PAKISTAN

Seventh National Report for 2017 Review Meeting

CONVENTION ON NUCLEAR SAFETY

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Report by the Government of

Islamic Republic of Pakistan

for the

Seventh Review Meeting, 2017

Prepared on behalf of the

Government of Pakistan

by the

Pakistan Nuclear Regulatory Authority

in collaboration with the

Pakistan Atomic Energy Commission

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Pakistan Nuclear Regulatory Authority

P. O. Box. 1912. Islamabad, Pakistan

ABSTRACT

The Pakistan Nuclear Regulatory Authority submits this Seventh National Report of Pakistan for peer review at the Seventh Review Meeting of the Convention on Nuclear Safety at the International Atomic Energy Agency. The report presents the steps taken by the Government of Pakistan to meet the main objectives of the Convention — to achieve and maintain a high level of nuclear safety by enhancing national measures and international cooperation.

This report also includes the update on actions taken to improve safety in response to Fukushima Daiichi Accident as well as measures taken to implement the objectives of the Vienna Declaration on Nuclear Safety as agreed in February, 2015.

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Part I

1 Introduction

1.1 Purpose and Structure of the Report

The Convention on Nuclear Safety (CNS) was signed by Pakistan on 20th of September 1994 and subsequently ratified on 30th of September 1997. The Government of the Islamic Republic of Pakistan considers the Convention on Nuclear Safety to be one of the most important instruments for enhancing nuclear safety. As a matter of policy, highest priority is accorded to safety in nuclear installations.

The Seventh National Report (7NR) of Pakistan to the Convention on Nuclear Safety has been prepared by the Pakistan Nuclear Regulatory Authority (PNRA) in collaboration with Pakistan Atomic Energy Commission (PAEC) and other governmental organizations in fulfillment of obligations under the Convention on Nuclear Safety on behalf of the Government of Islamic Republic of Pakistan.

The Seventh National Report (7NR) is an updated version of the Sixth National Report; however, it can be used as a stand-alone document. The 7NR begins with an introduction in Part I, followed by Part II which gives a summary of the progress made after the Sixth National Report. This also includes the progress on actions taken/being taken to improve safety after Fukushima Daiichi Accident along with a section on measures taken as implementation of the Vienna Declaration on Nuclear Safety (VDNS). Brief description of the future challenges is presented in Part III and the report then continues with Articles 4 to 19 in Part IV according to the guidance provided by the INFCIRC/572.

Annexures are included to supplement information and data to elaborate the article's text, where required. Progress on implementation of the IAEA Nuclear Safety Action Plan is presented in Annexure XII.

The Government of the Islamic Republic of Pakistan is committed to make all possible efforts in achieving and maintaining a high level of safety and has met its obligations under the Convention on Nuclear Safety.

1.2 Electrical Energy Market in Pakistan

As of June 2015, the present installed electricity generation capacity of Pakistan is 24,874 MWe. Major sources of electricity generation in the country are fossil fuel fired thermal power plants and hydroelectric plants. The fossil fuel fired plants fall under the purview of 5 generation companies (GENCOs), K-Electric and Independent Power Producers (IPPs). Nuclear Power Plants are constructed and being managed by Pakistan Atomic Energy Commission whereas all the wind power plants run through IPPs, and the hydropower units are under the Water and Power Development Authority (WAPDA). The share of electricity production from nuclear energy to national grid is about 3% and renewable (wind) is contributing only 1.03% of the total power generation capacity as indicated in the following table.

Table 1.2-1: Pakistan's Electricity Generation Capacity

Generation Type	*Generation Capacity*	*Share*
Fossil fuels fired	16,748 MW	67.33%
Hydroelectric	7,115 MW	28.60%
Nuclear	755MW	3.04%
Renewables	256 MW	1.03%
Total	24,874 MW	

Source: Power System Statistics, 2014-2015, 40th Edition, Planning Power, National Transmission & Dispatch Company (NTDC), Lahore, Pakistan.

1.3 National Policy Pertaining to Nuclear Energy

Energy from Nuclear and Renewable sources are considered as viable options in the energy mix for the socio-economic development of the country. Prime Minister of Pakistan recently approved the national carbon emission reduction strategy, which was later submitted to the United Nations Convention Framework on Climate Change (UNCFCC) as Intended Nationally Determined Contribution (INDC) by the Ministry of Climate Change. Pakistan's INDC is rooted in Pakistan Vision 2025, which is a roadmap of economic growth, social inclusion and sustainable development aimed at transforming the country into a vibrant and prosperous nation by 2025.

The Government is fully cognizant of its responsibilities regarding preservation and improvement of the quality of the environment. Organizations at various levels of the Government have been established, under legislation and statutes, to regulate salient sources of environmental degradation and to carry out research on climatic changes due to global warming, etc. In case of nuclear energy, PNRA is the competent authority for regulating nuclear safety and radiation protection aspects whereas PAEC undertakes promotional activities in the use and application of nuclear energy including research, development, education, etc. PAEC owns and operates all nuclear power plants in Pakistan and has more than 43 years of nuclear power plant operating experience. The safety record of the operation of nuclear power plants has remained excellent as concluded from the findings of the national regulatory reviews and inspections. This has also been substantiated by international peer reviews.

Pakistan has been facing severe electricity shortage for the last many years which has adversely affected its economic growth. Shortfall of electricity reached up to 5,000 MW during the last summer. Nuclear power is a proven base-load electricity generation option to enhance the security of supply and diversity of the power system.

After the Fukushima Daiichi Accident, Pakistan has continued its policy of responsible use of nuclear power technology, with stringent safety controls. Progress on actions related to upgrades/ modifications at NPPs in the light of Fukushima Daiichi experience feedback is presented in Part II (Section 2.2) of the report.

In fulfillment of the "Energy Security Plan 2005-2030" of the Government, PAEC intends to construct more nuclear power plants. Accordingly, new sites are being identified for detailed evaluation. Construction of 1100 MW PWR units of K-2 and K-3 near Karachi Coast is a step in this direction.

1.4 Ongoing National Program Related to the Nuclear Installations

The national program related to nuclear installations is focused on:

a. Continued safe operation of nuclear installations.
b. Construction of new nuclear installations to meet energy requirements in line with the targets of "Energy Security Plan 2005-2030".
c. Preparation for decommissioning of KANUPP.
d. Strengthening and capacity building of regulatory infrastructure in the country.
e. Strengthening and capacity building of nuclear related research and development in the country.

PAEC has enhanced its corporate oversight programs and processes in the light of experience feedback of Fukushima NPP accident. Teams comprising senior level experts reporting directly to Chairman PAEC, made thorough assessments of each operating plant (for details please see Sixth National Report of Pakistan) and continued follow-up to ensure implementation of the identified actions for further safety improvements.

A comprehensive Periodic Safety Review (PSR) of KANUPP was conducted from 2013-2015 following the recommendations of latest IAEA safety standard "Periodic Safety Review of Nuclear Power Plants (NS-G-2.10)" (please refer to section 2.1.3 and 14.2 for more details). An internal Peer Review of KANUPP was conducted by the Corporate office in March, 2016 based on WANO Performance Objectives and Criteria (PO&Cs) to identify weak performance areas and take necessary corrective actions for improvement of plant safety.

KANUPP underwent a long shutdown from Feb to Aug, 2014 during which planned maintenance activities and some major safety significant jobs were performed that included FRAP related modifications, inspection of feeder pipes, steam generators water lancing, steam generator tube inspection, partial re-tubing of main condenser, health assessment of all main transformers, cleaning of intake cooling water bay and installation of some accident monitoring instrumentation. Installation of Passive Autocatalytic Recombiners (PARs) was carried out in 2015 as recommended under FRAP program to mitigate hydrogen hazards inside containment following severe accident.

During the reporting period, C-1 underwent two refueling outages. In 2014, an event related to exposure to a worker at C-1 in excess of Plant Administrative Limit was reported to INES. The event was classified as INES Level 1.

Similarly, C-2 underwent two refueling outages during the reporting period and has started its fourth operating cycle in September, 2015.

The analysis of individual doses at NPPs reveals that during the reporting period, the doses to radiation workers remained well within the regulatory limits.

WANO Peer Review missions were conducted at C-1, C-2 and KANUPP while an OSART Mission was received at C-1 during the reporting period. An IRRS mission of PNRA was also conducted by IAEA in April-May, 2014.

The construction of Chashma Nuclear Power Plants (unit-3 & 4) of 340 MWe gross capacity each, are near completion. Prior to that, review and assessment of commissioning program and Pre-Service and In-Service Inspection program of C-3 & C-4 were performed by PNRA during 2014. Cold commissioning of major systems have been completed for C-3 whereas, hot commissioning is in progress. Further, cold commissioning of C-4 is underway.

Following the review and assessment of the Final Safety Analysis Report (FSAR) and other necessary submissions, permission to load fuel in the reactor of C-3 was granted by PNRA in May 2016 as per requirements of the Regulations for the Licensing of Nuclear Installations in Pakistan (PAK/909). Currently, the application for issuance of fuel load permit for C-4 is under review at PNRA.

K-2/K-3 site was registered after review and assessment of Site Evaluation Report by PNRA and upon completion of other legal and regulatory requirements in 2013. K-2/K-3 applied for construction license along with other necessary submissions as per Regulations PAK/909 which includes PSAR, QAP & PSA reports. After regulatory review of these licensing submissions pertaining to the construction license, PNRA awarded the construction licenses to K-2/K-3 in August and November, 2015 respectively.

Recognizing the increasing use of nuclear energy for electricity and radioactive materials in the country and potential of Nuclear or Radiological emergency , PNRA has pursued a project for up-gradation of National Radiological Emergency Coordination Centre (NRECC) which has been approved by the Government of Pakistan under Public Sector Development Program (PSDP).

The human resource development in PNRA continues to expand in terms of increase in manpower and continuous enhancement of technical competence achieved through various basic, intermediate and advanced level training courses conducted at the National Institute of Safety and Security (NISAS) at PNRA and training institutes within the country along with regular participation in international events e.g. workshops, training courses, fellowships etc. organized under the auspices of the IAEA.

PAEC is continually enhancing the capacity and quality of its key training institutes, such as Pakistan Institute of Engineering and Applied Sciences (PIEAS), Karachi Institute of Nuclear Power Engineering (KINPOE), and CHASNUPP Center for Nuclear Training (CHASCENT). For details, please refer to Annexure-XII.

Part II

2 Progress after the Sixth Review Meeting and Special Reporting

2.1 Progress after the Sixth Review Meeting

Progress made after the Sixth Review Meeting in significant areas is presented below:

2.1.1 Regulatory Framework

Currently, following regulations are in the process of revision:

i. Regulations on Licensing Fee by Pakistan Nuclear Regulatory Authority - (PAK/900) (Rev.1);

ii. Regulations on Radiation Protection-(PAK/904) (Rev.1);

iii. Regulations for Licensing of Nuclear Safety Class Equipment and Components Manufacturers - (PAK/907) (Rev.0);

iv. Regulations for the Licensing of Radiation Facility(ies) other than Nuclear Installation(s) - (PAK/908);

v. Regulations on the Safety of Nuclear Power Plant Design - (PAK/911) (Rev.1);

vi. Regulations on the Safety of Nuclear Power Plants Operation - (PAK/913) (Rev.1);

vii. Regulations on Management of a Nuclear or Radiological Emergency (PAK/914);

viii. Regulations on Radioactive Waste Management - (PAK/915); and

ix. Regulations for the Safe Transport of Radioactive Material - (PAK/916).

Moreover, the Authority approved the amendments in the following regulations which have been duly gazette notified during the reporting period :

a. Regulations on the Safety of Nuclear Power Plants-Quality Assurance - (PAK/912);

b. Regulations on the Safety of Nuclear Power Plants Operation - (PAK/913);

c. Regulations on the Safety of Nuclear Research Reactor(s) Operation - (PAK/923).

During the reporting period, work on development of following new regulations initiated, which are now under various stages of development:

[i] Regulations on Authorization of Organization for Non Destructive Examination (NDE) of Safety Class Equipment for Nuclear Installation(s) - (PAK/ 906);

[ii] Regulations on Safety of Spent Nuclear Fuel Management - (PAK/918);

[iii] Regulations on Physical Protection of Nuclear Material(s) and Nuclear Installation(s) - (PAK/925);

[iv] Regulations on Security of Sealed Radioactive Sources (SRS) - (PAK/926); and

[v] Regulations on Decommissioning of Facilities using Radioactive Material - (PAK/930).

Following regulatory guides are being developed:

[a] Radiation Safety in Industrial Radiography (RG 904.03);

[b] Protection of Patients in Diagnostic Radiology (RG 904.05);

[c] Radiation Protection and Safety in Radiotherapy (RG 904.06);

[d] Format and Contents of Radiation Protection Program (RG 904.07);

[e] Guidelines for Medical Professionals on Transport, Diagnosis & Management of Overexposed & Contaminated Individuals in Radiological Emergency (RG 904.08);

[f] Format and Contents of Radiation Emergency Plans of Radiation Facilities and Activities (RG 914.02);

[g] Format and Content of Safety Analysis Reports (SARs) of NPPs (PNRA-RG-909.01);

[h] Format and Contents of Physical Protection Program of Nuclear Installations (PNRA-RG-909.02).

2.1.2 Organization of PNRA and PAEC

The organization structure of PNRA has been modified as a result of completion of some projects and their absorption within PNRA as well as establishment of an Evaluation and feedback setup under a Director General. The PSDP Projects “National Environmental Radioactivity Surveillance Program” (NERSP), “National Dosimetry and Protection Level Calibration Laboratory” (NDCL) and "Nuclear Security Action Plan" (NSAP) were concluded during the reporting period and merged into PNRA as regular Directorates. NERSP was renamed as National Environmental Monitoring Program (NEMP) while NSAP was renamed as Physical Protection and Security Directorate (PPSD).

The two training set-ups of PNRA i.e., the School for Nuclear and Radiation Safety (SNRS) and the Nuclear Security Training Centre (NSTC) of the Nuclear Security Action Plan (NSAP) were merged to form the "National Institute of Safety and Security (NISAS)" in 2014. The new PNRA organizational chart is given in Annexure IV.

Organizational structure of PAEC (Annexure-V) has changed with strengthening of Corporate office under Member (Power) to effectively manage nuclear installations with comprehensive Corporate oversight.

2.1.3 KANUPP Operation after Re-Licensing

During 2014, the plant underwent long outage for about six months from February to August, 2014 to carry out necessary maintenance, assessments, evaluation, testing and refurbishment jobs. PNRA granted permission to KANUPP for making the reactor critical after satisfactory completion of jobs and actions related to inspection findings.

The Second Periodic Safety Review (PSR) of KANUPP, initiated in 2013, was completed in 2015. Review strategy for the PSR was based on IAEA Safety Guide "Periodic Safety Review of Nuclear Power Plants" (NS-G-2.10). In this regard, KANUPP submitted Global Assessment Report and Corrective Actions Plan after the submission of PSR safety factor reports. A total of two hundred and seventy (270) queries were raised by PNRA on one hundred (100) reports submitted by KANUPP covering thirteen (13) safety factors of PSR. Four (04) review meetings were conducted to discuss and settle the queries raised by PNRA review team during review process. Based on the review of PSR safety factor reports and Global Assessment Report, PSR has been accepted by PNRA.

Radioactive Waste Storage Facility (RAWSA) at KANUPP is designated for collection of radioactive waste from operating radiation and nuclear facilities in the southern part of Pakistan. KANUPP extended its site to increase the available storage capacity for its solid

radioactive waste. Accordingly, as required by PNRA, KANUPP submitted the Safety Assessment of RAWSA which has been approved upon satisfactory completion of the regulatory review process.

Various WANO peer review missions were conducted at KANUPP during the reporting period (For details, please see Section 2.1.8).

2.1.4 C-1 Operation

Chashma Nuclear Power Plant Unit-1 (C-1) has been operating safely. C-1 underwent the 9th refueling outage for about five (05) weeks in April-May, 2014. PNRA witnessed selected activities and conducted various regulatory inspections during refueling outage. PNRA allowed criticality and subsequent power operation of C-1 upon satisfactory completion of RFO activities. During the year 2015, the plant remained in shutdown state from September 11, 2015 for 10th refueling outage till December, 2015. During ISI activities on the secondary side, cracks were found on the blade roots of turbine and the duration of shutdown was extended for one and half month in order to resolve the issue. In this regard, PNRA also carried out independent investigation to gather firsthand information related to the turbine issue. Objective evidences were collected to facilitate decision making on the licensee's application for acquiring permission to make the reactor critical. In response to appropriate steps taken by the licensee, PNRA allowed C-1 to make the reactor critical in December, 2015.

