Orders have also been passed by the DAE and AERB under various provisions of the Act as well as Rules.

17. A note on Institutional and Legislative changes required in respect of various sources of energy in meeting future challenges.

As a developing country, India's energy requirements are constantly on the rise and there is a growing need to identify all the resources and exploit each one in a balanced manner. The non-conventional resources like solar, wing, biogas, tidal etc. have an important role to cater to the decentralised energy needs. The two conventional sources *viz.* thermal and hydel are the major contributors in the present stage. For an energy starved country which is looking forward to globalisation of its economy, nuclear power provides an opportunity to augment energy resources for economic growth and prosperity.

India has vast thorium reserves, which is planned to be tapped to generate electricity on large scale. This involves in evolving a suitable technology, based on our inhouse research in frontier areas. Energy scarcity in the long term, necessitates development of nuclear power to play an important role. The country has proven scientific, industrial and managerial expertise in this field along with a strong R&D infrastructure, which needs to be nurtured.

Nearly 17% of the world's electricity needs now are met through nuclear power. While in India against total capacity of about 72,000 MWe from all sources, the installed capacity of a commercially operating nuclear power plants is 1720 MWe. The Indian Nuclear Power Stations therefore generate about 3% of the country's electricity.

However, financial constraints have affected the expansion programme of Nuclear Power Corporation of India Ltd. also. The follwoing points are relevant with regard to resources for the nuclear power sector:

(a) Technology and design for 500 MWe units have been indigenously developed at great cost and effort. It is necessary to start work on the field for the 500 MWe projects to ensure that morale and enthusianm of the engineers and scientists does not come down.

(b) China and South Korea apart from Japan are going ahead with the development of nuclear power in a big way. A number of reactors are under construction/in the pipe line in both countries. India which has been in the forefront among developing countries in the development of nuclear power, should not lag behind. The growth of technology will be hampered if the nuclear power expansion programme does not proceed at a reasonable pace.

Even though the expansion programme at present has been hit by the resource constraints it would be appropriate to consider investments in nuclear power as a necessity for establishihg the country's self-sufficiency with respect to energy requirements in the long term. It is thus necessary to provide resources for this high technology sector.

For this the following strategy can be adopted with reference to:

A. Investments

(1) Support by the Central Government Nuclear Power Plant are capital intensive with long gestational periods and can benefit greatly only with low-interest bearing funds. In case interest rates remain high, as at present, provision of 'interest subsidy' would facilitate viability of the projects. Hence, availability of adequate resources as 'equity' is vital for maintaining the viability of this sector.

(2) Joint ventures with the user State Government : The present institutional framework, *i.e.*, the creation of Nuclear Power Corporation of India Ltd. in 1987 under Companies Act, working under administrative control of DAE, was evolved with a view to mobilise resources from the market. Of late, this mobilisation has not been very successful. As the budgetary support for this programme is also declining, the option of having joint ventures with user State Governments is being explored. In such a case NPCIL will have to float a subsidiary company in which it

could retain the major share of 51% with the State Government holding the rest of the shares.

The present Section 3(a) and 3(f) of Atomic Energy Act, 1962 read with Section 2(1) (bb) do not expressly permit a subsidiary company of a government company to produce electricity from Atomic Energy.

B. Revenue Realisation

(1) *Fixing of remunerative tariff*

Nuclear Power Sector being high technology sector is capital intensive and has longer gestation period. There is a case, therefore, for adopting a policy for fixing tariff which is based on the remunerative basis rather than merely on cost plus basis as at present.

While Section 22(i)(b) of the Atomic Energy Act, 1962 only requires "consultation" with CEA for fixation of tariff, the practice as it exists involves meeting concurrence of CEA and also a certain degree of acceptability from State Electricity Boards (SEBs). This not only results in delay in fixation / revision of tariff, but also limits the ability of NPCIL to fix a remunerative tariff for the power generated by it as per market forces.

So though the legislative provision is flexible enough, the administrative practice evolved is restrictive. Hence it is proposed that there should be 'Standing Committee' in the concerned Administrative Ministry for review of parameters and recommending a remunerative tariff within a given time frame.

A remunerative price for power would encourage producers of power to make more investments. Surpluses would also be generated for investment in this sector.

(2) *Prompt payment by SEBs*

The mounting balance of payments from SEBs to the NPC has gone into making the financial viability of the Corporation still worse. Recovery of dues is in fact a major problem in the entire power sector. It needs to be appreciated that electrical energy which is at the core of economic growth and development has to be transacted purely on fare commercial terms between the generating companies and the distributing agencies / consumers, failing which not only the finalcial health of the generating companies but the overall growth of the country will get jeopardised. An institutional mechanism is therefore, needed to be developed to ensure that the electrical energy be sold mostly to such consumers who are able to pay for it fully and in time. Power generating companies should be afforded the flexibility and competence to alter the pattern of supply relating the share of supply to prompt payments. An institutional framework is required to be developed to ensure that the brunt of the subsidies granted, if at all in this sector is not to be faced by the generating companies, and the loss in terms of timely payments from such constituencies of consumers as are subsidised by the Government be fully compensated by the Government to the power generating companies.

18. Please indicate the present power plant efficiencies? What steps are proposed to be taken to improve the thermal efficiency?

The overall plant efficiency of the PHWR nuclear plants is about 30% based on gross generation. Since the thermodynamic efficiency is a function of terminal temperature condition in the existing plants in operation and construction there is not much possibility to significantly increase the efficiency except by adopting energy conservation measures.

With increasing concerns on thermal pollution of water body, cooling towers at inland sites have mostly been adopted which have resulted in marginal reduction in efficiency.

19. All present modes of power generation (major) are polluting and are not environmentally friendly, both for local as well as global environment. As coal based thermal power plants provide about 65% of the total energy in the country, are there any plans to increase the share of hydro and nuclear power? Is this planning governed by environmental or economic reasons?

Fast Breeder Reactors can achieve a higher efficiency of about 40% due to higher temperatures and in India an experimental fast breeder is in the initial phase of operation. Design and technical development works related to prototype fast reactor are in progress.

Nuclear power plants are not associated with chemical pollutants or phenomena like acid rain, green house effect. It requires small quantities of fuel (1/25,000 as compared to coal) and therefore not associated with any significant transportation infrastructure as in coal. A large transportation infrastructure has more environmental impact. Land utilisation in nuclear is much smaller as compared to hydro.

Nuclear Power Plant is environmentally friendly. Impacts from normal operation of reactors due to radioactivity is much lower than the natural radioactivity. Technology for disposal of wastes have been developed and the problems could be overcome.

About 17% of World's electricity needs are met through nuclear power generation. Countries like Japan, South Korea and China in the Asian Region are proceeding with their nuclear power programmes. India having developed indigenously technology for the entire range of nuclear fuel cycle, can not lag behind.

Having regard to long term energy options, optimisation of contribution of electricity generation from different energy resources, rapidly dwindling fossil resources, and significant growth in demand for electricity, nuclear power has to play an important role and progressively increase its contribution by the early part of the next century. The constraint, as of now, is the availability of funds. Nuclear power does not have avenues for overseas funding.

General

20. **Copy of safety policy document of Nuclear Power Corporation.**
Copy of the Safety Policy is enclosed.

21. **A detailed note on Statutes and Rules and Regulations regarding Atomic Energy issued thereunder.**

Government promulgated the following acts/rules for safety related aspects of Atomic Energy and these include:

(i) Atomic Energy (Working of mines, minerals and handling of prescribed substances) Rules, 1984.

(ii) Radiation Protection Rules, 1971.

(iii) Atomic Energy (Factories) Rules, 1971.

(iv) Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.

(v) Radiation Surveillance Procedures for Safe Transport of Radioactive Materials, 1987.

Atomic Energy Regulatory Board set up in 1983 is the agency in India to enforce radiological safety standards. Extracts of relevant Atomic Energy Act is reproduce below:

Under the Constitution of India 'atomic energy and mineral resources necessary for its production' form Item No. 6 of the 'List I— Union List' under the Seventh Schedule which indicates that in respect of this field Parliament has exclusive power to make laws under Art. 246 (1) thereof. 'Electricity' forms Item No. 38 of 'List III—Concurrent List' of the Seventh Schedule of the Constitution which indicates that in respect of that field notwithstanding anything in Clause (3) Parliament and also, subject to Clause (1) the Legislature of any State, have power to make laws under Art. 246 (2) of the Constitution. (2) Accordingly, Parliament has enacted the *Atomic Energy Act, 1962* (Act No. 33 of 1962—repealing the earlier Act of 1948) to provide as per the Preamble 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. Under *Section 3(a)* of the said Act, subject to the provisions of that Act, the Central Government shall have power to produce develop use and dispose of atomic energy either by itself or through any authority or corporation established by it or a government company and carry out research into any matters connected therewith. So also, under *Section 3 (b)* thereof, subject to the provisions of that Act, the Central Government shall have power to manufacture or otherwise produce, to buy or otherwise acquire, store and transport any prescribed or radioactive substance and any articles which in its opinion are, or are likely to be, required for or in connection with the production, development or use of atomic energy or such research as aforesaid and to dispose of such prescribed or radioactive substance or any such articles either by itself or through any authority or corporation established by it or a Government company. The Central Government has moreover the power to declare as 'restricted information' any information not so far published or otherwise made public relating to the categories of information listed under Section 3 (c) of the Act. Further, under *Section 3 (f)* thereof, the Central Government shall have power, subject to the provisions of that Act, to provide for the production and supply of electricity from atomic energy and for taking measures conducive to such production and supply and all matters incidental thereto either by itself or through any authority or corporation established by it or a government company. (3) The Atomic Energy Act, 1962 makes a basic assumption that uranium in its natural state is the property of the Central Government, wherever it is found. Even though not expressly stated, this is necessarily implied because of the provision that in calculating compensation payable for compulsory acquisition of prescribed substances, the exclusive right to work any minerals from which prescribed substances can be obtained, any prescribed equipment and plant, any mine or part of a mine, etc., no account shall be taken of the value of uranium (in its natural state) contained in the substance regarding the mining, processing and production of which is controlled or totally prohibited or compulsorily acquired by the Central Government — *see, Sections 5(3) & (4), 6(2) & (3), 10(3), Proviso to 12 & Proviso to 15(1). [N.B.*—Strangely, this reservation is absent in *Section 11(9)*. Under the *Proviso to Section 15(1)* plutonium also finds a place alongwith uranium for the said exclusion of consideration. With respect to thorium only an intimation in writing to the Central Government of the discovery thereof is required to be furnished by every person under *Section 4* of the Act. Some of the inconsistencies can be removed through an amendment to the said Act.] The principles to be observed for payment of compensation, wherever compensation is payable, are provided for under *Section 21* of the Act.

(4) Under *Section 14(1)* of the said Act, the Central Government may, subject to rules as may be made in this behalf, by order prohibit except under a licence granted by it regarding all the categories of activities relating to prescribed substances or minerals from which any of the prescribed substances can be obtained as specified thereunder.

N.B.—Earlier, *vide* an Order dated 19-5-1953 passed in the exercise of powers conferred by Section 10 of the Atomic Energy Act, 1948, the Central Government through the then Ministry of Natural Resources and Scientific Research has sought to prohibit the production and use of atomic energy including the prescribed substances and scheduled minerals, which is still being enforced by invoking Section 24 of the General Clauses Act, 1897 since it is not inconsistent with the provisions of the Atomic Energy Act, 1962. Later, in the exercise of powers conferred by Section 14 read with other enabling provisions of the Atomic Energy Act, 1962, the Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules, 1984 was framed by the Deptt. of Atomic Energy (the nodal Department administered the said Act under the G.O.I., Allocation of Business Rules, 1961); Under *sub-section (2) of Section 14,* notwithstanding anything in the Section, the Central Government has the power to refuse a licence or to include in a licence such conditions as it thinks fit or to revoke a licence granted by it. Under *sub-section (3) of Section 14,* certain matters to which the rules (referred to in the Section) may provide for are set out. *Sub-section (4) of Section 14* provides that the Central Government may also prescribe the fees payable for issue of licences under sub-section (1). Control over manufacture, possession, use, etc. of radioactive substances is ensured through *Section 16* of the Act.

(5) *Section 17* of the Act sets out special provisions as to safety. *Sub-section (1) thereof* provides that the Central Government may make such provisions by rules as appear to it to be necessary with regard to premises or places in which radioactive substances are manufactured, produced, mined, treated, stores or used or wherein any radiation generating plant, equipment or appliance is used for the purpose of: (a) preventing injury being caused to the health of the persons employed at such premises or places or to other persons either by radiation or by the ingestion of any radioactive substance. [*N.B.*—Accordingly, the Radiation Protection Rules, 1971 has been framed by the Deptt. of Atomic Energy]; (b) securing that any radioactive waste products resulting from such manufacture, mining, production, treatment, storage or use as aforesaid are disposed of safely. [Accordingly, the Deptt. of Atomic Energy has framed the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.];

(c) Prescribing qualifications of the persons for employment at such premises or places and the regulation of their hours of employment, minimum leave and periodical medical examination.