One event related to Exposure to Worker in Excess of Administrative Limit at C-1 was reported to INES in 2014-15. The event was rated at Level 1.

A WANO follow-up peer review mission was conducted at C-1 during 2015 while an OSART Mission was also received. (For details, please see Section 2.1.8).

2.1.5 C-2 Operation

C-2 underwent its second refueling outage in June, 2014 and remained shut down for four (04) weeks. PNRA witnessed selected activities and conducted various regulatory inspections during the refueling outage. During this outage, problems with the main feed water pump controllers were resolved. These malfunctioning controllers were the major initiating factor for tripping the plant thrice in the second cycle. C-2 was shut down for its third refueling outage in August 2015. Over-hauling of motor of one Reactor Coolant Pump, Eddy current testing of steam generators, replacement of source and intermediate range instrumentations assembly and replacement of 3 stage mechanical seals of both Reactor Coolant Pumps (RCP) were performed. Fourth Operating Cycle has started from September 2015.

A WANO peer review mission was conducted at C-2 during 2015. (For details, please see Section 2.1.8).

2.1.6 C-3 & C-4 Construction and Commissioning

The construction of C-3 & C-4 has almost been completed and commissioning of plant equipment and systems is in progress. Review and assessment of commissioning program, Pre-Service and In-Service Inspection program and Physical Security Plan (PSP) of C-3/C-4 were completed by PNRA during 2014. Based on the completion of review and assessment of commissioning program, authorization for commissioning was granted in 2015. PNRA is conducting regulatory inspections at C-3 and C-4 according to its inspections program and plans.

The review of application for introducing nuclear fuel into the reactor was conducted in 2014-2015 by a team of PNRA experts. The queries raised during the review were discussed with the licensee (supported by its vendors/designer) in review meetings for resolution. PNRA issued Fuel Load Permit to C-3 in May 2016. A similar decision on issuance of Fuel Load Permit for C-4 is expected in the last quarter of 2016 subject to fulfillment of regulatory requirements.

2.1.7 K-2 and K-3 Construction

PAEC submitted an updated Environmental Impact Assessment report to Sindh Environmental Protection Agency (SEPA) for issuance of environmental licence which is one of the pre-requisites for licensing by PNRA. SEPA organized review of the report by a team of renowned experts and organized a public hearing as required by the law. Upon completion of its licensing process, SEPA issued environmental licence to K-2 and K-3.

Subsequently, K-2 and K-3 submitted the application for issuance of construction licence to PNRA in December, 2014.

During 2015, the safety review of K-2 and K-3 submissions for issuance of construction licenses was conducted. Review meetings to discuss PNRA queries on the submitted reports were conducted with the applicant, supported by its designer and the main contractor, in March and May, 2015 in China. Accordingly, construction licenses have been issued to K-2 and K-3. The construction of K-2/K-3 is in progress and PNRA is conducting inspections of the construction activities to verify compliance with the construction licence.

Regulatory inspection to verify implementation of the quality assurance program of subcontractor of K-2 and K-3 construction activities has also been conducted by PNRA. The manufacturing of Nuclear Safety Class Equipment for K-2 and K-3 e.g. Reactor Pressure Vessel, Steam Generators, Pressurizer, etc. is also in progress.

2.1.8 Continuous Improvement

Pakistan has continued its policy of openness, and sharing its experience with others. The activities at the nuclear power plants are reported to, and kept open for reviews at national and international level by PAEC. Significant events are reported by PAEC to WANO and by PNRA to IAEA through International Nuclear Event Scale **(**INES) and International Reporting System for Operating Experience (IRS). One event related to exposure to worker in excess of plant administrative limit at C-1 was reported to INES in 2014-15. The event was rated at Level 1.

An IAEA IRRS mission was conducted at PNRA in April-May, 2014 and the report has been made public. The mission reviewed the effectiveness of the Pakistan Nuclear Regulatory Authority (PNRA) in regulating the safety of the use of nuclear and radioactive material including nuclear power plants, research reactors, waste management facilities, radiation source applications and facilities, decommissioning activities and transport of radioactive material.

The IRRS team identified a number of good practices, as well as recommendations and suggestions where improvements are necessary or desirable to continue enhancement of the effectiveness of PNRA's regulatory processes in line with the IAEA Safety Standards. Good practices identified included:

a. The Government's willingness to provide and PNRA's use of extra-budgetary financial resources;

b. PNRA's well-developed training program to maintain PNRA staff technical and regulatory competence during rapid expansion of PNRA;
c. The development and implementation of a national public awareness program for nuclear and radiation safety;
d. PNRA's self-assessment of safety culture; and
e. Extensive and in-depth long-term operations focused training for some inspectors.

Some areas identified by the IRRS team that may need further improvement or warrant additional attention in order to enhance the overall regulatory effectiveness were as follows:

i. Incorporation of IAEA Fundamental Safety Principles in the national framework for safety.
ii. Stipulation of the legal responsibilities and obligations with respect to the financial provisions for the management of radioactive waste, spent fuel and decommissioning.
iii. Development of work procedures for appeal against regulatory decisions.
iv. Modernization of the existing National Radiation Emergency Coordination Centre (NRECC).
v. Grading of Inspections and enforcement actions according to their safety significance.

An action plan was developed to address the areas identified by IRRS for further improvement and the progress made on the action item is being continuously monitored.

PAEC invites International Review Missions to its nuclear power plants. Accordingly, an OSART mission was conducted at C-1 while, WANO Peer Review Missions have been conducted at KANUPP, C-1 and C-2 during the reporting period. A WANO Peer Review of PAEC Corporate office was conducted in May, 2015 with follow-up in Nov, 2015.

At KANUPP, a WANO Review Mission was invited in 2014 to review implementation status of recommendations of WANO Significant Operating Experience Reports (SOERs). Improvements in the following areas were reported by the mission;

[i] Procedure use and adherence to procedure

[ii] Installation of biometric access control system in main control room

[iii] Fire prevention and control measures

[iv] Use of error reduction tools by plant workers

[v] Solid progress on implementation of post Fukushima action plan

A full scope WANO Peer Review Mission is expected at KANUPP in last quarter of 2016. IAEA safe guard inspectors are routinely invited in every quarter of the calendar year. Four WANO technical support missions (TSM) were conducted at KANUPP during the reporting period (Please see Section 14.5 or Annexure XII). These TSMs were very useful in improving plant safety in the following key areas;

[a] Station performance indicators for emergency diesel generators and emergency injection system have been improved.

[b] Radiological emergency awareness program for nearby general public has been strengthened.

[c] Station onsite and offsite radiological emergency plans have been revised.

[d] Maintenance program for single point vulnerability equipment has been developed

[e] Life cycle monitoring program for main output transformers has been developed and transformer oil has been treated/ replaced.

[f] KANUPP initial decommissioning plan has been updated.

[g] Training and qualification program of operating personnel and technical support group has been strengthened.

One WANO follow-up peer review (May, 2015) and one OSART mission (Nov - Dec, 2015) were conducted at C-1 during the reporting period. Following are the improvements made at C-1 after implementation of findings of WANO peer review (2012) and WANO Follow up peer review (May, 2015)

[1] Maintenance Personnel Training and Re-training program has been developed and implementation is in progress.

[2] Procedure for Operational Decision Making process has been developed and implemented.

[3] Internal Operating Experience Program and its relevant procedures were updated based on Corporate Review and WANO Peer Review.

[4] Self-Assessment Program is established and implemented

For establishment of Integrated Improvement Plan, the software (database) of integrated improvement plan has been developed. Implementation is in progress.

A WANO peer review mission was conducted at C-2 in April-May, 2015. The following measures are being taken as outcome of WANO peer review:

a) Development and Implementation of Safety Culture Assessment Program.

b) Development of Key Performance Indicators.

c) Strengthening Root Cause Analysis (RCA) Program.

d) Strengthening monitoring of chemistry parameters and implementation of advanced monitoring techniques.

e) Enhancement in existing capabilities of emergency response facilities.

f) Strengthening implementation of Radiation Protection Program.

C-3 has hosted a WANO Pre Start-Up Peer Review (PSUR) in January, 2016. A PSUR for C-4 is planned for January, 2017. WANO Technical Support Mission on "Management of Installation Verification Activities" was conducted on request of C-3 and C-4 in February, 2015.

KANUPP, C-1 and C-2 issue a brief daily production report, monthly technical reports covering all aspects of their operation and maintenance, annual reports analyzing their safety performance, quarterly performance indicator reports to WANO, reports about events and their analysis (besides those reportable under PNRA regulations), reports about their significant outages, technical reports on specific topics. KANUPP has shared several events with WANO during the reporting period's part of operating experience feedback with the nuclear industry. KANUPP also sends monthly reports to COG. PAEC issues an annual report which includes the significant aspects and achievements of nuclear power plants.

PNRA has also established open communication, cooperation and linkages with national and international organizations for improvement in regulatory performance and information sharing. PNRA keeps the general public informed about its on-going activities through its website and annual report. Draft regulations are also placed on the PNRA website for comments.

2.2 Update of Activities Undertaken to Improve Nuclear Safety in Response to Fukushima Daiichi Accident.

Post Fukushima assessments of each nuclear installation were conducted under the Fukushima Response Action Plan (FRAP) and the issues identified during the assessment were addressed in the form of various activities to be undertaken as short, intermediate and long term activities. These were also presented in the Second Extraordinary meeting of the Convention on Nuclear Safety held in August 2012 and their progress was reported upon in the Sixth National Report. The following table describes updated status of activities performed under FRAP during the current reporting period.

Topic 1 : External Events			
KANUPP			
Earthquake Hazard			
Task	**Target**	**Activity Status**	**Results**
Re-evaluation of seismic capacity of all structures for the revised seismic input of 0.2 g	30-06-17	In Progress	All structures at KANUPP are qualified to withstand 0.2g SSE except that of EFW room. Necessary upgrades in the frame structure of EFW Room for its seismic qualification have been analyzed and implementation work will be completed by contractor.
Re-assessment of earthquake hazard (with field work) based on the new IAEA methodology	30-10-15	Completed	Earthquake hazard for KANUPP site has been re-assessed based on new IAEA methodology. The Safe Shutdown Earthquake (SSE) for KANUPP site is re-assessed as 0.2g.
Tsunami / Flooding Hazard			
Task	**Target**	**Activity Status**	**Results**
Fresh Estimate of Tsunami hazard for KANUPP	31-03-14	Completed	The probability of occurrence of Tsunami waves at KANUPP site has been ruled out by analysis. Moreover, the safety grade level (SGL) of KANUPP against tsunami / natural hazards is 9.107 m (9.11m). The

			KANUPP ground elevation is 11.89m (~12 m) from MSL. So the plant is safe from the severe natural hazards in terms of water inundation due to its higher elevation from the calculated safety grade level. Considering the effect of submarine land-slide, the calculated Tsunami height is 3.24m at KANUPP site , which shows adequate safety margin . Hence, KANUPP site is also safe against submarine landslide generated tsunami.
Construction of 8 ft flood retaining wall around FIJW and EFW room	30-09-15	Completed	An 8 ft high, RCC wall has been constructed around the area enclosing the emergency boiler feed water system equipment and medium pressure injection system equipment. Moreover, the flood-retaining-wall enclosure also houses a 300 KW diesel generator placed on a seismically qualified platform. This DG can provide power to plant essential buses in case of prolonged SBO.
Storms/ Cyclones Hazard			
Task	**Target**	**Activity Status**	**Results**
Fresh study of hazard due to cyclones & rain	30-06-14	Completed	The wind speed against 100 and 1000 years return period has been estimated as 45 m/s and 62 m/s respectively. The safety related structures (Reactor building, Turbine building, and exhaust stack) are designed against wind speed of 45 m/s. Ability to withstand wind speed of 62 m/s has also been analyzed and it is concluded that these buildings / structures are safe against wind loading of 45 m/s (100 year return period) and also against 62 m/s (1000 year return period).
Fire Hazard			
Task	**Target**	**Activity Status**	**Results**
Explore redundancy in fire tenders	31-05-14	Completed	The existing fire tender available at KANUPP site has been refurbished and a new fire tender has also been procured and made

			available on-site. Both the fire tenders are placed at different locations to meet the single failure criterion.
Strengthening of Fire Water (FW) system of KANUPP.	30-06-15	Completed	To strengthen fire fighting capability following measures have been implemented at KANUPP: • Provision has been made to pressurize Fire Water ring through newly installed Emergency Water Injection (EWI) system. • Provision has been made to pressurize Fire Water ring via Fire tender. • Existing fire tender was refurbished and an additional fire tender has been procured. • Portable equipment has been procured to fill fire tender with sea water.
Ageing assessment of fire water (FW) system fiber glass piping.	30-06-15	Completed	Based on the analysis of actual specimen taken from buried FW line, it has been concluded that no surface damage and strength deterioration in three decades fiber glass material of FW line is observed. It is highly unlikely that it will get damaged in next several years under similar conditions. Therefore, it can be concluded that used pipe is as durable as the new one.
C-1/C-2			
Earthquake Hazard			
Task	**Target**	**Activity Status**	**Results**
Study combined effect of earthquake and dam break/ flooding to determine how much it differs from DB	28-02-17	In Progress	Study to analyze the combined effect of earthquake and flooding is in progress.

Determine, improve the worst earthquake / flooding that the plants can sustain with minor back fits (identify the most vulnerable equipment)	30-06-17	In Progress	Based on walk-downs of Nuclear (NX) & Electrical Island (EX) buildings, entry points of cable trenches, piping galleries and drain lines were found potential sources of external flooding. Therefore, process for the installation of non-return valves and flood protection gates has been initiated.
Identify potential failure of seismically non qualified equipment/ systems making safety, safety related & safety support SSCs vulnerable to flooding	31-10-12	Completed.	Interaction of non-seismic (NS) chilled water system and NS service air system on nearby seismically qualified systems was checked. No adverse interaction identified. None of the Non Seismic SSCs was identified whose failure during an earthquake will result in a concurrent external flooding to damage a safety system. During the walk-down, some room cranes were found not parked at safe distance from the equipment. Some fire related portable equipment found unsecured. These deficiencies have been rectified.
Acquire PSHA capability and estimate the probability of earthquake exceeding DBE and consequent flooding exceeding DBE	31-12-14	Completed.	The task, “Probabilistic Seismic Hazard Analysis, PSHA” has been completed and the report has been submitted to PNRA. In order to establish confidence, an IAEA mission was conducted in April, 2016.
Fire Hazard			
Task	**Target**	**Activity Status**	**Results**
Revisit design basis of Fire Protection System	30-06-17	In Progress	Only fire detection basis will be reassessed based on case to case basis i.e. during investigation of fire related items. The fire incident investigation procedure now includes a check of related fire detector design.
Improve Resilience of Fire Brigade Station to external Hazards	30-06-17	In Progress	Arrangements are being made to establish soft sheds to secure emergency vehicles.

Augment equipment and training for Rescue and Recovery Operations	31-12-19	In Progress	An MOU with District Rescue Service has been signed for imparting training related to rescue and recovery operations for CNPGS personnel. CNPGS has a plan to strengthen its equipment base needed for typical rescue and recovery operations.
Perform Fire PSA for C-1 and C-2	31-12-15	Completed	Fire PSA has been completed.
Topic 2 : Design Issues			
KANUPP			
Electrical Power			
Task	**Target**	**Activity Status**	**Results**
Shifting of emergency lighting from 230 VDC to 220 V AC (UPS)	30-06-17	In Progress	Fluorescent Lamps have been procured. 04 Distribution Room Panels have been installed, while 02 MCR panels are being installed. Necessary cabling and commissioning is in progress. Major portion of the job has been completed. i.e., 8 out of 9 loops have been replaced. Replacement of one loop will be done in the next long shutdown planned in 2017.
Increase diesel fuel storage capacity onsite	31-05-14	Completed	The storage capacity (as per design) of on-site 9,500 IG diesel fuel is sufficient for 6 days. However, another new seismically qualified diesel fuel storage tank of 5000 IG has been constructed on site, and administrative control is in place to ensure 5000 IG diesel fuel inventory. Hence, with the combined minimum capacity of approximately 14500 IG diesel fuel, DE-DGs can now operate up to 9 days, without any further make-up.

Emergency Core Cooling			
Task	**Target**	**Activity Status**	**Results**
Provision of additional points for fresh water injection and use of fire fighting system (as a last resort) for emergency core cooling	31-12-14	Completed	Emergency Water Injection (EWI) system has been commissioned. This system can inject fresh water (as well as sea-water) into boilers, medium pressure ECC system, Reactor vault, Containment Dowsing and Spent Fuel Bay.
Containment Integrity			
Task	**Target**	**Activity Status**	**Results**
Installation of PARs	30-06-14	Completed	Twelve (12) Passive Autocatalytic Recombiners (PARs) have been installed inside boiler room, to address the issue of explosion due to Hydrogen accumulation inside containment.
Provision of Hydrogen monitoring equipment under PAMs.	31-12-17	In Progress	Efforts are underway for procurement of Hydrogen Monitoring equipment.
Feasibility of installing system for relieving containment pressure automatically / manually	30-12-17	In Progress	Feasibility study for installation of Filtered Containment Venting System (FCVS) is completed. After installation of FRAP modifications related to heat sink / power, installation of PARs and availability of large containment volume, it is highly unlikely that containment pressure would rise beyond its design value.
Preparation of Procedure to decide when to vent the containment.	30-04-15	Completed	In the revised SAMG, guideline has been included for operator to vent the containment when its integrity is challenged.

Spent Fuel Cooling			
Task	**Target**	**Activity Status**	**Results**
Provision of measures against loss of cooling or drainage of SFP	31-12-14	Completed	In case of loss of recirculation ample time (19 days) is available to restore cooling before boiling starts in the bay. However, to further enhance the safety of spent fuel bay, a spray header has been installed over the bay as part of Emergency Water Injection (EWI) system, for water addition in the bay through diesel-engine driven pumps, fire water ring and fire tender.
C-1/C-2			
Electrical Power			
Task	**Target**	**Activity Status**	**Results**
Feasibility for increase in DC Power capacity	31-12-15	Completed	A dedicated Diesel Generator for use as DC batteries charger with hook-up arrangements has been installed.
Preparation of Procedure for conserving DC Power to prolong availability	30-06-16	In progress	A Procedure, “DC Load Shedding” is under preparation which will be made part of SEOP, “Loss of all AC”

Containment Integrity			
Task	**Target**	**Activity Status**	**Results**
Installation of PARs at C-1 (as of C-2)	30-04-17	In Progress	Design has been completed. Letter of Intent to respective stakeholders for construction and installation has been issued.
Ultimate Heat Sink			
Task	**Target**	**Activity Status**	**Results**
Improvement in design of Essential service water pumping station entrance to prevent inundation in case of extreme flooding	31-12-16	In Progress	In order to increase the margins for all entrances of safety related structures by a further 1m, order for manufacturing of doors has been placed.
Spent Fuel Cooling			
Task	**Target**	**Activity Status**	**Results**
Study of measures against SFP loss of cooling or drainage	31-12-16	In Progress	• Internal spray has been selected as internal strategy which is at the final designing stage. • For the sake of makeup, direct injection (which has been demonstrated using fire tenders) and using installed piping have been adopted.

Topic 3 : Severe Accident Management			
KANUPP			
Task	**Target**	**Activity Status**	**Results**
Availability of all necessary equipment / gears for implementing EOPs, SAMGs	30-11-17	In Progress	Data is available from C-1 & C-2 and other PAEC establishments regarding radiological equipment. Requirement for necessary emergency assistance through national emergency response organizations for portable diesel generators, diesel fuel, power cable / connectors, diesel driven fire pump, fire hose, browsers, petrol boats, personnel transportation, etc. is being handled by corporate office The equipment / gears required for implementing EOPs and SAMGs have been made available on site. Installation of Accident Monitoring Instrumentation (AMI) is in progress.
Develop / improve EOPs for external Postulated Initiating Events (PIEs). Define transition point to SAMGs	30-04-15	Completed	EOP for Spent Fuel Cooling has been issued. Revised EOP for earthquake has also been issued. For extreme weather condition, guidelines in the form of Technical Manual (TechMan) have been issued. In case of any damage due to severe weather which may be a threat to core, EOPs will be activated to prevent core damage. However, if EOPs fail to prevent core damage, transition points to SAMGs already covered in relevant EOPs. The transition from EOP to SAMGs for KANUPP is defined in the KANUPP SAMGs which is consistent with CANDU SAMGs.
Revision of SAMGs based on supporting analyses	30-04-15	Completed	SAMGs have been revised in the light of lessons learned from Fukushima Daiichi Accident. Validation procedures as per SAMGs has also been completed.

C-1/C-2			
Task	**Target**	**Activity Status**	**Results**
Preparation of C-1 SAMGs	31-12-16	In Progress	SAMGs are under development.
Enhancement of capability of Technical Support Personnel for severe accidents		Continual Action	• Procedure regarding roles and responsibilities of Technical Support Personnel during severe accidents issued. • A joint seminar with PNRA and IAEA was arranged in Dec. 2012 to enhance capacity building of Technical Support Personnel. • Periodic Exercises/drills to test the capability of Technical Support Personnel and consequential follow up actions.
Development of a reserve force of workers to cope with severe accident consequences at C-1/C-2	31-12-16	In Progress	Assessment of On-Shift Emergency Response Organization Staffing and Capabilities is under way in the light of NEI 10-05. Actual requirement will be identified after validation and training on SAMGs.
Preparation of proposal for common alternate ECC/ resource center for Chashma site	30-06-17	In Progress	A conceptual design and location has been identified. Detailed technical proposal is under preparation.
Availability of necessary equipment / gears for implementing SAMGs	31-12-17	In Progress	In the process of development of SAMGs, FLEX equipment are being identified to restore key safety functions, Core Cooling, RCS Inventory control/makeup, Containment and Spent Fuel Pool. These include portable DGs, pumps, hoses, compressors and other commodities etc.

Topic 4: National Organizations			
PNRA			
Task	**Target**	**Activity Status**	**Results**
Revision of PNRA regulations in the light of feedback from Fukushima Daiichi Accident	31-12-17	In progress	Documentation Preparation Profile has been prepared and initial review is in progress at relevant work units of PNRA
PAEC			
Task	**Target**	**Activity Status**	**Results**
Review of progress of all NPPs on FRAP		Continual Action	Since NPPs are following FRAP as per commitment, therefore, review frequency from Corporate office has been changed from six-monthly to annual basis.
Follow-up of the implementation of FRAP		Continual Action	Seventh progress review of K1 and C-1 & C-2 were conducted in April 2016 and May 2016 by the Corporate office team and progress found satisfactory in most of the areas.
Topic 5: Emergency Preparedness and Response and Post-Accident Management (Offsite)			
KANUPP			
Task	**Target**	**Activity Status**	**Results**
Exploration of alternate communication links at plant and AECC	30-05-14	Completed	Satellite Phone Sets for plants and AECC have been made available.

Provision of Post Accident Monitoring Equipment	30-03-17	In Progress	Accident Monitoring Instrumentation (AMI) Loops have been commissioned and will be installed in the next long shutdown planned in 2017. Procurement of 24V DC Power supply breakers is still pending due to poor response from vendors on account of embargo.
Enhancement of Emergency Preparedness Infrastructure	28-02-15	Completed	Radiation Monitoring Equipment has been provided to KANUPP under Radiological Assistance Group (RAG). An Emergency Control Center (ECC) is available on site and Alternate Emergency Control Center (AECC) is away from site. Necessary plant documents / procedures are available at AECC. Satellite phone has also been made available beside the already available land-line and mobile communication facilities. Diesel Generator is also available at AECC.
C-1/C-2			
Task	**Target**	**Activity Status**	**Results**
Exploration of alternate communication links at MCR and ECC at C-1 /C-2	30-06-12	Completed	Alternate communication equipment is provided at C-1 and C-2 MCRs and also at ECC.
Reassessment of EPZ	30-06-17	In Progress	Re-assessment of EPZ considering impact of simultaneous accident at both units (C-1/C-2) is in progress.
Assessment & development of possible additional access routes to the site	31-12-17	In Progress	Initial studies have been completed. It has been decided that an additional 2-lane bridge will be built on CJ Link canal. Design is under review by the concerned quarter (WAPDA).
Development of Public Awareness Program	30-06-17	In Progress	Draft Program is in review process.
Topic 6 : International Cooperation			
Task	**Target**	**Activity Status**	**Current status /Results**
IRRS Mission at PNRA	April, 2014	Completed	IRRS mission conducted in April-May 2014.

WANO Mission to review implementation status of recommendations of WANO Significant Operating Experience Reports (SOERs) at KANUPP	May, 2014	Completed	WANO Mission reviewed the implementation status of 266 recommendations of WANO SOERS. 254 recommendations were implemented up till December 2015.
WANO Mission on Peer Review Standard Training.	October, 2014	Completed	This mission on Peer Review Standard Training was conducted by WANO Tokyo Centre. Expertise of training participants is utilized in Internal Peer Reviews of NPPs conducted by PAEC.
WANO Mission on Improvement in WANO Performance Indicators SP1, SP2 and SP5.	January, 2015	Completed	Recommendations have been implemented to improve the SPIs.
WANO Mission on Benchmarking visit on KANUPP Spent Fuel Dry Storage.	October , 2015	Completed	Dry fuel storage facility is under construction. Testing and qualification of concrete cask is in progress.
WANO Peer Review of KANUPP.	2016	Planned	Planned for 2016 but date is not yet finalized by WANO
WANO Mission on Improvement in Human Factor in wake of Fukushima Disaster.	February , 2016	Completed	Radiological emergency awareness program for nearby general public has been strengthened. Station onsite and offsite radiological emergency plans have been revised.
WANO Mission on Contamination Control and Dose Reduction at KANUPP	October , 2016	Planned	
WANO Peer Review at C-2	April - May, 2015	Completed	Please see Section 2.1.8
WANO Technical Support Mission on Installation Verification Activities at C-3/C-4	February , 2015	Completed	
WANO Follow-up Peer Review Mission at C-1	May, 2015	Completed	Please see Section 2.1.8
OSART Mission at C-1	Nov-Dec, 2015	Completed	Please see Section 14.2.2
WANO Pre Startup Mission for C-3	January, 2016	Completed	

WANO Pre Startup Mission for C-4	January, 2017	Planned	
WANO Follow-up of Pre Startup Mission for C-3	July, 2016	Planned	Revised Schedule from WANO is awaited
WANO Technical Support Mission on Challenging Scenarios for Simulator Exercises	July, 2016	Planned	Revised Schedule from WANO is awaited

2.3 Progress on Challenges Identified during the Sixth Review Meeting 2014.

Following Challenges were identified for Pakistan during the sixth review meeting

i. Development of Public Awareness Program
ii. Risk Informed Regulatory Approach
iii. Installation of NPP Parameters Display System

Development of Public Awareness Program

Since the last review meeting, PNRA and PAEC have taken initiatives towards the public awareness program in Pakistan. Compared with the previous strategy of PAEC to focus towards the population residing around nuclear installations as part of effectively implementing offsite emergency planning and preparedness plans, PAEC initiated activities in the national electronic media in the context of public awareness program. Several national seminars/talk shows were organized involving intellectuals, professionals, media, public and representatives of local government functionaries of various departments to initiate debate on the nuclear power program, its viability, associated risks and consequences in case of accidents and corresponding preventive, protective and preparedness measures. Further, PAEC with the involvement of all stakeholders conducted public hearing, taking into account the public perception in the installation of nuclear power projects in line with the energy security plan of the country. Work on the new projects was initiated after the broader public acceptability of nuclear power program, as a result of public hearing for the new projects. PAEC also continued its practice for apprising public around nuclear installations as part of implementation of offsite measures in accordance with the approved emergency plans and preparedness programs.

PNRA also continued its efforts regarding consideration of public perception in the regulatory decision making process as an effort of public involvement in the regulatory decision making process. In this regard, various efforts are underway and various activities are being accomplished. These mainly include public education towards safety aspects of nuclear installations and associated radiation risks and the role of a national regulatory body. Lectures, seminars and workshops are being organized at the PNRA premises and educational institutions to educate general public and the radiation workers about the radiation hazards, functional domains of nuclear regulatory body and the process of giving input in the regulatory functions. Furthermore, during the regulation development process, the draft regulations are also placed on the PNRA website for seeking comments from the public before finalization. Although limited input is being received from the public in terms of comments on the draft regulations, however, further efforts are in the thought process to stimulate effective response from the public. The other aspects include consideration of relevant issues raised by the public in the safety assessment of nuclear installations both during the initial licensing and for the operational safety assessment of existing nuclear installations.

Risk Informed Regulatory Approach

Regarding development of risk informed regulatory approach for the regulatory decision making process, progress has been made during the reporting period. PNRA has completed development of PSA Regulator's Model under IAEA Technical Cooperation Program for Chashma NPP Unit-1 (C-1). Taking the benefit of similar designs of C-1, C-2, C-3 and C-4,

applicability of this PSA model is being considered for all the four units. Currently, this model is being used in the safety assessment of some important regulatory activities such as approval of design modifications. Taking into account the success of PSA model, development of level-2 PSA was initiated. However, it is also being considered that some activities of Level-3 PSA which are not entirely dependent on the results of PSA Level-2 studies may also be initiated simultaneously so that the risk insight in reassessment of emergency plans may be conducted.

Installation of NPP Parameters Display System

PNRA has initiated activities for the installation of NPP safety parameter display system at its Headquarters in Islamabad to further enhance its regulatory information system necessary for performing regulatory activities during normal operation and in case of emergencies and incidents/ accidents as part of modernization of the NRECC. In this regard, the government has approved a project within the domain of public sector development and allocated necessary resources for further enhancement of the existing regulatory infrastructure in areas of emergency planning and preparedness. Installation of real time safety display parameters, meteorological information, advance dose projection models essential for assessment of emergency conditions, enhancing the capabilities of manpower, etc., are the major milestones of the project.

2.4 Pakistan's Implementation of the Vienna Declaration on Nuclear Safety

The fundamental safety objective in all nuclear applications is to protect people and the environment from harmful effects of ionizing radiation.

In order to achieve this objective, IAEA has established ten fundamental safety principles which have further been extended in the form of IAEA safety standards. As a policy decision, the regulatory framework of Pakistan is mainly based on IAEA safety standards covering nuclear, radiation, emergency preparedness, waste and transport safety areas. In addition, Pakistan is intensively involved in international level initiatives for the enhancement of nuclear safety worldwide and has shown commitment to make all efforts to implement the decisions, recommendations and suggestions of such initiatives.

Pakistan, along with other Contracting Parties, agreed to uphold and implement the Vienna Declaration during the CNS Diplomatic Conference in February 2015.

The implementation of the Vienna Declaration would result in not only the design improvements, but also improvement of mitigatory actions and emergency management.

The direct implications of the Vienna Declaration include a commitment to continuous improvement of safety through strengthening of all five Defence-in-Depth (DiD) levels, along with minimization of both early releases (evacuation) and extended releases (land contamination). This can be achieved through addition of barriers and improvement of severe accident management strategies considering both severe accident mitigation systems and administrative measures.

These commitments affect Articles 6, 7, 14, 17, 18 and 19 of the Convention on Nuclear Safety. Activities related to the implementation of the Vienna Declaration according to each of these Articles is given below:

Article 6:

Pakistan has three operating Nuclear Power Plants i.e. Karachi Nuclear Power Plant (KANUPP), Chashma Nuclear Power Plants Unit-1 and Unit-2 (C-1 & C-2)

Four new Nuclear Power Plants are being built in Pakistan after the Fukushima Daiichi Accident. These include Chashma Nuclear Power Plants Unit-3 and Unit-4 (C-3 & C-4) and the Karachi Nuclear Power Plants Unit-2 and Unit 3 (K-2 & K-3).

The objective of practical elimination of early and large releases is to be demonstrated by a combination of:

a) Use of Defence in Depth philosophy for Safety
b) High Reliability of Plant Safety Systems
c) Comprehensive On-site Accident Management
d) Use of Passive Systems for Severe Accident Management and Mitigation
e) Use of Special Systems for Severe Accident Management

Article 7:

The most important lesson learnt from the Fukushima Daiichi Accident is that the CPs need to prevent and mitigate accident situations and scenarios beyond those considered during the initial design of nuclear installations.

In keeping with the overriding concept of priority in safety, PNRA has proposed in the revision of PAK/911 that design objective of NPPs be modified to include practical elimination of event sequences which may result in significant radiation release. This necessitates that off-site intervention measures to mitigate radiological consequences be limited or even eliminated in technical terms.

National regulations already require the Periodic Safety Review of its operating nuclear power plants at least every 10 years. This includes re-evaluation of the site related aspects along with other factors.