Sub-section (2) of Section 17 provides that the Central Government may make such rules as appear to be necessary to prevent injury being caused by the transport of any radioactive substance or any prescribed substance specified as being dangerous to health by an order issued under the Act [Rules are yet to be framed in this regard]. *Sub-section (3) of Section 17* provides that rules made under this Section may impose requirements, prohibitions and restrictions on employers, employed persons and other persons. *Sub-section (4) of Section 17* provides for authorised representative of the Central Government to enter into any premises or vehicle or vessel or aircraft at all reasonable hours for the purpose of detecting any contraventions of the rules made under this Section. *Sub-section (5) of Section 17* enables the Central Government to take such measures as it may deem necessary to prevent further inury to persons or damage to property arising from radiation or contamination by radioactive substances including the right to seal the premises, vehicle, vessel or aircraft and to seize the radioactive substances and contaminated equipment besides enforcement of penalties under *Section 24* of the Act.

(6) *Section 18(1)* of the Act provides that the Central Government may by order restrict the disclosure of information whether contained in a document or in any other form which relates to an existing or proposed nuclear reactor, its processes and method of operation. Accordingly, an order dated 4-2-1975 has been issued under the said Sub-section by the Deptt. of Atomic Energy. The Central Government may also by order prohibit the entry of any person, without obtaining permission, into a prohibited area under *Section 19(1)* of the Act. No patents can also be granted in respect of inventions relating to atomic energy and allied matters falling within the scope of *Section 20(1)* of the Act [see also, *Section 4* of the Patents Act, 1970.]

(7) There are certain special provisions as to electricity generation from atomic energy under *Section 22* of the Act. *Sub-section (1) of Section 22* provides that notwithstanding anything contained in the Electricity (Supply) Act, 1948, the Central Government shall have authority — (a) to develop a sound and adequate national policy in regard to atomic power; to co-ordinate such policy with the Central Electricity Authority and State Electricity Boards (constituted under that Act of 1948) and other similar statutory corporations concerned with the control and utilisation of other power resources; to implement schemes for the generation of electricity in pursuance of such policy; and to operate either by itself or through any authority or corporation established by it or Government company, atomic power stations in the manner determined by it in consultation with the C.E.A., the Boards or Corporations concerned with whom it shall enter into agreements regarding the supply of electricity so produced;

(b) to fix rates for and regulate the supply of electricity from atomic power stations either by itself or through any authority or corporation established by it or a Government company in consultation with the Central Electricity Authority;

(c) to enter into arrangements with the Electricity Boards of the State in which an atomic power station is situated either by itself or through any authority established by it or a Government company, for the transmission of electricity to any other State;

Provided that in case there is difference of opinion between the Central Government, or such authority or corporation or Government company, as the case may be, and any State Electricity Board in regard to the construction of necessary transmission lines, the matter shall be referred to the Central Electricity Authority whose decision shall be binding on the parties concerned.

It is added under *sub-section (2) of Section 22* that no provision of the Indian Electricity Act, 1910 or any rule or order made there under shall have any effect so far as it is inconsistent with any of the provisions of this Act. *Sub-section (3) of Section 22* provides that save as otherwise provided under this Act, the provisions of this Act shall be in addition to and not in derogation of the Indian Electricity Act, 1910 and the Electricity (Supply) Act, 1948.

(8) Under *Section 23* of the Act, it is provided that notwithstanding anything contained in the Factories Act, 1948, the authority to administer the said Act and to do all things necessary for the enforcement of its provisions including the appointment of inspecting staff and the framing of rules there under shall vest in the Central Government or any authority or corporation established by it or a Government company and engaged in carrying out the purposes of this Act. [*N.B.*— Accordingly, the Atomic Energy (Factories) Rules, 1984 has been framed by the Deptt. of Atomic Energy.]

(9) It may be added that as per *Section 28,* the provisions of the Act shall have effect notwithstanding anything inconsistent there with contained in any enactment (or any rule or order framed the under) other than this Act.

(10) Under Section 13 of the (repealed) Atomic Energy Act, 1948 the Govt. of India had *earlier* set up an Atomic Energy Commission with the objectives of protecting the interests of the country in connection with atomic energy and exercising the powers conferred upon the Govt. by the provisions of the Act, *vide* the then Deptt. of Scientific Research Notification No. F-402/DSR/48, dated the 10th Aug., 1948. The Department of Atomic Energy was established by the President under Art. 77(3) of the Constitution, *vide* Notification dated 2nd Aug., 1954 and since then research and development in the peaceful uses of Atomic Energy have made important strides. These developments called for an organisation with full authority to plan and implement the various measures on sound technical and economic principles and free from all non-essential restrictions or needlessly inelastic rules. The special requirements of atomic energy, its newness, strategic nature and its international and political significance had to be taken into account in devising such an organisation. Hence, at Atomic Energy Commission (A.E.C.) with full executive and financial powers, modelled more or less on the lines of Railway Board had replaced the earlier Commission, *vide* Resolution dated 1st Mar., 1958. The business of the Commission is—

(1) To formulate the policy of the Deptt. of Atomic Energy for the consideration of the Prime Minister;

(2) To prepare the capital, revenue and foreign, exchange budgets of the Deptt. for each year;

(3) To ensure the implementation of Government's policy in all matter concerning atomic energy and all other matters which have been allocated

to the Deptt. of Atomic Energy by the G.O.I., Allocation of Business Rules, 1961.

(11) It may be further that in the exercise of the powers conferred by *Section 27* of the Act and all other powers enabling him in that behalf, the President of India was pleased to constitute an Atomic Energy Regulatory Board (A.E.R.B.), *vide* DAE Notification dated 15.11.1983, to carry out certain regulatory and safety functions as envisaged under *Sections 16, 17 and 23* of the Act, *vide* S.O. 4772, dated 15th Nov., 1984 issued by the Deptt. of Atomic Energy. As per its Constitution as well as sbusequent Notifications of the Deptt. of Atomic Energy, the Chairman of the A.E.R.B. has been declared to the 'Competent Authority' to enforce the Rules & Regulations framed under the Atomic Energy Act, 1962 for ensuring radiation safety in the country. The A.E.R.B. also has been given the authority to administer the provisions of the Factories Act, 1948, for ensuring industrial safety in the units of the Deptt. of Atomic Energy as per Section 23 of the A.E. Act. It has been notified as the Competent Authority for enforcing the provisions the Environment Protection Act, 1986 in respect of DAE installations.

22. **A note on any inquiry or investigation conducted into any mattergermane to the subject 'Nuclear Power, Environment and Nuclear Safety'.**

Subject relevant to investigations relating to nuclear power, and environment is presented in 6 (iv) and that relevant to nuclear safety in 5 (vi).

23. Any other information which the Ministry may like to place before the Committee in connection with examination of the subject.