Keeping in view the lessons learnt from the Fukushima Daiichi Accident, the following changes have been proposed in PNRA Regulations:

i. Periodic re-evaluation and re-assessment of all hazards (natural or man-made) – PAK/910;

ii. Provision of reliable filtered venting system independent of any AC power with limited operator action for operation – PAK/911;

iii. Provisions for withstanding and recovering from extended Station Blackout (SBO) to withstand Postulated Initiating Events (PIEs) of very low probability (internal and external) and any event that may occur as a consequence to the PIEs – PAK/911;

iv. Consideration of low probability independent events to occur simultaneously – PAK/911;

v. Consideration to control hydrogen within the spent fuel storage building in the event of loss of spent fuel cooling and to maintain integrity and functionality of fuel building- PAK/911;

vi. Combined means to provide emergency power having reliability and form consistent with the safety requirements of the systems to be supplied, and performing their safety functions for longer durations on the assumption of a single failure – PAK/911;

vii. Encourage introduction of passive design features in the plant systems specially the emergency core cooling systems, Hydrogen recombining systems and spent fuel pool cooling systems -PAK/911.

These regulations are currently being revised.

It is, thus, evident that the objectives set out in the Vienna Declaration are either already part of the Pakistani regulations on Nuclear Safety or in the process of the adoption. As such the legal aspect of the Vienna Declaration is already consistent with the national approach to nuclear safety.

Article 14

Assessment and verification is required for site evaluation, preliminary and final safety analyses of the design, and then after every ten (10) years during operation in the form of periodic safety reviews. Requirements related to assessment for allowing operation beyond design life have been addressed in PAK/909. In addition, PAK/909 links requirements for safety assessment and verification present in other PNRA regulations.

PNRA regulation PAK/910 establish requirements for site evaluation and determination of site characteristics to be used as design parameters and assessment of the effects of plant operation on site. PNRA regulations PAK/911 address assessment and verification of safety including the following:

a. A comprehensive safety assessment shall be carried out to confirm that the design meets the safety requirements set out at the beginning of the design process.

b. The safety assessment shall be part of the design process, that is strongly supported by analytical analyses, with the increase in the scope and level of details as the design program progresses.

c. The basis for safety assessment shall be the data derived from the safety analysis, previous operational experience, results of supporting research and proven engineering practice."

PNRA regulation PAK/913 specify requirements for assessment and verification during commissioning and operation e.g. the assessment and verification of design modifications, events and incidents, operational aspects and periodic safety reviews.

Reassessments at KANUPP:

The first PSR of KANUPP was conducted in 2007 for re-licensing after completion of design life. Some major changes included;

i. Seismic Retrofitting of Safety Significant SSCs.

ii. Increasing the number of EDGs from 2 to 3.

iii. Redundancy and automation in emergency feed water system

iv. Qualification of low pressure ECCS motors for harsh condition following LOCA.

v. Installation of redundant trains of medium pressure ECCS.

vi. Installation of Automatic Boiler Crash Cool down (ABCC) system to facilitate ECC flow injection in case of small LOCA.

vii. Screening of containment building sump for protection against debris following LOCA.

viii. Removal of booster rods (meant for reactor restart) from reactor core and storage in spent fuel bay.

ix. Replacement of reactor regulation computers and C&I loops to overcome obsolescence

x. Revision of Final Safety Analysis Report

xi. Establishing safety improvement program like corrective action program, safety performance indicator program and self assessment program

A special WANO Peer Review mission was conducted at KANUPP in April, 2013. Information on the improvements made is given in the Sixth National Report (available at www.pnra.org). KANUPP completed its second Periodic Safety Review during 2013-2015. Details are provided in Section 14.2.1.

KANUPP core assessment was performed by CANDU Energy Incorporated, Canada in 2013-2014 using FCIA 2011 inspection data. This core assessment (fitness-for-service evaluation) was performed in accordance with CSA Standard N285.4 to demonstrate acceptance of KANUPP fuel channels. Stress analysis of the feeder pipes was also performed by AMEC NSS, Canada in 2013-14 to evaluate the Minimum Acceptable Wall Thickness (MAWT) as per the requirements of latest CSA Standard N 285.4 and ASME B&PV NB-3600 code 2001 Edition. These tasks were carried out through a contract with Candu Energy Incorporated and AMEC NSS, Canada under an IAEA Technical Cooperation Project on “Long Term Operation of KANUPP (LTSK) Phase II”.

Reassessments at Chashma Unit 1 (C-1) and Unit 2 (C-2)

C-1 underwent a PSR in 2010. The details are given under Article 14 of the Sixth National Report of Pakistan available at www.pnra.org. Updated status of implementation of corrective actions for the PSR is as follows:

i. Complete suite of SAMGs is expected to be completed at the end of 2016.
ii. On-going refresher training program for on-site and off-site Emergency Response Personal is being implemented.
iii. Implementation of equipment qualification program is in progress.
iv. Aging Management Program has been developed :
    a. Procedures of RPV and SG have been developed and implemented. Re-evaluation report will be prepared after removal of irradiation surveillance capsule.
    b. Implementation of procedures for Isolated Bus Bar-B, Cables and Main Transformer is in-progress.
    c. Development of aging program for Containment, Primary Piping, CRDM and Reactor Internals is in progress
v. Containment aircraft crash analysis was performed
vi. PSA on internal Fire and Flood Analysis was conducted and completed. Work on Low Power and Shutdown PSA is in progress.

Information on International Peer Review missions conducted at KANUPP, C-1 and C-2 during the reporting period is given in Section 2.1.8, Section 14.5 and Annexure XII of this report.

Assessments after the Fukushima Daiichi Accident:

After the Fukushima Daiichi Accident, PNRA required the licensees of Nuclear Power Plants to revisit /re-assess the design and safety features and accident management guidelines as well as emergency preparedness measures and submit a detailed action plan.

The re-assessments required by PNRA comprised the following:

i. Re-assessment of natural hazards
ii. Availability of infrastructure (necessary for plant safety such as AC power supply sources, heat sink)
iii. Consideration of the station black-out condition (loss of all AC power) for longer duration

iv. Re-evaluation of the design features provided at nuclear power plants for controlling and removing Hydrogen such as hydrogen recombining system, Hydrogen mixing system
v. Re-evaluation of the Emergency Operating Procedures (EOPs) and Severe Accident Management Guidelines (SAMGs)
vi. Re-evaluation of the off-site Emergency Preparedness Plans (EPPs) including Emergency Plan Implementing Procedures (EPIPs)
vii. Re-evaluation of the training program in the light of the Fukushima accident with particular emphasis on the limitations of simulator since such scenarios may not be possible to simulate.

PAEC carried out initial safety assessment of its NPPs at Corporate level and formulated a "Fukushima Response Action Plan" (FRAP) in May 2011, which identified certain actions pertaining to the following review areas:

a. External Natural Hazards
b. Make-Shift AC Power
c. DC Power Capacity
d. Fire Protection and Control
e. Emergency Core Cooling
f. Hydrogen Hazard
g. Containment Integrity
h. Spent Fuel Cooling
i. EOPs, SAMGs (On-Site Actions)
j. Emergency Preparedness

The actions taken under the FRAP have been reported in the Special National Report (2012) and the Sixth National Report. Progress on the actions/upgrades are given in Section 2.2.

Article 17:

Seismic re-assessment for KANUPP site was conducted in 1992 which re-estimated the original g value of 0.1g to be 0.2g. For details, please see Section 3.1.1.1 and 3.1.1.2 of Pakistan Special National Report for the CNS Extraordinary meeting available at www.pnra.org.

Re-assessments of Site related Hazards (Seismic ,Tsunami flooding etc.) was again conducted for KANUPP and Chashma site as part of FRAP. Please see Section 2.2 for details.

Article 18

Passive Autocatalytic Hydrogen Re-combiners (PARs) are available in C-2 , C-3/C-4 and K-2/K-3 as part of original design whereas PARs have been installed at KANUPP and are being installed at C-1as part of FRAP. Similarly, Filtered Venting is available in K-2/K-3 design. Measures are available to cope with extended SBO scenarios through availability of mobile Diesel Generator Sets and special power supplies for safety related and safety support equipment/severe accident management systems.

The following design features act as preventive measures against severe accidents (in C-1, C-2 and C-3/C-4):

a. Large Water Inventory of Steam Generator (SG) Secondary Side Water
b. Large Pressurizer Volume

c. Large containment free volume
d. Two relief valves in each main steamline
e. Two diverse pumps in each train for Auxiliary Feedwater System (SAF)
f. Additional startup-shutdown feedwater pump
g. Safety grade Reactor Pressure Vessel (RPV) venting valve for release of non-condensable gases.
h. Station Blackout (SBO) recovery: For C-1, diesel generators are provided as Alternate AC source (AAC) for each safety bus. For C-2, a diverse AAC diesel generator is provided on swing bus.

For C-2 and C-3/C-4, specific additional design features are provided to mitigate the consequences of severe accidents. These include:

[i] Reactor Cavity Flooding System (SCF)
[ii] A dedicated throttle valve on Pressurizer to preclude High Pressure Melt Ejection (HPME)
[iii] An independent UPS for reactor coolant pump seal return water valves to address seal LOCA concerns during severe accidents
[iv] Passive Autocatalytic Hydrogen Re-combiners (PARs)

Feasibility study for installation of Filtered Containment Venting System (FCVS) at C-1 and C-2 was conducted. A study conducted by the designer concluded that no such system is needed as enough time (130 hrs) is available for the containment to reach its ultimate bearing capacity.

Article 19

After the Fukushima Daiichi Accident, Fukushima Response Action Plan (FRAP) for KANUPP was prepared and following actions were taken in relation to Emergency Operating Procedures (EOPs):

i. Verification, validation and training of operators on EOPs
ii. Updating EOP on earthquake safety & surveillance (Incorporation of mitigating actions for spent fuel storage bay)
iii. Development/improvement of EOPs for external flooding

Emergency Operating Procedures (EOPs) have been reviewed and validated through Table Top and Walk Through Exercises. Issue of Spent Fuel Cooling has been addressed in EOP of earthquake safety & surveillance. Revised EOP for earthquake has been issued. Guidelines have also been issued to deal with extreme weather conditions.

Severe accidents analyses in the light of Fukushima accident (considering prolonged SBO) were carried out to assess the following:

a. Need and feasibility of increasing pumping head (EFW system)
b. Extent of Hydrogen Hazard
c. Feasibility and need for (passive) Hydrogen Recombiners and Hydrogen Igniters
d. Flow requirements in different systems for long term core cooling
e. Adequacy of passive cooling such as natural circulation
f. Adequacy of DSW System for alleviating reactor building pressure
g. Feasibility of installing system for releasing containment pressure
h. Containment behavior

Additional supporting analyses for Severe Accident Management Guidelines (SAMGs) were conducted. SAMGs have been revised in the light of lessons learned from Fukushima NPP accident. Process of Validation of sample procedures as per SAMGs is in progress.

Technical Support Committee (TSC) and Emergency Response Team (ERT) are established to assist the Emergency Management Group (EMG) aiming to bring the plant to stable condition and minimize the radiological consequences in case of severe accident. Training / briefing has been given to EMG, ERT and TSC personnel for their intended response in case of severe accident conditions.

At C-1 and C-2, Emergency Operating Procedures (EOPs) are available to mitigate the consequences of failures and to limit the core damage and radiation dose to the plant personnel and the public. C-1 and C-2 initially received Event Based EOPs from the vendor. According to the licensing requirement and international practice, complete set of Symptom Based EOPs (SEOPs) to deal with DBAs and BDBAs has been developed and are in place at C-1 & C-2. At present, C-2 has developed SAMGs based on generic SAMGs which are transformed into plant specific based on additional background analysis and set-point calculations.

At C-1, revision of SAMGs is also in progress. Minimum inventory of Boric Acid to cover potential emergencies has been increased.

A reserve force of workers to cope with severe accident consequences at Chashma site is being developed. The study has been completed and reserve workers are identified. In O&M sections, CNPGS has sufficient manpower while in RP/EPP/EM, additional workers will be needed from PAEC establishments. Database to acquire assistance/manpower from PAEC establishments has been prepared.

Part III

3 Future Challenges

Future challenges may include:

a. Maintaining and further enhancing organizational capabilities of PAEC and PNRA for decommissioning of nuclear installations.
b. Management of Spent Fuel after exhausting the capacity of wet storage at site
c. Maintaining and further enhancing organizational capabilities for design and regulating nuclear installation of diverse and advanced designs (Digital I&C, Passive Safety Systems, Fuel, integrity etc.)
d. Sustainable development of human resource for operation and maintenance of nuclear installations in view of GoP's Energy Security Plan 2030 to increase the share of nuclear power to 8800 MW

Part IV

Article 4 – Implementing Measures

"Each Contracting Party shall take, within the framework of its national law, the legislation, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention".

4 Implementing Measures

This report presents legislative, regulatory and administrative measures and steps that Pakistan has taken, within the framework of its national law, which are necessary for the fulfillment of its obligations under this Convention. These measures have been described in earlier six national reports. The main legislative instruments have been enacted and essential national regulations are in place. An approach of continuous and gradual fulfillment of the safety obligations is adopted by Pakistan and priority is given to the most safety significant issues.

Pakistan has, therefore, met the obligations of Article 4 of the Convention.

Article 5 – Reporting

“Each Contracting Party shall submit for review, prior to each meeting related to in Article 20, a report on the measures it has taken to implement each of the obligations of this Convention”

5 Reporting

After signing the Convention on Nuclear Safety, six national reports have been submitted by Pakistan which were reviewed by the contracting parties in the respective review meetings. A special National report was also submitted by Pakistan to the IAEA in response to the Fukushima Daiichi Accident which underwent peer review by the Contracting parties during the Second Extraordinary meeting in August, 2012. This is the seventh national report by Pakistan in compliance with Article 5 of the Convention.

Pakistan has, therefore, met the obligations of Article 5 of the Convention.

Article 6 – Existing Nuclear Installations

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

6 Existing Nuclear Installations

There are three nuclear power plants which are in operation while four units are under construction. The existing nuclear installations are listed in Annexure–I. Following paragraphs briefly describe information about existing nuclear installations in Pakistan. The post Fukushima assessments and implementation of activities related to each nuclear installation are presented in Section 2.2.

6.1 Karachi Nuclear Power Plant

Karachi Nuclear Power Plant (KANUPP) continued to operate safely since its licensing beyond design life in 2005. Since then, the operating license of KANUPP has been extended several times at different intervals depending upon several refurbishments carried out from time to time in order to fulfill the regulatory requirements. The last extension of KANUPP operating license was granted by PNRA in April, 2012 for allowing operation up to December 31, 2016. The extension was a result of thorough assessment of remaining useful life of steam generator and integrity of fuel channels. The activities performed by KANUPP were thoroughly assessed by PNRA to verify compliance with the regulatory requirements and to ensure that the plant can operate safely for the intended duration.

Prior to this extension, KANUPP conducted its second PSR (PSR-2) after a comprehensive re-assessment of overall plant safety performed by KANUPP that would provide the basis of operation for the next ten years. Review strategy for PSR-2 was based on IAEA Safety Guide NS-G-2.10. From the very beginning of PSR activity, PNRA laid strong emphasis on aging and limiting factors emerging from assessment of remaining life of certain safety significant equipment (such as fuel channels, feeder pipes and steam generator tubes).

All the queries raised by PNRA and corresponding corrective actions were included in revised Global Assessment Report submitted by KANUPP. All issues raised during the review were satisfactorily resolved and on the basis of review, the PSR was accepted.

KANUPP remained shut down from Feb – Aug, 2014 and Sep – Oct, 2015 to fulfill the regulatory commitments and carry out major maintenance activities. The major areas of focus for this outage were as follows:

i. Boiler sludge lancing, inspection of boilers tubes and tube plugging
ii. Feeder pipe inspection
iii. Containment dampers replacement
iv. Condenser tube inspection and replacement
v. Fire proofing of cable trays by installing passive and active fire suppression system

vi. Complete refurbishment of hanger supports of main steam and boil feed water lines
vii. Replacement of inlet/outlet headers of component cooling water heat exchangers
viii. De-silting of all the four intake water bays
ix. Overhauling of various motors, pumps, and other equipment in nuclear and conventional Island
x. Implementations of design modifications as per change approvals

The activities performed by KANUPP were thoroughly assessed by PNRA to verify compliance with the regulatory requirements and to ensure that the plant can operate safely. Based on the review and assessment, KANUPP was allowed to make the reactor critical and subsequent power operation after each long shutdown.

During 2013-15, two incidents took place in KANUPP. The first incident occurred on July 4, 2013, when a tin Smith fell down from turbine building ventilation duct during a maintenance job and died on the spot. In a second incident, on July 14, 2015, a mason fell down from the roof of plant canteen during repair job of roof, leading to the death of the mason. The corresponding industrial safety procedures and practices were reviewed and revised to avoid recurrence. Both incidents were shared with WANO.