Please see the subject covered under 17

NEW DELHI;
March 16, 1994

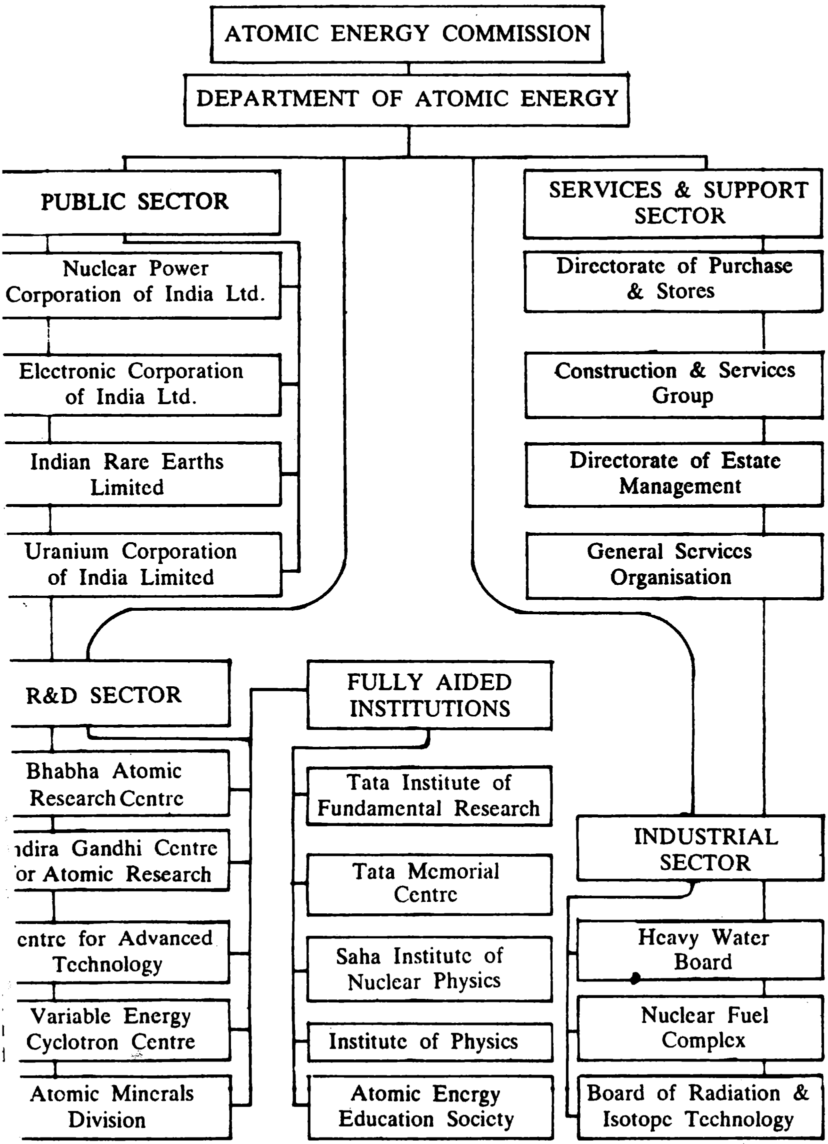
Phalguna 25, 1915 (Saka)

JASWANT SINGH
Chairman,
Standing Committee on Energy.

ANNEXURE I

(*Vide* reply to Question No. 1)

ATOMIC ENERGY ORGANISATIONAL STRUCTURE



ANNEXURE II

(*Vide* reply to Question No. 1)

DEPARTMENT OF ATOMIC ENERGY

The Department of Atomic Energy was established on August 2, 1954 with headquarters at Bombay and a branch secretariat at New Delhi. At that time, this was the only Department with headquarters located ouside New Delhi. The Department, which is under the charge of the Prime Minister, is responsible for the execution of the policies laid down by the Atomic Energy Commission. The main functions of the Department of Atomic Energy are the following:

1. All matters relating to Atomic Energy in India, e.g.

(A) Research, including fundamental research in subjects connected with atomic energy and the development of its uses in agriculture, biology, industry and medicine;

(B) Survey, prospecting, drilling, development mining, acquisition and control of atomic minerals;

(C) Administration of the Atomic Energy Act, 1962, including control of radioactive substances and regulation of their possession, use disposal and transport;

(D) All activities connected with the development and use of atomic energy, including—

(a) projects and industries concerned with substances and minerals prescribed under the Atomic Energy Act and their products and by products;

(b) generation of electricity through the use of atomic energy;

(c) design, construction and operation of research and power reactors;

(d) construction and operation of facilities and plants.

(i) for research in nuclear sciences and atomic energy;

(ii) for the production of materials and equipment required for the use of atomic energy;

(iii) for the separation of isotopes, including plants adapatable to the separation of isotopes as by-products, and plants for the production of heavy water as a main or subsidiary product.

(E) Supervision of State undertakings concerned with prescribed or radioactive substances, including

(a) Indian Rare Earths Ltd.

(b) Fertilizer Plants, in so far as production of heavy water is concerned.

(c) Electronics Corporation of India Ltd. (ECIL).

(d) Uranium Corporation of India Ltd. (UCIL).

2. Financial assistance for the furtherance of studies in the nuclear sciences and for building up adequately trained manpower for the development of the atomic energy programme, including

(A) Assistance to institutions and associations engaged in scientific work, and to universities for advanced study and research in the nuclear sciences; and

(B) Grant of scholarships in scientific subjects to students in universities, and other educational institutions and other forms of financial aid to individuals, including those going abroad for studies in the nuclear sciences.

3. International relations in matter connected with atomic energy, including

(A) Matters relating to atomic energy in the United Nations, Specialised Agencies, International Atomic Enegy Agency and in relations with other countries; and

(B) Correspondence with foreign institutions, universities, etc., in connection with fellowships and training of Indian scientists.

4. All matters relating to personnel under the control of the Department of Atomic Energy.

5. Execution of works and purchase of land debitable to the Capital Budget of the Department of Atomic Energy.

6. Procurement of stores and equipment required by the Department of Atomic Energy.

7. All matters connected with the advancement of higher mathematics, including

(A) Matters relating to the promotion and coordination of advanced study and research;

(B) International relations in higher mathematics, including in particular, matters relating to the Indian National Committee for Mathematics and the International Mathematical Union;

(C) Grants to institutions and associations engaged in the advancement of higher mathematics; and

(D) Grant of scholarships and other forms of financial aid for advanced study and research.

8. All matters relating to aided institutions such as the Tata Institute of Fundamental Research, the Saha Institute of Nuclear Physics and the Tata Memorial Centre.

Department of Atomic Energy, apart from enjoying the full powers like any other Ministry, has been given certain additional powers. The Department has been exampted from the purview of UPSC in making appointments, promotions or confirmations, Promotions of scientific and technical personnel are governed by a merit promotion scheme delinked from availability of posts. It carries out the civil works through its own agencies. The Department also has its own directorate of Purchase & Stores and need not approach DGS&D for its purchases. The Department has its own rules for delegation of financial powers.