6.2 Chashma Nuclear Power Plant Unit 1 (C-1)

Chashma Nuclear Power Plant Unit-1 (C-1) is operating safely since award of the Operating Licence in 2000 which was valid for 10 years, after which C-1 conducted its first Periodic Safety Review (PSR) and submitted its report to PNRA. Based on the review of PSR report, the operating licence of C-1was revalidated up to December 2020. C-1 has completed ten refueling outages since the start of commercial operation of the plant.

In the early 2014, C-1 completed its ninth operating cycle and the plant was shut down for refueling outage- 9 (RFO-9). During the outage, besides refueling and removal of RPV 3rd surveillance capsule assembly, other major jobs were also performed including nuclear island equipment overhauling, RCP-A seal replacement and maintenance of main and step-down transformers. Upon completion of RFO-9 activities, C-1 applied for permission of making reactor critical along with the documents required under PNRA regulations PAK/913. Upon completion of review of these documents and ensuring that the licensee has completed all actions required under the directives issued by PNRA, permission was granted to make C-1 reactor critical. During 2014, C-1 also complied with the already extended time specific licence condition regarding additional storage of radioactive waste.

C-1 was shut down for Re-Fuelling Outage (RFO-10) in September, 2015. Major jobs performed were turbine generator overhauling, RPV and lower internals inspection, main transformer and step-down transformer overhauling, RCP-A motor overhauling, and RPV Omega weld inspection. The planned duration of RFO-10 was 59 days and Reactor was likely to be made critical in November, 2015. However, during the in-service inspections of Low Pressure (LP) turbine blade, cracks on roots of twenty three (23) blades were observed (i.e. six (06) on LP-1 and seventeen (17) on LP-2 turbines). Due to this reason, the duration of outage was extended for 128 days and after satisfactory completion of corrective actions, C-1 was connected to grid in January, 2016.

The plant operated within the approved operating envelope during the reporting period. The radioactive releases to the environment and doses to workers and public remained well below the administrative limits.

6.3 Chashma Nuclear Power Project Unit 2 (C-2)

C-2 was connected to grid in 2011 and was granted Operating Licence by PNRA till 31st December, 2021 after verification of the fulfillment of commitments made by the licensee in response to review and assessment and inspections.

During the reporting period, two re-fueling outages of C-2 were carried out. During the 2nd Refueling Outage (RFO-2), the recurring problems with the main feed water pump controllers were rectified. In the past, malfunctioning of these controllers had been the major contributor to tripping the plant in the second cycle. There was not a single outage in 3rd operating cycle due to any other equipment failure or plant issue. C-2 was shut down for its third Refueling Outage (RFO-3) in August 2015. Over-hauling of motor of one Reactor Coolant Pump (RCP), eddy current testing of steam generators, replacement of source and intermediate range instrumentations assembly and replacement of mechanical seals of both RCPs were the significant activities performed during the outage. Fourth Operating Cycle has started from September, 2015.

Overall the plant operated safely within operating limits and conditions, fulfilling all the regulatory requirements during the reported period.

6.4 Chashma Nuclear Power Plant Units 3 & 4 (C-3, C-4)

After review of the construction licence application including necessary licensing submissions i.e., Preliminary Safety Analysis Report (PSAR), Probabilistic Safety Analysis (PSA) Report and Overall Quality Assurance Program (OQAP), C-3 and C-4 were awarded construction licenses in May, 2011 and December, 2011 respectively.

Civil work for the construction and installation of C-3 and C-4 has been completed. On satisfactory review of commissioning program C-3 / C-4 has been granted the authorization for starting commissioning tests of C-3 and C-4 Project. Cold and hot Commissioning tests of major systems without fuel have been completed for C-3 while cold commissioning tests have been performed at C-4.

The application for issuance of fuel load permit to C-3 and C-4 was submitted to PNRA in August 2014, along with the submission of Final Safety Analysis Report (FSAR) and other documents as per requirement of PNRA regulations PAK/909. The review of FSAR was completed in December, 2015 during which a total of 1150 review queries were raised by PNRA. In order to discuss these queries, two review meetings were held with the designer and licensee during which all the safety issues were satisfactorily resolved. After verification of the necessary actions taken as per commitments made during the licensing process, PNRA granted permission to C-3 for loading fuel into the reactor in May, 2016 whereas, the application for issuance of fuel load permit to C-4 is under review at PNRA. All the manufacturing activities have been completed for C-3 and C-4 projects.

6.5 Karachi Nuclear Power Plant Units 2 & 3 (K-2, K-3)

The safety review of K-2/K-3 application and regulatory submissions (Preliminary Safety Analysis Report and other submissions required by PAK/909) for the issuance of Construction

Licence was completed in April, 2015. After necessary review of licensing submissions, and ensuring compliance with the applicable safety requirements, K-2 and K-3 were awarded Construction Licenses by PNRA in August, 2015 and November, 2015 respectively.

Pakistan has, therefore, met the obligations of Article 6 of the Convention.

Article 7 – Legislative and Regulatory Framework

"1.Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.

2. The legislative and regulatory framework shall provide for:

(i) the establishment of applicable national safety requirements and regulations;
(ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a license;
(iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and terms of licenses;
(iv) *the enforcement of applicable regulations and of the terms of licenses, including suspension, modification or revocation."*

7 Legislative and Regulatory Framework

Under the PNRA Ordinance of 2001, PNRA was established as an independent nuclear regulatory Authority to supervise all the matters related to nuclear safety and radiation protection in Pakistan. The said legislation empowers PNRA to formulate requirements to ensure nuclear safety & radiation protection and perform regulatory oversight of the facilities to assure that these are operated in a safe and secure manner.

7.1 Regulatory Framework

PNRA Regulations and Regulatory Guides, issued by PNRA, form the basis of the nuclear regulatory framework of Pakistan. Such guides provide acceptable methods for meeting the requirements specified in the regulations. However, methods other than those specified in guides can be adopted by the licensees provided that it can be demonstrated to the entire satisfaction of the Authority that the same or higher level of safety and quality can be achieved.

7.1.1 Pakistan Nuclear Regulatory Authority Ordinance 2001

The Ordinance provides the statutory basis for the Authority. PNRA ordinance authorizes PNRA to devise, adopt, make and enforce Regulations to protect workers, public and the environment from the harmful effects of ionizing radiation.

The Ordinance empowers PNRA to:

i. make regulations and rules in accordance with the provisions of the Ordinance;
ii. issue authorizations and licenses,
iii. inspect all nuclear installations, radiation facilities and waste facilities, nuclear substances or radioactive materials to ensure compliance with regulations, and
iv. take enforcement actions against non-compliance with the regulations.

7.1.2 PNRA Regulations

Section 56 of the Ordinance empowers PNRA to issue Regulations. To date, 17 Regulations related to different areas of nuclear safety and radiation protection have been promulgated which are mainly based on the IAEA Safety Standards.

List of gazette notified Regulations is given in Annexure-III .The Regulations have been placed on the website http://www.pnra.org for easy access of all the stakeholders.

7.1.3 Regulations Published Since the Last Report

Several regulations remained under preparation and revision.

7.1.4 Amendments in Regulations

In order to accommodate a few minor changes required to be made in the existing regulations, the amendments are made in the particular section, clause or phrase of the regulations. These changes may be based on regulatory experience, licensee's feedback, or promulgation of some specific requirements in a particular area.

Since the issuance of last report, amendments in the following regulations were made and gazette notified accordingly:

i. Regulations on the Safety of Nuclear Power Plants-Quality Assurance - (PAK/912);

ii. Regulations on the Safety of Nuclear Power Plants Operation - (PAK/913).

iii. Regulations on the Safety of Nuclear Research Reactor(s) Operation - (PAK/923).

7.1.5 New Regulations under Preparation

The following new regulations are being formulated:

i. Regulations on Authorization of Organization for Non Destructive Examination (NDE) of Safety Class Equipment for Nuclear Installation(s) - (PAK/906);

ii. Regulations on Safety of Spent Nuclear Fuel Management - (PAK/918);

iii. Regulations on Physical Protection of Nuclear Material(s) and Nuclear Installation(s) - (PAK/925);

iv. Regulations on Security of Sealed Radioactive Sources (SRS) - (PAK/926); and

v. Regulations on Decommissioning of Facilities using Radioactive Material - (PAK/930).

7.1.6 Regulations Currently under Revision

PNRA Regulations are usually reviewed, and revised if needed, after every 05 years or on the basis of the following reasons:

i. Obligations of PNRA Ordinance

ii. Obligations of International Conventions

iii. Feedback of Regulatory/Licensing Experience

iv. International Practice and Experience

The following regulations are being revised:

i. Regulations on Licensing Fee by Pakistan Nuclear Regulatory Authority - (PAK/900) (Rev.1);

ii. Regulations on Radiation Protection-(PAK/904) (Rev.1);

iii. Revision of Regulations for Licensing of Nuclear Safety Class Equipment and Component Manufacturers (PAK/907).

iv. Regulations for the Licensing of Radiation Facility (ies) other than Nuclear Installation(s) (PAK/908).

v. Regulation on the Safety of Nuclear Power Plant Design (PAK/911)

vi. Regulations on the Safety of Nuclear Power Plants Operation - (PAK/913)

vii. Regulations on Management of a Nuclear or Radiological Emergency (PAK/914)

viii. Revision of Regulations on Radioactive Waste Management (PAK/915) and

ix. Regulations for the Safe Transport of Radioactive Material - (PAK/916).

7.1.7 Regulatory Guides

The following regulatory guides have been issued during the reporting period:

i. Regulatory Guide on Format and Content of Application for Design Modifications in Nuclear Power Plants (PNRA-RG-913.02); and

ii. Regulatory Guide on Guidance for the Users of Iodine-131 in Nuclear Medicine Centers (PNRA-RG-904.02).

7.1.8 Guides under Preparation

The following regulatory guides are under preparation:

i. Radiation Safety in Industrial Radiography (PNRA-RG-904.03);

ii. Protection of Patients in Diagnostic Radiology (PNRA-RG-904.05);

iii. Radiation Protection and Safety in Radiotherapy (PNRA-RG-904.06);

iv. Format and Contents of Radiation Protection Program of Radiation Facilities/Activities (PNRA-RG-904.07);

v. Guidelines for Medical Professionals on Transport, Diagnosis & Management of Overexposed & Contaminated Individuals in Radiological Emergency (PNRA-RG-904.08);

vi. Format and Content of Safety Analysis Reports (SARs) of NPPs (PNRA-RG-909.01);

vii. Format and Contents of Physical Protection Program of Nuclear Installation(s) (PNRA-RG-909.02); and

viii. Format and Contents of Radiation Emergency Plans of Radiation Facilities and Activities (PNRA-RG-914.02).

7.1.9 Use of International Regulatory Guides and Industrial Standards

Under the provisions of the regulations PAK/909, PNRA authorizes its licensees to use relevant latest US Nuclear Regulatory Commission (USNRC) regulations, in areas where the PNRA regulations are not available. As an alternate, the licensee may choose to follow the latest revisions of the applicable IAEA Safety and Security Standards.

Since the guidance issued by USNRC takes account of internationally recognized industrial standards such as ASME, IEEE, etc., therefore, these standards can also be used by the licensees. In case the nuclear safety and security standards of another country are proposed to be followed, the applicant/licensee is bound to demonstrate to the entire satisfaction of the Authority, that the standards, proposed to be followed, offer the same or better standards of safety, security, quality and reliability than would have been offered by the nuclear safety and security standards approved by PNRA.

In addition, the industrial standards of the exporting countries such as RCC-M of France or GB of China can also be employed. If necessary, international standards such as ISO, IEC, etc. can also be referred.

Pakistan has, therefore, met the obligations of Article 7 of the Convention.

Article 8 – Regulatory Body

> *"1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities.*
>
> *2. Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy."*

8 Regulatory Body

Under the Pakistan Nuclear Regulatory Authority Ordinance, the Pakistan Nuclear Regulatory Authority (PNRA) was established in 2001 as an independent regulatory body to regulate and supervise all matters related to the safety of nuclear and radiation facilities in the country. PNRA is empowered to formulate and implement regulatory framework (related to radiation protection, nuclear safety and physical protection, issue licenses and authorizations for facilities and activities involving ionizing radiation, and carry out regulatory oversight to verify compliance with the national regulations, conditions of the authorizations and directives issued by the Authority) and has sufficient authority and funding to carryout day to day affairs.

8.1 Vision and Mission of PNRA

The vision of PNRA is to become a world class regulatory body with highly trained, competent and dedicated personnel working with diligence and motivation to promote a positive safety culture in its licensed facilities. PNRA regulates nuclear installations to protect the public, workers and the environment from the harmful effects of radiation.

The mission of PNRA is to ensure safe operation of nuclear facilities and to protect radiation workers, general public and the environment from the harmful effects of radiation by formulating and implementing effective regulations and building a relationship of trust with the licensees and maintain transparency in its actions and decisions.

8.2 Legal Basis of PNRA

PNRA Ordinance provides the legal basis for an independent nuclear regulatory body. It describes the constitution of the Authority, tenure and eligibility of the Chairman and full time Members, interface with Government of Pakistan, and functions and responsibilities of PNRA. The Chairman is the chief executive officer of the Authority and is responsible for the administration of the affairs of the Authority for ensuring nuclear safety in Pakistan.

PNRA is the sole national regulator responsible for the nuclear safety and radiation protection. Environmental Protection Agency (EPA) of the Government of Pakistan separately regulates all aspects of environmental protection except for those having radiological impact, which are regulated by PNRA.

8.3 Organization of PNRA

The organizational setup of PNRA is continually under review and is revised when deemed necessary. The organization of PNRA comprises a Chairman, two full-time Members and seven part-time Members, including representatives of the Ministry of Health, Pakistan Environmental Protection Agency, Strategic Plans Division (SPD) of the Joint Staff Headquarters, eminent professionals from the science, engineering and medical sectors, and Pakistan Atomic Energy Commission. The Federal Government appoints the Chairman and the Members of the Authority. Chairman is the chief executive of the Authority and reports to the SPD which is the Secretariat of NCA headed by the Prime Minister of Pakistan. Annexure–IV shows the organizational structure of PNRA.

The organizational structure of PNRA comprises of the executive and corporate wings, headed by Member (Executive) and the Member (Corporate) respectively. The executive wing is responsible for performing core functions of the Authority, whereas, the corporate wing is responsible to drive the Authority as an organization and also provides technical support to the executive wing through its Technical Support Organization (TSO). The Secretary of the Authority, the Advisory Committees and the Director General of the Chairman Secretariat, report directly to the Chairman. The latter assists Chairman in matters relevant to planning future activities of PNRA. D.G (Evaluation & Feedback) is also reportable to Chairman PNRA.

Member (Executive) has the overall responsibility of the Executive Wing and is assisted by Director General (Technical) and Director General (Inspections & Enforcement). The former looks after the four Technical Directorates {Directorate of Nuclear Safety (NSD), Directorate of Radiation Safety (RSD) and Directorate of Transport and Waste Safety (WSD), Directorate of Physical Protection and Security (PPSD)} and activities of National Radiological Emergency Coordination Centre (NRECC) which is responsible for coordinating the response of various stakeholders to nuclear accidents or radiological emergencies with stakeholders. Director General (Inspections & Enforcement) looks after three regional directorates and inspectorates. Directorate of Administration and Directorate of Finance also operate under the supervision of Member (Executive).

Three Directors General are working under the authority of Member Corporate, namely DG (Corporate), DG (Capacity Building) and DG (CNS). DG (Corporate) is responsible for the activities of corporate wing, DG (Capacity Building) looks after the progress of projects of national importance undertaken by PNRA and DG (CNS) supervises all technical, administrative and financial activities of Centre for Nuclear Safety (CNS). Further, Directorate of International Cooperation (ICD) and Directorate of Establishment are directly under supervision of Member (Corporate).

The following government funded Public Sector Development Program (PSDP) projects initiated by PNRA are being supervised by the DG Capacity Building:

i. National Dosimetery and Protection Level Calibration Laboratory (NDCL)
ii. National Environmental Monitoring Programme (NEMP)
iii. Safety Analysis Centre (SAC)
iv. Up-gradation of Nuclear Radiological Emergency Coordination Center (NRECC)

Main functions and responsibilities of the different directorates are summarized as follows:

Directorate of Nuclear Safety (NSD): NSD is mainly responsible for licensing/authorization of nuclear installations and manufacturer of nuclear safety class equipment & activities and service providers (NDT), establishing and maintaining regulatory framework for nuclear safety and manufacturing of nuclear safety class equipment and service providers, inspections and enforcement of manufacturers of nuclear safety class equipment; and review and assessment of licensees' submissions.