DEPARTMENT OF ATOMIC ENERGY-ORGANISATION

1. Research and Development Centre

1.1 Bhabha Atomic Research Centre

The Centre was set up in 1957 as the Atomic Energy Establishment, Trombay. In memory of its founder it was renamed in 1967. BARC is the premier national centre for multidisciplinary R&D work in nuclear energy. The facilities available at Trombay include research reactors DHURVA (100M Wt), CIRUS (40MWt), and APSARA (1MWt) which are providing valuable experience in various aspects of reactor technology in addition to producing a large number of radioisotopes for use in agriculture, medicine, industry and research. Besides these reactors, a 5.5 MeV Van de Graaff accelerator is also available for experimental research in physics. In addition to the various laboratories for carrying out research in physics, chemistry, biology, agriculture, medicine, food technology, nuclear engineering, isotope technology, metallurgy, etc., the Centre also has Uranium Metal Plant, Uranium Fuel Fabrication Plant, Fuel Reprocessing Plant and Mixed Oxide Fuel Fabrication Plant. It has set up a Beryllium Plant at Vashi. Fuel Reprocessing Plant (PREFRE) and a Nuclear Waste Vitrification Plant at Tarapur are also parts of BARC. The Radiation Medicine Centre of BARC at Bombay is the regional reference centre of the World Health Organisation in Sough East Asia. The centre has setup and operates a 14MV pelletron accelerator at Bombay in collaboration with Tata Institute of Fundamental Research (TIFR).

The Seismic Station at Gauribidanur, near Bangalore set up in 1965, helps in the detection and identification of underground nuclear explosions. The Nuclear Research Laboratory at Srinagar and the High Altitude Research Laboratory at Gulmarg conduct research in atmospheric and cosmic ray physics.

BARC activities cover a wide range of areas such as physics, chemistry, engineering, metallurgy, fuel reprocessing, fuel fabrication, radioisotopes, waste management, electronics, instrumentation, lasers, biology, agriculture, food technology, radiation medicine, etc. The Centre has developed a number of technologies, some of which have already been transferred to industry for commercial exploitation.

1.2 Indira Gandhi Centre for Atomic Research

Set up in 1971 at Kalpakkam, Tamil Nadu, the Centre undertakes research and development related to fast breeder reactor (FBR) technology. The major facility at this Centre is the Fast Breeder Test Reactor (FBTR), which attained its first criticality on 18th October, 1985. FBTR is operating at 10MWt power level operation. The reactor will reach full level of operation, after introducing additional fuel. The Centre is drawing up plans to design and build a 500 MWe Prototype Fast Breeder Reactor (PFBR).

1.3 Centre for Advanced Technology

The Centre at Indore, Madhya Pradesh is spearheading the national effort in research and development in high technology fields such as accelerators, lasers and other areas of advance research.

1.4 Variable Energy Cyclotron Centre (VECC)

The Variable Energy Cyclotron Centre (VECC) at Calcutta is a national facility for advance research in nuclear physics, nuclear chemistry, production of isotopes for various applications and radiation damage studies on reactor materials.

1.5 Atomic Minerals Division

The Division is entrusted mainly with the research and development activities pertaining to radiometric and geological surveys, exploration, prospecting and development of various mineral resources needed for the nuclear power programme.

2. Public Sector Undertakings

2.1 Nuclear Power Corporation

The Corporation is responsible for the design, construction, commissioning and operation of nuclear power plants. It is presently operating the atomic power stations at Tarapur, Rawatbhata, Kalpakkam, Narora, and Kakrapar (Unit-1) and constructing Kakrapar (Unit-2), RAPP-Unit 3 & 4, and Kaiga atomic power projects.

Tarapur Atomic Power Station : 100 Kilometres north of Bombay, TAPS is the first atomic power station in India. it has two boiling water type reactors presently operated at 160MWE (derated) gross capacity, fuelled by enriched uranium. The Station supplies electricity to Maharashtra and Gujarat.

Rajasthan Atomic Power Station : Located at Rawatbhata, Rajasthan, the station has two natural uranium fuelled pressurised heavy water reactors each of 220 MWe gross capacity. Construction work on two additional units (RAPP-3 & 4) of 220 MWe each has commenced at RAPS.

Madras Atomic Power Station: Located at Kalpakkam about 80 kilometers south of Madras, MAPS has two natural uranium fuelled pressurised heavy water reactor units each of 220 MWe capacity. Unit-1 of MAPS has been in commercial operation since 27 January, 1984 and Unit-2 has been operating commercially since 21 March, 1986. MAPS is the first totally indigenous Atomic Power Station.

Narora Atomic Power Station : The station consists of two pressurised heavy water reactor units each of 220 MWe gross capacity.

Kakrapar Atomic Power Station : Located at Kakrapar, Gujarat, the Unit-1 of the station has been in commercial operation since 6th May, 1993. The Unit-2 has reached an advanced stage of construction and commissioning. The two pressurised heavy water reactors are each of 220 MWe capacity.

Kaiga Atomic Power Project : Located at Kaiga in Karnataka, the station will have two units of 220 MWe each.

2.2 Uranium Corporation of India Limited

Formed in October 1967, UCIL is responsible for mining and milling of uranium ore. It is operating uranium mines at Jaduguda and Bhatin and indigenously designed 1000 tonnes per day uranium mill at Jaduguda. The corporation has set up uranium recovery plants at Surda Rakha and Mosaboni. A by product recovery plant has also been set up by UCIL to recover minerals such as copper, magnetite and molybdenum.

2.3 Indian Rare Earths Limited

IRE is a Government company functioning since 1950. The Company has two mineral sands separation plants at Manavalakurichi and Chavara and a Rare Earths Plant at Alwaye. IRE has set up a project at Chhatrapur, Orissa known as Orissa Sands Complex (OSCOM) for production of various minerals and value added products. The Company is also managing Thorium Plant at Trombay.

2.4 Electronics Corporation of India Limited

The ECIL was set up at Hyderabad in 1967 to manufacture electronic systems, instruments and components developed at BARC. The Corporation has pioneered the production of a varied range of sophisticated electronic systems, instruments and components, based primarily on indigenous technology. The company is a leading producer in computers, control instrumentation and other sophisticated electronic systems.

3. Industrial Organisations

3.1 Heavy Water Projects

There are eight operating heavy water plants:

Heavy Water Plant, Nangal: Based on the electrolysis of water and low temperature hydrogen distillation, the Heavy Water Plant at Nangal, Punjab has an annual capacity of 14 tonnes heavy water. The plant was commissioned in August 1962.

Heavy Water Plant, Baroda: Based on the monothermal ammonia-hydrogen exchange process, the plant at Baroda, Gujarat is linked to the synthesis gas stream of the fertilizer plant of Gujarat State Fertilizer Corporation.

Heavy Water Plant, Kota: Based on the knowhow developed by BARC on hydrogen sulphide-water exchange process, the plant is located at Rawatbhata, Rajasthan. Its design production capacity is 100 tonnes per year.

Heavy Water Plant, Tuticorin: Linked to the fertilizer plant of the Southern Petrochemical Industries Corporation, the plant is similar to the Baroda plant. Its design production capacity is 70 tonnes per year.

Heavy Water Plant, Talcher: The plant based on bithermal ammonia hydrogen exchange will use the synthesis gas stream of ammonia plant of Fertilizer Corporation of India. It is designed to produce 60 tonnes of heavy water a year.

Heavy Water Plant, Thal: Based on monothermal ammonia-hydrogen exchange process, the plant at Thal-Vaishet, Maharashtra is annual production capacity of 110 tonnes.

Heavy Water Plant, Manuguru: Based on the bithermal hydrogen sulphide-water exchange process, the plant has annual production capacity of 185 tonnes.

Heavy Water Plant, Hazira: This 110 tonnes per annum heavy water plant is based on monothermal ammonia hydrogen exhange process at Hazira, Gujarat. The plant is integrated with the two stream ammonia plant of KRIBHCO.

3.2 Nuclear Fuel Complex

Located at Hyderabad, NFC produces fuel for the nuclear power reactors of the country. The complex consists of various plants for the conversion of yellow cake into ceramic grade natural uranium oxide, enriched uranium hexafluoride into enriched uranium oxide, zircon sand to zircaloy components and uranium dioxide to sintered pellets and finally to fuel assemblies. Production of components such as blanket fuel containing thoria pallets, nickle and steel reflector assemblies etc. required for FBTR, forms part of the fuel fabrication programme. A plant for manufacturing very high purity materials for the electronic industry is also located at NFC. Plants have also been set up for the production of seamless stainless steel tubes. Quality control laboratory at NFC exists for assessing and assuring quality of products and inprocess control. Special control measures are ensured for effective effluent management. The unit is undergoing expansion to meet the further needs.

3.3 Board of Radiation and Isotope Technology

The Board of Radiation and Isotope Technology (BRIT) supplies on commercial scale radioisotope, radiopharmaceuticals, radiation sources, labelled biomolecules and equipment for industrial radiography.

4. Aided Institutions

4.1 The Tata Institute of Fundamental Research

Founded in 1945 as a Centre for pursuit of fundamental research in mathematics, theoretical physics, cosmic rays and nuclear physics. The research activities of the Institute have now expanded to areas such as astronomy and astrophysics, chemical physics, molecular biology, solid state physics, solid state electronics and computer science. The facilities being operated by the Institute are: the Balloon Facility at Hyderabad, the Radio Astronomy Centre at Ootacamund, the National Image Processing Facility for Astronomy at Ootacamund and 500 MHz FT NMR National Facility at TIFR, Bombay. The Institute in addition manages activities of the Homi Bhabha Centre for Science Education (HBCSE) and the Basic Dental Research Project. TIFR is one of the institutions aided by DAE.

4.2 Tata Memorial Centre

Located at Bombay, Tata Memorial Centre comprises the Tata Memorial Hospital and the Cancer Research Institute. The Centre is the foremost in the country in education, comprehensive care of cancer patients and in cancer research. The hospital is a full fledged post graduate centre affiliated to the Bombay University.

4.3 Saha Institute of Nuclear Physics

SINP at Calcutta was formally opened in January 1950. The Institute provides facilities in advanced research in the fields of experimental and theoretical nuclear physics, solid state atomic and molecular physics, plasma physics, high energy physics, crystallography, molecular biology, biophysics, nuclear chemistry and instrumentation.

4.4 Other DAE-Aided Institutes

Incepted in 1974, the Institute of Physics, Bhubaneswar, was a registered Society funded by the Government of Orissa till March, 1985. Thereafter it became one of the fully aided institutes of DAE. The Institute provides facilities in advanced research in the fields of theoretical solid state, nuclear and high energy physics and in the field of experimental solid state physics. It has a 3 MV tandem pelletron accelerator for experimental research in atomic, nuclear, solid state and applied physics.

The other aided Institutes of DAE are Mehta Research Institute, Allahabad, National Board for Higher Mathematics, Bombay, Institute of Mathematical Sciences, Madras and Atomic Energy Education Society, Bombay.

4.5 Atomic Energy Regulatory Board

AERB carries out certain regulatory and safety functions envisaged under Section 16, 17 and 23 of the Atomic Energy Act 1962. The Board has a full-time Chairman, a full-time Member-Secretary and three other part time members. The Board is responsible to the AEC. Atomic Energy Regulatory Board has the powers to lay down safety standards and frame rules and regulations in regard to regulatory and safety requirements.

ANNEXURE III

(Vide reply to Question No. 5 (iii)

LIST OF IAEA COMMITTEES WHICH HAVE INIDA'S PARTICIPATION

1.	International Atomic Energy Agency (IAEA)	India	Associated with the formation **Member** of the Board of Governors since its inception.
2.		BARC	**Member** of: Standing Advisory Committee for Safeguard Implementation
3.		BARC	Standing Advisory Committee for Rad. Waste Management
4.		AERB	International Nuclear Safety Advisory Committee
5.		IGCAR	International Working Group for Fast Reactors.
6.		BARC	Radioactive Waste Safety Standards Committee
7.		BARC AERB	Standing Committee for Transport of Radiocative Material
8.		AERB	International Nuclear Events Scale Committee
9.		AERB	International Reporting System Committee
10.		NPC	International Working Group on life Management of Nuclear Power Plants
11.		NPC	International Group on Plant life Management
12.		BARC	International Consultants' Group on Food Irradiation
13.		NPC	International Working Group on Water Reactor Fuel Performance and Technology
14.		AERB	Nuclear Safety Standards Advisory Group
4.n.		BARC	United Nations Scientific Committee on the Effects of Atomic Radiation
4.o.		All DAE Units	Several Technical and Standards Committees. The numbers of scientists and engineers who participated in this meeting, are about 170 in 1991, 180 in 1992, 180 in 1993.

5.	International Commission on Radiological Protection (ICRP)	AERB	This is an internationally reknowned body on radiological safety

ANNEXURE IV

Vide reply to Question No.5 (iii)

INTERNATIONAL ATOMIC ENERGY AGENCY

PRESS RELEASE FROM DR. MORRIS ROSEN, ASST. DIRECTOR GENERAL INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA), VIENNA

During my present visit to India, I was given an opportunity to have detailed discussions with Dr. A. Gopalakrishnan, Chairman of India's Atomic Energy Regulatory Board (AERB), and his staff on details of the regulatory process employed by the AERB with respect to nuclear facilities in this country. The series of AERB Codes, Guides and Standards currently in use in India have been framed on the basis of guideline documents of the IAEA. I am happy to note from these discussions, and from the feedback we have been receiving lately at the International Atomic Energy Agency (IAEA), that the AERB is making substantial progress in implementing the rquired safety standards, which are comparable to internationally acceptable levels.