Directorate of Radiation Safety (RSD): RSD is responsible for regulation and supervision of matters related to radiation protection. It ensures that harmful effects of radiation on human health and the environment arising from activities of licensed facilities are 'As Low As Reasonably Achievable' (ALARA). RSD also operates the National Radiological Emergency Coordination Centre (NRECC), which is the national and international focal point for notifying nuclear or radiological emergencies and provision of assistance, if required, in case of radiological incident(s) in any member state (RANET).

Directorate of Transport and Waste Safety (WSD): WSD is responsible for regulating matters related to radioactive waste management, spent fuel management, control of radioactive discharges to the environment, remediation and safe transport of radioactive material, licensing of pre-disposal & disposal facilities, independent spent nuclear fuel storage facilities , decommissioning of nuclear installations & radiation facilities and certification of transport packages including spent fuel cask, along with review and assessment of licensees, submissions pertaining to these areas.

It establishes and maintains regulatory framework in these areas and ensures compliance with regulatory requirements through joint regulatory inspections with regional directorates.

Regional Nuclear Safety Directorates (RNSDs): Regional Nuclear Safety Directorates are established at Islamabad, Chashma and Karachi respectively. The regional directorates are responsible for inspections and enforcement within their jurisdiction. RNSDs conduct routine and special regulatory inspections to provide a high level of assurance that all activities performed at the installations during all stages of licensing process and all phases of the life cycle of a nuclear installation are carried out according to regulations and conditions of licence. The areas covered by inspection programs are radiation protection, operations, maintenance, testing and surveillance, quality assurance, emergency preparedness, industrial safety, fire protection, etc. RNSDs provide administrative and technical support to NDCL, NEMP Labs and SAC and also coordinate with NRECC during nuclear & radiological emergency exercises.

Regional Nuclear Safety Inspectorates (RNSIs): Three RNSIs are established under each Regional Nuclear Safety Directorate at Peshawar, Multan and Quetta. The RNSIs work under the administrative control of RNSDs for support of their functions in respective regions. They are responsible for the review and assessment, licensing and Inspection & enforcement of radiation facilities.

Directorate of Physical Protection and Security (PPSD): PPSD is responsible to establish and maintain regulatory framework for physical protection and nuclear security, Review and assessment of licensees, submissions on physical protection and nuclear security, assistance to Regional Directorates in inspections of physical protection of nuclear material and sealed radioactive sources, technical support to Regional Directorates, SPD, FBR for response to nuclear security events and illicit trafficking of nuclear materials and radioactive sources.

Directorate of Information Services (ISD): ISD maintains computer networks, PNRA official website, PNRA internal network site, PNRA library, conducts media campaigns for public

awareness and education, issues of press releases on important matters and interacts with the media.

Directorate of International Coordination (ICD): ICD interacts with IAEA and other international bodies for visits/trainings/workshops. Matters related to international cooperation with other organizations such as NNSA, NSC, CNPO, etc. are also dealt through ICD. In addition to other activities, ICD also facilitates processing of security clearance/visa of foreign experts to PNRA and departure formalities for PNRA officials while proceeding on visits or training abroad.

Directorate of Policies and Procedures (PPD): PPD is the custodian of the development and maintenance of all regulatory documents such as PNRA Regulations and Regulatory Guides as well as internal documents including PNRA policies, programs, criteria and procedures for internal working. PPD maintains a central registry of all these documents including record of different phases of development and revision. PPD is responsible for coordinating, within PNRA, the reviews of draft IAEA Safety Standards and communication of comments at different stages of development of the Standards.

Directorate of Regulatory Affairs (RAD): RAD is mainly responsible for monitoring, evaluation and revision of PNRA management system, safety culture self-assessment of PNRA, performance evaluation of PNRA based on SPIs, preparation of PNRA annual report, internal audit of all PNRA directorates, self assessment; and coordination for preparation of PNRA Strategic Plans, tasks and functions and their oversight.

Directorate of Human Resource Development (HRD): The Human resource directorate is responsible for training and education of the PNRA staff members at institutes within Pakistan. HRD is also responsible for the Human resource planning, succession & career planning, and Competence Need Assessment (CNA) of PNRA officers and Staff.

Centre for Nuclear Safety (CNS): CNS is one of the Technical Support Organization (TSO) of the PNRA which performs all the review and assessment and audit calculations of the analyses submitted by the licensees in the areas of deterministic and probabilistic safety analysis to support the licensing and regulatory decision making of PNRA. The CNS also performs research and development activities in safety analysis in collaboration with the universities and other technical organizations. The scientists and engineers of the Centre of Nuclear Safety have been trained in different areas of regulatory aspects and nuclear power plant design and operation through in-house training programs as well as local and foreign trainings and workshops.

During the reporting period, the TSO provided valuable technical support in different licensing activities pertaining to operating nuclear power plants and C-3/C-4 & K-2/K-3.

PNRA Legal Cell - PNRA has established a legal cell for implementation of enforcement actions. The Legal cell operates under the authority of DG (I&E). The functions and responsibilities of the Legal Cell are as under:

i. Performing all legal actions pertaining to the implementation of PNRA Enforcement Procedure.

ii. Make arrangements for the hearings by DG (I&E) and maintain the smooth running of the proceedings.

iii. Audio, video or both types of recordings of the proceedings of the hearing for further usage in the Court of Law.

iv. Register and record the offence reports.

v. Examine the offence reports and verify the facts.

vi. Serve legal notice to the accused person.

vii. File complaint in the Court of Law for prosecution of the accused person.

viii. Follow-up litigation cases in the Judicial fora.

Public Sector Development Projects

PNRA executes different projects under the Public Sector Development Program (PSDP) to achieve sustainable regulatory effectiveness through capacity building and institutional strengthening in response to the emerging needs of nuclear and radiological safety and security. Projects which are completed, become a regular part of PNRA. The following PSDP projects were completed by PNRA during the reporting period and have now become part of PNRA:

National Dosimetry and Protection Level Calibration Laboratory (NDCL): PNRA has developed Radiation Protection Regulations and Annual Radiation Dose Limits for occupational workers as well as for general public so that the risk of adverse radiation effects to the human body may be reduced. Assessment of radiation exposure is a fundamental mechanism to ensure the radiation safety of occupational personnel. In this regard, PNRA has established National Dosimetry and Protection Level Calibration Laboratory (NDCL) with the objective to provide internal and external radiation dosimetry Services to the licensed radiation facilities for regulatory verification purposes.

National Environmental Monitoring Program (NEMP): PNRA has the responsibility to ensure that the public is protected from any buildup of environmental radioactivity in the country. PNRA renamed National Environmental Radioactivity Surveillance Program (NERSP) to National Environmental Monitoring Program (NEMP) after its successful completion in 2014. The National Environmental Monitoring Program (NEMP) is responsible for environmental surveillance throughout the country in order to establish the reference levels of ionizing radiations. It ensures that the radioactive discharges to the environment from the operation of nuclear installations and radiation facilities are within specified limits and pose no threat to the public and the environment. It also performs radiation analysis at Natural Occurring Radioactive Material (NORM) producing industries. It will also serve the purpose of determining buildup of environmental radioactivity due to any abnormal releases or nuclear incident/accident in Pakistan or neighboring states.

Safety Analysis Centre (SAC): Safety Analysis Centre is another Technical Support Organization (TSO) whose function is to provide technical support in safety analyses for NPPs. SAC is responsible for research and analytical support in Design Bases Accidents (DBAs), Beyond Design bases Accidents (BDBAs), Seismic Analysis, Probabilistic Safety Assessment (PSA) of K-2/K-3 and Computational Fluid Dynamics (CFD) analysis for PWR plants and CANDU type NPP. SAC is also working on development of Desktop Simulator for Three Loop PWR.

National Institute of Safety and security (NISAS): Considering training and competency development as the essential elements in effective functioning of the regulatory body, PNRA

has established a training institute named NISAS which offers specialized trainings in nuclear safety, radiation protection, physical protection and emergency planning & preparedness. NISAS is equipped with qualified faculty and has a number of laboratories, a soft-panel training simulator, physical models of nuclear power plant equipment, and various computer software.

8.4 PNRA Management System

Please see Section 13.5

8.5 Human Resources

The existing workforce at PNRA stands at around three hundred (300) professionals. Manpower strength has to be increased to four hundred and fifteen (415) vis-à-vis expansion of nuclear program, through direct recruitments and fellowship schemes for masters level programs which is continuously rationalized depending upon the pace of nuclear power development.

PNRA sponsors outstanding Pakistani graduates in Masters level programs of Nuclear Engineering, Systems Engineering, Medical Physics and Nuclear Power Engineering at Pakistan Institute of Engineering and Applied Sciences (PIEAS) and Karachi Institute of Power Engineering (KINPOE). These fellows join PNRA after completion of their Masters degree programs from these institutions. During the reporting period, twenty four (24) graduates were awarded fellowships for MS degrees in nuclear/system engineering at PIEAS and KINPOE while twenty five (25) fellows joined PNRA workforce after completion of their Masters degree programs from these institutions.

A leadership development Program was initiated at PNRA in collaboration with Lahore University of Management Sciences (LUMS). The Program continued during the reporting period and a third batch of future leaders was selected in 2015.

The manpower requirements of each Directorate are assessed regularly and manpower distribution is made according to the workload of the Directorate and nature of activities.

Special teams comprising professionals drawn from all Directorates are formed in the case of specialized tasks such as review of Safety Analysis Reports (SARs), preparation and revision of regulations, etc.

8.6 Financial Resources

Funds provided to PNRA consist of grants from the federal government, income generated from the licensing fees and special grants for the PSDP funded projects for capacity building. Up till now, these funds have been adequate enough to meet the financial requirements of PNRA. PNRA is financially independent from the organizations it is regulating.

8.7 Separation between Regulatory and Promotional Functions

No function or responsibility assigned to PNRA by the PNRA Ordinance is related with the promotion of nuclear energy, and none of its functions and responsibilities conflict with its responsibility for regulating nuclear safety and radiation protection in operating the licensed nuclear facilities. PAEC or any other organization, responsible for promotion or utilization of nuclear energy or ionizing radiation, does not have any regulatory function. Moreover,

Chairman PNRA reports to the Prime Minister through the Secretariat of the National Command Authority (NCA) which is headed by the Prime Minister of Pakistan.

8.8 Monitoring and Evaluation

Monitoring and Evaluation is an integral part of the management systems of PNRA. The monitoring of the regulatory performance of the PNRA is based on 12 strategic performance indicators (SPIs). These indicators are shown in Annexure–VI. The submission of annual report describing the activities of PNRA to the Government of Pakistan and the general public is a regular feature of PNRA. This submission enables PNRA to keep the public, the Government and other stakeholders informed about its efforts for ensuring safety of the public, the workers and the environment from ionizing radiation.

As part of its self assessment program, PNRA completed third internal audit of its directorates during the reported period and issued departmental audit reports containing audit findings, recommendations, and suggestions to the respective departments for further improvement.

A pilot study on assessment of Safety Culture was conducted by PNRA in collaboration with the IAEA. An action plan to improve Safety Culture is being developed in the light of the results of the assessment.

8.9 Use of External Technical Support

PNRA has adequate arrangements for obtaining technical or other expert professional advice or services in support of its regulatory functions and retains full responsibility for its decision-making on safety matters. PNRA has adequate resources and competence to carry out most of its core and support functions. However, room for improvement always exists. PNRA seeks technical advice from several external sources whenever needed, but this advice is not legally binding for PNRA and does not have any impact on regulatory decision making.

PNRA has established strong bilateral relationships with National Nuclear Safety Administration (NNSA), Nuclear Power Operation Technology Corporation (CNPO) and Nuclear Safety Centre (NSC) of China. The bilateral agreements with these organizations provide a forum for free exchange of information on matters related to nuclear safety. These prestigious Chinese institutes have been assisting PNRA in the review and assessment as well as inspections of nuclear power plants.

8.10 Cooperation with National Organizations

PNRA keeps liaison with other governmental organizations for maintaining nuclear and radiation safety in Pakistan. In addition to close interaction with the Pakistan Atomic Energy Commission (PAEC), PNRA also liaises with other national regulators such as Oil and Gas Regulatory Authority (OGRA), Pakistan Telecommunications Authority (PTA), Public Procurement Regulatory Authority (PPRA), Civil Aviation Authority (CAA), and the National Electric Power Regulatory Authority (NEPRA). In addition, liaison is maintained with national universities and academic institutes of national repute to keep abreast with latest national and international research and developmental activities.

PNRA professionals delivered lectures at leading national universities to spread awareness about radiation protection, nuclear power plants safety, etc. During the reporting period, PNRA arranged thirteen (13) courses for industrial radiographers, radiotherapists/ nuclear medicine technologists, x-ray radiographers and paramedical staff of radiation facilities. A number of

participants from various x-ray facilities, medical centers, industries, and irradiation facilities attended these courses. In addition, more than 1500 personnel from nuclear installations, radiation facilities, and other relevant organizations participated in various training courses offered by PNRA.

During the reporting period, PNRA conducted 66 lectures and seminars (till June 2016) involving around 10,000 participants for public awareness in Islamabad, Lahore and Peshawar.

PNRA professionals are members of the committee which decides about adoption of international standards by the Pakistan Standard and Quality Control Authority (PSQCA).

8.11 International Cooperation

PNRA has been actively participating and contributing to the international efforts to promote nuclear safety and security. These efforts include fulfillment of international obligations/implementation of international legal instruments i.e. Conventions, Treaties, and codes & standards and exchange of technical information & expertise with international community under IAEA umbrella through participation in Technical Cooperation & Regional Asia Projects, technical meetings and exchange of expert missions etc. Representatives from PNRA participated and contributed in international events organized by IAEA and other international organizations and shared their experience and knowledge in the field of nuclear safety and regulatory affairs. These events include, technical meetings, training courses, fellowships & higher study programs, conferences, scientific & consultancy missions, etc.

8.11.1 International Conventions and Treaties/Participation in International Conventions

Pakistan is signatory to four international conventions related to nuclear safety, physical protection, and nuclear and radiological emergencies. Pakistan acceded to Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency on September 11, 1989. Pakistan signed Convention on Nuclear Safety on September 20, 1994. Pakistan acceded to Convention on Physical Protection of Nuclear Materials (CPPNM) in September 2000 and has ratified the amendment of CPPNM in March, 2016. With respect to these conventions, PNRA is the point of contact for implementing the obligations of these conventions. In addition, Pakistan implements the IAEA Codes of Conduct on Safety of Research Reactors and Safety & Security of Radioactive Sources.

PNRA attaches great importance to fulfillment and implementation of its international obligations and represents the country at related international fora. During the reporting period, Pakistan participated in the “Diplomatic Conference for Discussing Swiss Proposal for Amendment to Article-18 of the Convention on Nuclear Safety” held at IAEA Headquarters, Austria from February 9-10, 2015. PNRA provided necessary feedback and input to Pakistan's delegation who participated in the conference. Pakistan agreed to implement the commitments of "Vienna Declaration on Nuclear Safety" which was adopted at the Diplomatic Conference. PNRA also participated in the Informal Technical Meeting "Following-up on the Vienna Declaration" during which discussions were held to clarify some aspects of the implementation of the Vienna Declaration.

8.11.2 Bilateral and Multilateral Cooperation

Experience sharing to improve, harmonize, strengthen and promote nuclear safety and security regime and regulatory infrastructure through the bilateral and multilateral cooperation is considered to be very crucial by the nuclear regulatory bodies worldwide. PNRA, in its capacity as nuclear regulatory authority, lays emphasis on establishing and maintaining close cooperation with other regulatory authorities and promotes sharing of necessary information and experiences among the nuclear regulatory bodies to provide support in regulatory matters. PNRA Ordinance empowers the Authority to enter into bilateral cooperation agreements with regulatory bodies of other countries and international organizations for peaceful uses of nuclear technology.

PNRA has a working protocol for cooperation in the field of nuclear safety, assistance in safety reviews, exchange of information and human resource development with National Nuclear Safety Administration (NNSA) of China since April 1992, which was further extended during 2014. Since April 2011, a bilateral agreement with Northern Regional Office (NRO) & Nuclear and Radiation Safety Centre (NSC) of NNSA, China has been in place for technical exchange and cooperation in the field of nuclear safety including radiation protection. In March 2013, this bilateral agreement has been renamed as Long Term Cooperation Framework Agreement between PNRA and China Nuclear Power Operation Technology Corporation (CNPO) for cooperation in the field of training, consultation, scientific research, information exchange, development and technical supports of nuclear power plant safety. Moreover, efforts are continued to expand bilateral and multilateral cooperation with regulators of other countries and international organizations.

PNRA and NNSA of China have formulated a Steering Committee to review and discuss the issues of bilateral cooperation and mutual interests and progress made on agreed actions. During the reporting period, two (seventh and eighth) Steering Committee Meetings (SCM) between PNRA and NNSA were held during 2014 and 2015 in China. In addition, officials from PNRA participated in the ceremony for first concrete pouring at Fuqing 5 NPP in May, 2015. Moreover, after completing eleven (11) month Chinese language course, PNRA officers were placed at Chinese regulatory organizations for on-the-job trainings.

8.11.3 Pakistan - IAEA Collaboration/Cooperation

The role of IAEA is crucial in strengthening regulatory infrastructure in Pakistan and capacity building of scientists and engineers of PNRA in the field of nuclear & radiation safety and security. Officers from PNRA regularly participate and contribute in the activities of IAEA committees, and various networks. PNRA is also a beneficiary of IAEA’s Technical Cooperation and Regional Asia Projects.

PNRA is contributing to IAEA activities by providing its experts' services in the field of nuclear safety and security and by offering training opportunities to the embarking countries in the field of nuclear safety and security. PNRA also hosts delegations from IAEA Member States who are interested in learning about established nuclear regulatory infrastructure of Pakistan to take benefit from its regulatory experience. An IRRS Mission was conducted at PNRA in 2014. The details of the IRRS Mission are provided in Section 2 of this report

8.11.3.1 IAEA Committees, Forums and Networks

PNRA contributes to several IAEA activities conducted through various IAEA committees and other relevant fora and networks.

The Authority represents Pakistan and participates in activities as member of Commission on Safety Standards (CSS), Nuclear Safety Standards Committee (NUSSC), Transport Safety Standards Committee (TRANSSC), Waste Safety Standards Committee (WASSC), Radiation Safety Standards Committee (RASSC), Nuclear Security Guidance Committee (NSGC), Emergency Preparedness and Response Standards Committee (EPReSC), Advisory Group on Nuclear Security (AdSec), Global Nuclear Safety and Security Network (GNSSN) and Regulatory Cooperation Forum (RCF).

PNRA also participated as the national coordinator in the activities of the International Event Scale (INES), Incident Reporting System (IRS) forums of IAEA, IAEA Response Assistance Network (RANET) and Radiation Safety Management System (RASIM), etc.

During the reporting period, experts from PNRA participated in the meeting of the Director General's Advisory Group on Nuclear Security (AdSec), meetings of the Commission on Safety Standards, meetings of the Radiation Safety Standards Committee (RASSC) and meetings of the Waste Safety Standards Committee (WASSC).

PNRA Officials also represented Pakistan in the following:

i. 4th Meeting of the Working Group on Radioactive Source Security,
ii. International Generic Ageing Lessons Learned (IGALL) Working Group Meeting,
iii. First Meeting of Emergency Preparedness and Response Standards Committee (EPReSC),
iv. Program Element Working Group (PEWG 4) Meeting of AdSec,
v. 3rd Technical Meeting of the Application of the Practical Illustration and Use of the Safety Case Concept in the Management of Near Surface Disposal Project (PRISMA),
vi. Incident and Trafficking Database (ITDB) Meeting,
vii. 2nd Meeting of the Program Committee for the International Conference on Effective Nuclear Regulatory Systems: Sustaining Improvements Globally,
viii. 6th Steering Committee Meeting of the Global Nuclear Safety and Security Network; and
ix. 20th Annual Nuclear Forensics Expert Meeting.

Pakistan is a permanent member of United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR) and PNRA represents the country in UNSCEAR by contributing to the activities of this UN committee through sharing necessary information and expertise. During the reported period, PNRA participated in 62nd session of the UNSCEAR.

8.11.3.2 IAEA Technical Cooperation Projects

PNRA has been implementing two IAEA Technical Cooperation Projects “PAK/9/035-Further Strengthening of Regulatory Performance for the Pakistan Nuclear Regulatory Authority” and “PAK/9/037- Strengthening Infrastructure for Radiation, Transport and Waste Safety”. These

projects were successfully completed during the reporting period achieving their intended objectives.

Following workshops were conducted under the umbrella of PAK/9/035 and PAK/9/037 during the reporting period:

i. Aging management and periodic safety review of research reactors
ii. Developing capability in the review and assessment and validation of preventive and mitigative symptom based emergency operating procedures (SEOPs) and severe accident management guidelines (SAMGs) for NPPs
iii. Decision making and termination of protective measures during a nuclear or radiological emergency
iv. Safety culture self assessment of PNRA
v. Environmental radiation monitoring in Pakistan
vi. Level-2 PSA model development in Pakistan
vii. Technical aspects of internal dosimetry,
viii. Management system for radiation safety, technical & dosimetry services and
ix. Atmospheric dispersion analysis.

IAEA has further awarded two projects for continuation of objectives of these projects for the cycle 2016-17 by initiating TC Project PAK/9/041: Enhancing Nuclear Safety and Expansion/Sustainability of Regulatory Framework - Phase II (continuation of PAK/9/035) and TC Project PAK9/040: Strengthening of Infrastructure for Radiation, Transport and Waste Safety - Phase II (continuation of PAK/9/037).

8.11.3.3 IAEA Regional Asia Projects (RAS Projects)

PNRA participates in IAEA projects specially focused on development in Asia region termed as IAEA Regional Asia (RAS) projects in different areas related to nuclear and radiation safety.

Presently, PNRA is benefiting through participation in the activities of eighteen (18) IAEA RAS projects including workshops and training courses. During 2015, PNRA also participated in the Project Review and Coordination Meeting on Strengthening Regional Nuclear Regulatory Authorities and Safety Culture under RAS/9/061 in Bangkok from 21-24 April, 2015.

8.11.3.4 Expert Missions

PNRA collaborates with IAEA for institutional capacity building and experience sharing through IAEA expert Missions. During the reporting period,various IAEA experts visited PNRA under PNRA-IAEA Technical Cooperation Projects. In addition, twenty seven international / IAEA experts visited PNRA under IAEA-Pakistan Nuclear Security Cooperation Program for project coordination meetings and training of security professionals.

PNRA also provides its expert services to IAEA for international regulatory missions, arranging training courses in other countries, as well as providing assistance to IAEA in the development of IAEA documents and training material for the countries embarking on nuclear power.

During the reporting period, PNRA officials participated in around a hundred expert missions and consultancies. During the course, PNRA experts contributed to the IAEA Integrated

Regulatory Review Services (IRRS), Emergency Preparedness Review (EPREV), Education and Training Review Services (ETRES), and IAEA Safety Culture Self-Assessment missions.

Pakistan has, therefore, met the obligations of Article 8 of the Convention.

Article 9 – Responsibility of the Licence Holder

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

9 Responsibility of the Licence Holder

Pakistan has ensured that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence. Appropriate steps are taken to ensure that the licence holder fulfills this responsibility.

9.1 Regulatory Requirements

PAEC is the sole owner and operator of the nuclear installations. PAEC is entrusted with performing all functions including research work, necessary for the promotion of peaceful uses of atomic energy in the fields of agriculture, medicine and industry and for the execution of development projects including nuclear installations and generation of electric power.

PNRA, under the regulatory framework, regulates various aspects of nuclear installations such as licensing, design, quality assurance and operation. The regulations mention clearly that the licence holder is responsible for the safety of nuclear installations. PNRA regulation for licensing, PAK/909, states that the prime responsibility of safety lies with the licensee of the nuclear installation. Similarly, according to the quality assurance regulations, PAK/912; it is a requirement that the licensee shall retain the responsibility for the effectiveness of the quality assurance program, likewise, regulations for the safety of NPP operation PAK/913 also delineates that the licensee shall have the responsibility for safe operation.

All authorizations/licenses issued by PNRA explicitly delineate that the licensee shall retain prime responsibility for safety. The management of the installation is also responsible for providing clear and adequate guidance to its contractors to ensure that safety is integrated into all the activities and any other activity such as production shall not have priority over the responsibility for safety. PAEC, being the licensee of nuclear installations, has overall responsibility for the fulfillment of safety requirements for its nuclear installations and provides necessary resources and support to the respective management for safe operation in accordance with regulatory requirements.

9.2 Responsibilities of PAEC

The responsibilities of PAEC Headquarters with regards to nuclear installations are described below.

9.2.1 PAEC Headquarters

According to the licence of the nuclear installations, issued by PNRA, PAEC is the licensee on record for the nuclear installations in Pakistan. PAEC has delegated its responsibilities related to the safe operation of the plant to the respective plant management as per PNRA authorization, with the provision of necessary financial and human resources to meet the requirements for:

a. safe and continued operation of nuclear installations during the operating life
b. safety upgrades/modifications needed for safe operation

c. safe design, construction and operation of new nuclear installations

PAEC has established safety and quality infrastructure at the corporate and nuclear installation levels. At the corporate level, the Directorate of Nuclear Safety (DNS) and Directorate of Quality Assurance (DQA) are established to disseminate the corporate expectations and to advise the corporate management on safety and quality issues. At corporate level, Corporate Safety Review Committee (CSRC) has been established to review problems encountered during nuclear power plants operation, scientific and engineering issues of safety significance, radiation protection arrangements, physical security plans, emergency preparedness plans, quality assurance programs, administrative control and training.

At the nuclear installation level, there are approved organizational structures having required authority and independence of each unit, responsible for nuclear safety, licensing and quality assurance related activities. In addition, safety committees advise the management on safety and quality related issues. Representatives of Directorate of Nuclear Safety (DNS) at NPP sites conduct external audits of various plant divisions such as health physics, quality assurance (QA), maintenance, etc. following standard practices of international organizations, and emergency preparedness on regular intervals through an established Independent Safety Oversight Program.

In addition, various directorates at corporate level are providing design and engineering support to nuclear installations. This indigenous capability in design and engineering has resulted in enhancing the operational safety of nuclear installations as well as in review and implementation safety upgrades, as and when required. PAEC organizational chart showing the corporate directorates is shown in Annexure–V.

PAEC interacts with PNRA both at the corporate level and at the nuclear installation level. At the corporate level interaction is through Chairman and Members of PAEC to their corresponding counterparts in PNRA. The interaction between the regulatory body and the nuclear installations is through the technical directorates and regional directorates at NPP sites.

9.2.2 Karachi Nuclear Power Plant (KANUPP)

The station vision and mission has clearly been defined and communicated to all workers so that they put in all efforts in the right direction for continued safe and reliable operation of the plant to ensure safety of workers, public, and environment. The vision of KANUPP is to maintain and operate plant safely throughout the extended period beyond its design life. The mission of KANUPP is to achieve excellence in safe and reliable operation of the plant by effective implementation of safety and quality policy and by fulfilling configuration control requirements with optimum use of operating experience in all work activities of operations, maintenance and engineering support for continuous improvement.

KANUPP Safety Committee (KSC) meets regularly to discuss safety issues and gives recommendations to the General Manager, KANUPP. The committee, amongst other things reviews, current safety issues, safety related design modifications, changes to the operating policies & principles, new safety issues, reportable events, implementation of radiological emergency response plans, etc. Nuclear Safety and Licensing Division (NSLD) directly reports to the General Manager, KANUPP. NSLD is the interface with PNRA and provides oversight of safety matters within the plant. Safety Culture Assessment Programs viz-programs for

implementing corrective actions through Self Assessment, Safety Performance Indicators and Root Cause Analysis Program are in place at the plant.

9.2.3 Chashma Nuclear Power Generating Station

Chashma site organization was restructured considering the requirements of multiunit site during the reporting period. Currently, Chashma Nuclear Power Generating Station (CNPGS) headed by General Manager (CNPGS) deals with two operating units (C-1 and C-2), a common directorate of technical support and a common training center.

The mission of CNPGS is to generate electricity in a demonstrably safe, reliable and cost effective manner, for the benefit of society and stake-holders, as well as to consolidate the basis for expansion of the nuclear power program in Pakistan. The vision is to establish a modern, effective and efficient management system within the organization, to enhance the standard of management. CNPGS is earnestly working to achieve its mission and vision.

Technical divisions of C-1 and C-2 are responsible for system performance evaluation of structures, systems and components related to safety, safety surveillance during operation and outage, review of safety and technical specification modifications etc. Nuclear safety and operating experience section of technical division is responsible for providing an interface with the regulatory authority and performs the function of collecting and utilizing operating experience feedback within C-1 & C-2 and manages Corrective Action Program. Technical division also coordinates the follow-up actions of C-1 PSR as part of the Corrective Action Plan.

Each plant has a high level safety committee, namely Operational Safety Review Committee (OSRC) which is headed by the respective plant manager. Other members include the deputy plant manager, manager operation, manager health physics, manager quality assurance and manager technical. This committee, among other functions, reviews and assesses changes to approved technical specifications, safety related equipment/systems, tests, new safety issues, violations of approved technical specifications, deficiencies in design or operation that may affect safety, radiological emergency response plan, physical protection plan etc.

9.2.4 Chashma Nuclear Power Project Unit -3 (C-3) and Unit-4 (C-4)

The Safety and Licensing Division of C-3/C-4 is responsible for addressing safety related matters. This Division is also responsible for coordinating safety review, implementing Configuration Management Plan during installation phase. A Quality Assurance Division ensures quality through the implementation of the Quality Assurance Program. It performs audit of the activities of designer, contractor and sub-contractors and performs QA surveillance during installation at site. Technical Coordination Division reviews basic and detailed design and design modifications in coordination with other design establishments of PAEC. The review performed by the Technical Coordination Division is independent of the review performed by the designer.

The licensee is committed to abide by the requirements set by PNRA regulations, licence conditions and directives of PNRA, issued from time to time. The licence holder submits the required safety reports and documentation as prescribed in the regulations or required by PNRA in support of safety case. In addition, the licence holder facilitates the regulatory body to perform regulatory inspections, during all phases of the plant life, which are carried out by PNRA to verify that the requirements of the regulations and conditions of the licence are met.

9.2.5 Karachi Nuclear Power Project Unit-2 (K-2) and Unit-3 (K-3)

The Safety Division of K-2/K-3 is responsible for addressing safety related issues. This division is also responsible for coordinating the safety review, dealing with licensing matters with regulatory body and implementing Configuration Management Plan during construction. A Quality Assurance Division (QAD) ensures quality through the implementation of the Quality Assurance Program. It performs audit of the activities of designer, contractor and sub-contractors and performs QA surveillance during installation at site. The licensee is committed to abide by the requirements of the PNRA regulations along with the licence conditions and directives of PNRA issued from time to time. The licence holder submits the required safety reports and documentation as prescribed in the regulations or required by PNRA in support of safety case. In addition, the licence holder facilitates the regulatory inspections, during all phases of the plant life, which are carried out by PNRA to verify that the requirements of the regulations and conditions of the licence are met.

9.2.6 Technical Support to Operating Units

KANUPP management ensures that effective technical support activities are provided as necessary for safe and reliable operation of the plant. The major activities of technical support are performed by Technical Division, Design and Development Division, Control Instrumentation Application Laboratory and Computer Design & Development Division. Roles, responsibilities and programs for each Technical Support Divisions of KANUPP are clearly defined and understood by plant personnel. Resources and engineering support are provided for plant life extension plans.

Directorate of Technical Support of CNPGS is composed of eight (08) divisions. Radioactive waste management division assists operating units in radioactive waste management activities. Technical coordination division assists in performing engineering and safety analysis, preparing design modifications, fuel management and core management activities and RFO planning activities. Information system division establishes and maintains information for the plants. Equipment management division develops and manages the PSI, ISI and ageing management programs. Structure & services division provides supporting activities related to construction and surveillance of structure/ buildings. In addition, three maintenance support divisions related to mechanical, I & C and electrical, maintenance assist the plants in major maintenance activities. Directorate of CHASCENT provides training and re-training to operating personnel of C-1 and C-2. Besides Operation Training, CHASCENT also provides basic training, maintenance and technical training.

Corporate technical support is also provided to monitor and prepare for different plant operational as well as improvement activities. PAEC Corporate office sends various technical support teams from time to time to evaluate and assess different on-going activities at KANUPP and CNPGS including implementation of Fukushima Response Action Plan (FRAP).

9.3 PAEC Mechanism for Maintaining Open and Transparent Communication with Public

Various measures have been adopted by PAEC to maintain open and transparent communication with public. This communication is carried out through PAEC website by posting information about nuclear power plants which is updated periodically.

At NPP site, plant management interacts with public residing in nearby areas to share information about nuclear power plants and their potential hazards. The education of public regarding protective actions to be taken during emergency situation is also carried out during these sessions.