Safety of nuclear facilities in primarily the responsibility of the operating agency. Safety or the lack of it cannot be judged merely by televising or publishing a few of the good or bad points. Safety is based on an overall safety consciousness and safety culture which have their roots not only in technical capability, but also in the socio-cultural make-up of a country and the openness with which safety-related issues are discussed with the media as well as national specialists and international counterparts. The same ultimate safety goals can be achieved by different countries in different ways, through systems and procedures differently adapted to suit the specific national conditions. What is important is an overall national commitment to safety and co-operative efforts and exchange of information between nationals on matters related to nuclear safety.

In the above context, the present Technical Committee Meeting on the Exchange of safety Experience of PHWR's is an important step. IAEA and the CANDU Owners' Group (COG) have taken the initiative to organize this week-long get-together, and I am glad that the Nuclear Power Corporation of India has made excellent arrangements for such a useful interaction.

On the basis of the discussions between IAEA and AERB,a joint decision has also been taken to organize an ASSET Seminar at Bombay, during the first week of May 1994. The methodology for assessing safety-significant events in nuclear power plants will be the subject of this

Seminar. Three IAEA experts will be in Bombay to conduct this five-day seminar to be organised by AERB, with participation of reactor operating staff, designers, and regulatory staff.

On 19.2.94, I had also the opportunity to visit Units—1 & 2 of the Kakrapar Atomic Power Station of NPCIL. A summary of the design features of these units and the AERB-approved plans for conducting the qualification tests on the Emergency Core Cooling System of Unit-2 were among the topics discussed. I find the team spirit and morale at Kakrapar to be high and comparatively young team of qualified personnel is manning the activities there. These aspects also contibute as essential elements towards building a healthy safety culture.

India and the IAEA have more options and avenues for interaction in safety-related areas. With the Indian AERB's commendable recent initiatives towards openness with the public and in bringing outside expertise into safety evaluation, I am sure IAEA assistance in safety areas can also be enhanced in future, wherever the AERB and the Government of India feel it will be helpful and requests the IAEA for such co-operation. My best wishes are always with the Indian Nuclear Programme, which has performed commendably well, mainly on the basis of indigenous capability.

-Sd-
(Morris Rosen)
Asst. Director General for
Nuclear Safety
International Atomic Energy Agency (IAEA)
Vienna
(*Camp*: **Bombay**)

(*vide* reply to Question No. 20)

Revision 1
September 1993

SAFETY POLICY OF NUCLEAR POWER CORPORATION OF INDIA LIMITED

(Approved by MD, NPC and Issued by
Director, (Health & Safety), NPC)

1. INTRODUCTION TO THE SAFETY POLICY

The Nuclear Power Corporation of India Ltd, (NPCIL) is vested with the responsibility of design, construction, operation, maintenance and subsequent decommissioning of all nuclear power reactors in India. It is the objective of NPCIL to carry out these responsibilities in a manner which is safe to the environment, to the public and to its own personnel. Towards this end, NPCIL has drawn up this document which outlines the "Safety Policy of NPCIL". The primary features of this policy are:

1.1 It is based on internationally acceptable basic safety principles for nuclear power plants as well as on guidelines laid down by the Atomic Energy Regulatory Board (AERB).

1.2 The management of NPCIL accords great importance to safety in all its aspects - be it nuclear, radiological, industrial, or environmental.

1.3 NPCIL recognises that all industrial activities involve certain risks and that in the event of any accident, it may have an impact on the environment.

1.4 Consequently, it has adopted a three tier strategy comprising of: accident prevention, provision of engineered systems to minimise the consequences of an accident if any and finally drawing up comprehensive emergency preparedness plans at plant, on-site and off-site locations.

1.5 This safety policy will be periodically reviewed so that it keeps abreast with advances in technology, evolving industrial practices and prevalling statutory regulations.

2. OBJECTIVES OF THE SAFETY POLICY

The Objectives of the Safety Policy of NPCIL are:

2.1 To specify and maintain high standards for safety within the plant as well as in the surrounding environment.

2.2 To ensure that the Safety Standards conform to prevalling regulations as stipulated by the Central and State Governments, Local bodies and the Atomic Energy Regulatory Board (AERB).

2.3 If necessary, to evolve its own standards in areas where the regulations in the Statute are considered to be inadequate.

2.4 To ensure that all the employees and others working for NPCIL are kept informed about the Safety Standards and adhere to whilst carrying out their responsibilities.

2.5 To keep the public at large informed about the Safety Standards and Regulatory Practices that are being adopted.

2.6 To maintain Joint Consultation programmes with Design and Regulatory personnel as well as with employees on Health and Safety matters so as to encourage effective participation in accident prevention measures by all categories of employees.

2.7 To ensure that potential Health, Safety and Environmental factors are properly assessed at all projects and operating power stations.

2.8 To effectively coordinate and communicate with the AERB, Safety Authorities at the State and Central as well as with National and International Technical Bodies dealing with Health & Safety issues.

3. IMPLEMENTATION OF THE SAFETY POLICY

While the nodal agency for ensuring this Safety Policy will be the "Directorate of Health & Safety" (DHS) the actual implementation of the same will be the responsibility of the management of individual units of NPCIL. All interactions with AIRB will be carried out through Directorate of Health & Safety on matters related with safety for better coordination and resolution of safety issues. Towards this end, the following measures will be implemented:

3.1 Safety related objectives to be achieved at the Corporate level, at the stations and at the projects will be set up and reviewed, periodically.

3.2 All Safety related Reports and Documents will be reviewed, assessed and monitored to ensure that nuclear safety standards are complied with in areas of Design, Manufacture, Eretion, Quality Surveillance, Commissioning and Operations. It will also ensure that all documents conform to standards set by AERB and its functionaries.

3.3 It will be ensured that all applicable National and International Safety codes for sitting, design and operation of nuclear power stations are adhered to.

3.4 The management of individual units of NPCIL will ensure that the work place is safe and that employees adopt safe working procedures in acoordance with this safety policy. They will aslo ensure that effective On-Site and Off-Site Emergency Response Plans are implemented and periodically rehearsed so that in the event of any safety related accident, the impact on the public and the environment is minimised by prompt and well organised action plans.

3.5 Station personnel shall be trained in fundamentals of Radiation Exposure Control procedures. Training programmes shall be conducted for familiarisation with legislation and for developing industrial safety aids such as audio visual programmes, etc.

3.6 The DHS shall carry out its functions through Groups assigend with responsibilities as detailed below:

3.6.1 Health Physics—to ensure Radiation Safety and monitoring of Personnel and Environment. This will include reveiw of radiation protection measures and procedures at operating units, provision of radiological survey and monitoring functions to ensure that radiation exposure levels to all personnel are maintained at levels specified by AERB. Efforts shall be made to achieve levels which are As Low As Reasonably Achievable (ALARA levels).

3.6.2 Nuclear Safety— to review the design of process equipment and operation procedures pertaining to nuclear reactors and develop codes for Safety Analysis.

3.6.3 Industrial Safety—to ensure implementation of Safe Industrial practices, including conformance with Statutory Acts. The industrial acts, rules and codes relevant to safety as applicable to NPCIL are given in annexure.

3.6.4 Computer Systems—to ensure Reliability of Computer based Systems, Validation of computer codes and Development of special Computer based systems related to safety.

3.7 The DHS shall effectively interact with International and National Organisations such as International Atomic Energy Agency, Atomic Energy Regulatory Board, Central Labour Insitute, National Safety Council, Loss Prevention Association of India and others in the area of Safety and Environment, so as to enhance the efficiency of its functioning.

3.8 A Corporate Data base on information pertaining to Health & Safety for plants as well as for individuals, will be maintained so as to disseminate experience gathered at different locations, provide adequate supervision during operations and analyse results to modify procedures if necessary. This will also include collection of and classification of accident/ incident related information in accordance with the Event Scale recommended by IAEA, which will facilitate in effective dissemination of such information to the public.

3.9 Collection of data regarding meteorology, hydrology, fisheries and other socio economic data around the sites will be ensured. NPCIL will also ensure that afforestation and provision of greenery around the project and plant site receive adequate attention.

3.10 NPCIL by adopting appropriate fire protection programme shall ensure the capability to shut down the reactor, maintain it in safe shut down condition and to minimize the radio active releases to environment in the event of a fire.

3.11 NPCIL will take all efforts to communicate effectively to the public, the credibility and genuineness of this Safety Policy. For this purpose it will disseminate educative information on safety related issues to the public around the plant locations as well as to other agencies like local municipal bodies.

3.12 The Management of NPCIL shall periodically review this Safety Policy to make it responsive to technological advances, changes in Statutory regulations and the reaction of the public to Safety and Environmental issues.

INDUSTRIAL ACTS, RULES AND CODES RELEVANT TO ACTIVITIES IN NPCIL

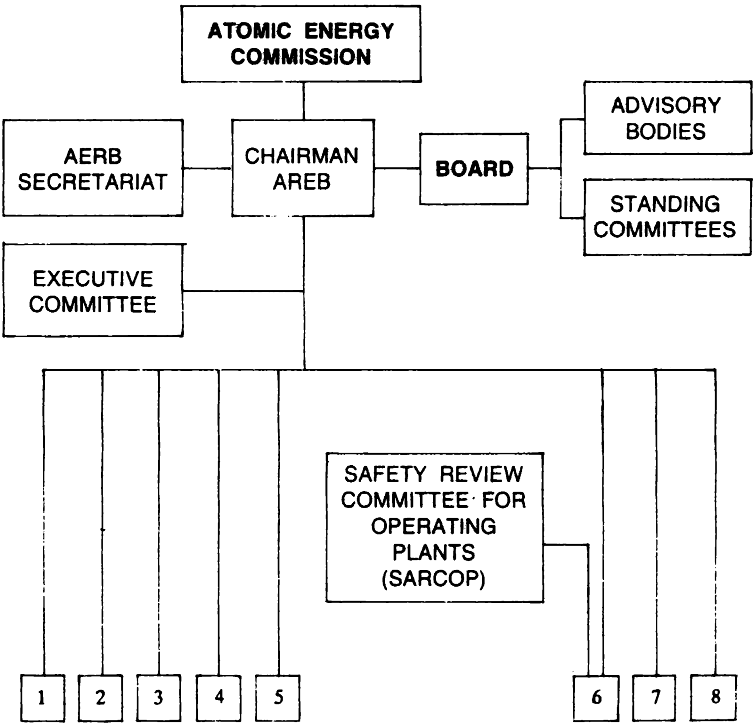
1. The Atomic Energy Act, 1962
2. The Factories Act, 1948
3. The Atomic Energy (Factories) Rules, 1988.
4. The Air (Prevention & Control of Pollution) Act, 1981
5. The Environment (Protection) Act, 1986
6. The Indian Forest Act, 1927.
7. The Gas Cylinder Rules, 1981
8. The Indian Boilers Act, 1923
9. The Indian Boiler Rules, 1950
10. The Indian Electricity Act, 1910
11. The Indian Electricity Rules, 1956
12. The Indian Electricity Supply Act, 1948
13. The Indian Explosive Act, 1884
14. The Explosive Rules, 1983
15. The Industrial Employment (standing orders) Act with Rules
16. The inflammable Substance Act, 1952
17. National Building Code of India, 1983 (ISI)
18. National Electrical Code, 1985 (ISI)
19. The Petroleum Act, 1934
20. The Petroleum Rules, 1976
21. The Radiation Protection Rules, 1971
22. The Water (Prevention & Control of Pollution) Act and Rules, 1977 & The Water (Prevention & Control of Pollution) Cess Act and Rules
23. The Employer's Liability Act, 1938
24. The Workmen's Compensation Act 1923.

N.B. Beside the above referred Industrial Acts, any other existing or those to come in force in future which are applicable to NPCIL will be complied with.

ANNEXURE-V

(*Vide* reply to Question No. 9)

ORGANISATION STRUCTURE OF AERB



1. ADMINISTRATION.
2. CIVIL ENGINEERING SECTION.
3. INDUSTRIAL SAFETY DIVISION.
4. LIGHT WATER REACTOR DIVISION.
5. NUCLEAR SAFETY DIVISION.
6. OPERATING PLANTS SAFETY DIVISION.
7. RADIATION SAFETY DIVISION.
8. SCIENTIFIC AND TECHNICAL SERVICES DIVISION.

Appendix

MINUTES OF THE FIFTH SITTING OF THE STANDING COMMITTEE ON ENERGY HELD ON 15TH MARCH, 1994

The Committee sat from 15.00 hrs. to 16.00 hrs.

PRESENT

Shri Jaswant Singh—*Chairman*

MEMBERS

2. Shri Motilal Singh
3. Shri Khelsai Singh
4. Shri Khelan Ram Jangde
5. Shri Shiv Charan Mathur
6. Shri Virender Singh
7. Shri Ram Tahal Choudhary
8. Shri Shanker Sinh Vaghela
9. Shri Anil Basu
10. Shri Vijay Kamar Yadav
11. Shrimati Dil Kumari Bhandari
12. Shrimati Ila Panda
13. Shri J.S. Raju
14. Shri Rajni Ranjan Sahu
15. Shri Viren J. Shah
16. Smt. Kamla Sinha

SECRETARIAT

1. Shri G.R. Juneja — *Deputy Secretary*
2. Shri A.L. Martin — *Assistant Director*

The Committee considered the Draft Report on "Nuclear Plant Safety and Spent Fuel Management" and adopted the same. The Committee also authorised the Chairman to finalise the report and present the same to Parliament.

The Committee then adjourned.