A hearing session was also carried out for K-2/K-3 units by PAEC in collaboration with Sindh (provincial) Environmental Protection Agency (SEPA) at the time of finalization of site before construction of these NPPs. This forum also provided an opportunity for open and transparent dialogue/ communication with public regarding their safety concerns about NPPs.

9.4 National Mechanism for Ensuring Effective Onsite Accident Management by PAEC

PNRA is authorized through section 39(2) of PNRA ordinance 2001 to ensure, co-ordinate and enforce preparation of emergency plans for action to be taken following foreseeable nuclear incidents/accidents that might affect the public and environment.

Emergency plans are submitted to PNRA at the licensing stage of "introduction of nuclear material into the nuclear installation" as per regulations on licensing of nuclear installations, PAK/909. These plans are reviewed and approved by PNRA. The full scope implementation of these plans is demonstrated by licensee and is witnessed by PNRA inspectors which is one of the contributor towards regulatory decision making regarding above mentioned licensing stage. PAEC corporate office also participates as observer and evaluator, for the independent assessment of such emergency exercises and recommends actions for improvement accordingly.

During the operation phase of NPPs, the emergency plans are regularly verified through exercises / drills by licensees to ensure that sufficient resources (human, technical and financial) and infrastructure is available for on-site management of incidents/accidents and mitigation of their consequences. These exercises / drills are carried out under regulatory oversight of PNRA.

On behalf of Government of Pakistan, PNRA ensures through its regulatory oversight process that licence holder has adequate resources and powers for effective on site management of an incident/accident and mitigation of its consequences.

Pakistan has, therefore, met the obligations of Article 9 of the Convention.

Article 10 – Priority to Safety

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

10 Priority to Safety

Pakistan has taken appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations have established policies that give due priority to nuclear safety.

10.1 Regulatory Requirements

PNRA Regulations PAK/909 require that 'safety first' shall be the guiding principle in the Siting, Design, Construction, Commissioning, Operation and Decommissioning of nuclear installations. Regulations PAK/913 requires that special emphasis shall be placed on safety during operation of NPPs. The operator is required to establish an effective organizational structure for making and implementing policies for prioritizing nuclear safety and quality, allocating adequate resources, enforcing requirements like fitness for duty, etc. PNRA Regulations PAK/913 further require that a policy on safety shall be developed by the licensee and adhered to by all site personnel. This policy shall give the utmost priority to the safety at the installation, overriding the demands of production and project schedules. The policy should include a commitment to excellent performance in all the activities important to safety and shall encourage an inquisitive attitude. All activities that may affect safety and which can be planned in advance shall be conducted in accordance with established procedures and shall be performed by suitably qualified and experienced individuals. Furthermore, regulations require that regular reviews of the operational safety of the plant are conducted, with the aim to ensure that an appropriate safety consciousness and safety culture prevails, the provisions set forth for enhancing safety are observed, documentation is up-to-date and no indications of overconfidence or complacency exist at the plant.

10.2 Nuclear Safety Policy of PAEC

Pakistan Atomic Energy Commission (PAEC) is the owner and operator of nuclear installations and has overall responsibility for safety. PAEC has formally established and implemented a Nuclear Safety Policy from which specific safety rules, procedures and other requirements are derived. Complete text of Nuclear Safety Policy of Pakistan Atomic Energy Commission is available at PAEC website: http://www.paec.gov.pk

10.3 Priority to Safety in Nuclear Installations

The licensee of nuclear installations in Pakistan is committed to give priority to nuclear safety. After Fukushima Daiichi Accident, PAEC corporate management formed a taskforce for safety assessments of nuclear installations in light of the lessons learnt from the Fukushima Daiichi Accident and the IAEA Nuclear Safety Action Plan. Areas were identified for improvement in terms of availability of equipment and measures to perform safety functions in case of severe accidents, extreme natural hazards and combined effects of severe accidents and extreme natural hazards such as Mobile Emergency Power Sources, Hydrogen Control & Mitigation Systems, Off-site Emergency Planning and Preparedness etc. PAEC also allocated financial resources for the implementation of the measures, as identified through FRAP on priority.

Considerable progress is realized relevant to the pending actions during the reporting period, however, implementation of some long term actions remained in progress.

Systems of reporting events such as low level events /near misses, corrective action program, equipment health monitoring, and operational experience feedback was further strengthened. WANO Peer Reviews have been carried out at C-1, C-2 and KANUPP in the reporting period. Such activities have added to the improvement of safety at nuclear installations in Pakistan.

Safety culture program for CNPGS has been developed and approved in October, 2014. The implementation of program has been established.

In 2015, 1073 personnel of CNPGS and C-3/C-4 have received training on safety culture. Continuous training is being arranged and conducted by CHASCENT for all employees of CNPGS. The internal assessment of safety culture at C-1 was conducted in March, 2016.

10.3.1 Priority to Safety at KANUPP

At KANUPP, the Plant Vision, Mission, Goals and Objectives have been clearly outlined so that all plant personnel remain well aware of their responsibility in ensuring safe and reliable operation of the plant.

In addition, Station Instructions for Corrective Action Program (CAP), Self Assessment Program (SAP), and Safety Performance Indicators (SPI) are implemented. Event reporting process has been made easy so that any worker can directly report an event to the CAP Group. After evaluation and/or investigation, wherever required, necessary corrective measures are taken and feedback is provided to the reporting person. An in-house database of CAP has been developed and is accessible to all the plant personnel through Local Area Network (LAN). Open training sessions / lectures are carried out on CAP and SAP to enhance awareness and acceptance of these programs amongst plant personnel. To further improve safety culture and event reporting attitudes, every year a shield is awarded to the Division having best reporting record and certificates are awarded to one officer and one staff member for best safety suggestion. Focused Self Assessment (FSA) is carried out on monthly basis to assess the areas in which deficiencies in soft issues are highlighted by the CAP. Necessary actions are developed and tracked to further improve these areas.

In compliance with the Safety Policy of PAEC, safety is given the highest priority at KANUPP. Safety upgrades as suggested in Regulatory Review, Corporate Review and International Missions are always given highest priority.

After completion of design life of 30 years in 2002, safety upgrades were implemented, as per 1st PSR and PNRA requirements in two phases during 2003 and 2006. Examples of improvements made are given in this report in Section 2.4 (Article 14 : 'Reassessments at KANUPP').

The 2nd PSR was completed in 2014. There were no high category safety issues identified as a result of this PSR. This was due to the fact that safety improvements suggested in FRAP-K1 action plan were given the highest priority during 2012-2014. Most of the safety upgrades given in FRAP-K1 action plan and 2nd PSR of KANUPP have been completed during 2013-2015. Please see Section 14.2.1 of this report for more details on second PSR of KANUPP.

Several WANO technical missions including a Peer Review Mission were conducted at KANUPP during the reporting period.

10.3.2 Priority to Safety at C-1

The safety policy of C-1 is being implemented. Management of C-1 bears full responsibility for the safety of the plant according to the Safety policy. Plant Manager holds daily work plan meetings to discuss safety issues and ways of their resolution. Safety and quality takes precedence over production objectives. Event reporting is encouraged and any plant worker can report events and near misses through a user friendly reporting system. After evaluation and investigation, wherever required, necessary corrective measures are taken and feedback is provided to the reporting person. An in-house database of low level events, near misses and corresponding corrective actions is accessible to all the plant personnel through Local Area Network. CNPGS has implemented safety performance indicators program to monitor trends of operational safety of the plants in various domains. A Follow-up Peer Review of C-1 was conducted by WANO in May, 2015. An OSART Mission to C-1 was also conducted from Nov - Dec,2015.

10.3.3 Priority to Safety at C-2

C-2 is operating safely and has completed its 2ndand 3rd refueling outages successfully during the reporting period. At C-2, event reporting is encouraged and any worker of the plant can directly report events and near misses through a user friendly reporting system. After necessary evaluation and investigation, wherever required, necessary corrective measures are taken and feedback is provided to the reporting person accordingly. An in-house database of event reports and corresponding corrective actions has been developed and made easily accessible to all the plant personnel through Local Area Network. C-2, along with C-1, has developed safety performance indicators to monitor operational safety of the plant. Plant personal are encouraged to report abnormal events and any “near misses” relevant to the safety and availability of the plant.

Operating experience is carefully examined to detect any precursor signs of possible tendencies adverse to safety and availability, so that corrective actions could be taken before any serious condition is encountered. Regular reviews of the operation of C-2 are arranged to ensure that safety consciousness exists and provisions set forth for enhancing safety are observed. Plant Manager holds daily work plan meetings to discuss safety issues and ways of their resolution. Safety and quality is given priority over production objectives. An operation safety review committee (OSRC) is in place which performs assessment and reviews for safety evaluations of procedures, modification(s) in procedures, equipment, system or facilities etc. and investigating any violations of the technical specifications. Periodic safety review of plant would be performed at regular time intervals of ten years of operation in order to ensure plants safety in light of operating experience and significant new safety information/issues.

A WANO Peer Review mission was conducted at C-2 in April -May, 2015.

In order to enhance safety and reliability, technical support organizations are established which provide the technical support required for operations and maintenance activities of the plants.

10.3.4 Priority to Safety at C-3 and C-4

Priority to safety at C-3and C-4 is considered the most important aspect in accordance with the safety policy and objectives. Safety has been ensured in different phases of Siting, Design and Construction in compliance with the regulatory requirements and international standards through reviews and assessments. An Overall Quality Assurance Program (OQAP) for C-3 and C-4 is developed in accordance with PNRA's "Regulations on the safety of nuclear power plants quality assurance "PAK/912, Rev.1 and IAEA Code on "Quality assurance for safety in nuclear power plants and other nuclear installations" 50-C/SG-Q. This OQAP is applicable to all the safety related structures, systems and components as well as important non-nuclear safety structures, systems and components.

A WANO Pre-Startup Review mission for C-3 was conducted in Jan, 2016.

10.3.5 Priority to Safety at K-2 and K-3

Utmost importance has been given to 'Priority to Safety' in safety policy/objectives at K-2 and K-3. Safety has been ensured in different phases of Siting, Design, Construction and manufacturing in compliance with the regulatory requirements and international standards through reviews, assessments and inspections. A 'Management System Manual for Design and Construction phase of K-2/K-3' is developed in accordance with PNRA's "Regulations on the safety of nuclear power plants quality assurance - PAK/912" and IAEA Safety Standard 'The Management System for Facilities and Activities, GS-R-3'. This Management System Manual is applicable to all the safety related structures, systems and components as well as important non-nuclear safety structures, systems and components.

K-2 and K-3 project organization is established to plan, monitor and control the design and construction activities to meet the safety objectives. Trained manpower has been made available to carry out all activities important to safety. At design stage, probabilistic safety assessment was performed in addition to the deterministic safety analysis.

Upon satisfactory completion of licensing process, Construction licences have been awarded to K-2 and K-3 in 2015 and currently both plants are in construction phase.

Priority to safety is given prime importance during the construction of safety related structures of K-2 & K-3 and regulatory oversight process is in place during the construction phase.

10.3.6 Corporate Safety Oversight Program for NPPs

Pakistan Atomic Energy Commission (PAEC) created Directorate of Nuclear Safety (DNS) to manage corporate safety policies, actions related to safety and to promote and enhance safety practices by conducting corporate safety reviews/inspections of all operating NPPs in accordance with Corporate Safety Oversight Program. The safety oversight process focuses on the plants' operational safety and practices for ensuring the safety of workers, public and the environment. Major elements of safety oversight include daily inspections, plants surveillance, periodic corporate safety reviews, follow-up reviews, inspection of RFO's activities and reactive safety oversight.

10.4 Verification of Safety by PNRA

To effectively influence, monitor, and provide oversight of operators' safety culture, PNRA conducted a pilot project on the assessment of its own safety culture in collaboration with the IAEA. Data for the assessment was collected through observations, interviews of employees, focus group discussions, surveys and documents review. A program is being chalked out to enhance the strengths and overcoming the weak areas in order to improve the safety culture of the organization. PNRA also shared its safety culture assessment process with the licensees.

PNRA regulatory oversight program covers verification of all nuclear safety related activities. PNRA promotes safety culture in nuclear installations by ensuring that it is on the agenda of the licensee at the highest organizational level. PNRA inspection program for nuclear installations cover safety culture inspections in addition to other safety significant areas.

In safety culture inspections, PNRA relies primarily on the notes and reports of inspectors collected during plant visits, reviews of documentation, and interviews with plant personnel, etc. It is supplemented through reviews of event and near misses reports, post event inspections and licensees' self assessment reports, etc.

The policy of priority to safety is closely followed by PNRA during its regulatory oversight of nuclear power plants.

10.5 Means used by PNRA to Prioritize Safety in its Own Activities

The policy of giving priority to safety is rigorously followed by PNRA as a top-down approach for handling nuclear safety related issues. PNRA formulated the regulatory processes in its Management System using the principle to giving priority to nuclear safety in its activities and decision making. Resources are allocated using the graded approach. Authorization of nuclear installations is focused on satisfactory resolution of all safety related issues pertaining to nuclear safety. During regulatory inspections, control points among the on-going activities of the licensee are selected based on their significance to nuclear safety and experience feedback.

The top management of PNRA adopted and inculcated specific core values that expect all employees of PNRA to demonstrate consciousness towards nuclear safety.

Pakistan has, therefore, met the obligations of Article 10 of the Convention.

Article 11 – Financial and Human Resources

"1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.

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

11 Financial and Human Resources

Pakistan has taken appropriate steps to ensure that adequate financial resources are available to support the safety of nuclear installations and that sufficient number of qualified staff with appropriate education, training and retraining are available for all safety related activities at each nuclear installation throughout its life. The adequacy of the resources was re-assessed after Fukushima Daiichi Accident and augmented wherever found necessary.

11.1 National Requirements for Financial Resources

The licensee is required to ensure that adequate resources, services and facilities are provided for the safety of the nuclear installation.

11.2 Financial Resources at Nuclear Installations

Nuclear installations are owned by PAEC (Government sector organization) with a clear commitment to provide financial resources required throughout their lifetime. National Electric Power Regulatory Authority (NEPRA) is the electricity tariff determining body in Pakistan. While fixing the unit (kilowatt-hour) price to be paid by the distribution companies to PAEC, it takes into consideration the specific issues related to nuclear installations such as operation and maintenance, refueling outages, decommissioning costs, storage and disposal of radioactive waste, periodic safety reviews and upgrades, etc. A fund is also maintained to cope with the radiological emergencies for each site.

11.3 National Requirements for Human Resources

PNRA Regulations PAK/912, and PAK/913 require that the nuclear installations are staffed with competent managers and qualified personnel having proper awareness of the technical and administrative requirements for safety. The regulations specify the requirements for academic qualifications, experience at nuclear and other installations, training and retraining, examination procedures, etc. The regulations also specify the requirements for qualification, training and experience required for issuance of licence to operating personnel, validity, conditions to be satisfied for renewal of the license and conditions for revoking or cancellation of license.

11.4 Human Resources, Training and Retraining for Nuclear Installations

At the national level, PAEC has established a number of institutions for the human resource development needed for operation of its nuclear installations. The Pakistan Institute of Engineering and Applied Sciences (PIEAS) at Islamabad imparts education at the post graduate level in several disciplines including Nuclear Engineering and Systems Engineering.

Karachi Institute of Power Engineering (KINPOE) at Karachi is also conducting post graduate level degree courses (MS) in addition to post graduate training program (PGTP) and post diploma training program (PDTP). In-Plant Training Center (IPTC) at KANUPP trains mainly the operating personnel for licensing examinations. CHASNUPP Center of Nuclear Training (CHASCENT) at Chashma fulfils the needs for training of plant personnel including training in radiation protection and industrial safety. CHASCENT also runs one year post graduate training program (PGTP) in the design and operation of PWR type plants.

Specialized training courses are offered by National Centre for Non-Destructive Testing (NCNDT) and Pakistan Welding Institute (PWI) in the fields of non-destructive testing and welding technology respectively. PAEC has a sizeable pool of specialists working in diverse fields to support the design and engineering activities in nuclear installations. Support from the original plant designers and vendors/suppliers is also available under various agreements to supplement the PAEC expertise. PNRA and PAEC organize symposia, workshops, training courses, etc. in collaboration with IAEA in the areas related to nuclear safety. The scientists and engineers of PNRA and PAEC also receive training in various areas of nuclear safety in other member states through the support of IAEA.

PAEC inducts fresh engineers, scientists and technicians every year so that the age profile of the organization remains balanced. Trainings and re-trainings are provided to the operation and maintenance personnel of the plants. PAEC employs engineers and scientists possessing high academic qualifications such as Master of Science and/or Bachelors in Engineering in relevant disciplines or other post graduate degrees. Many engineers and scientists have received comprehensive training in relevant fields both in Pakistan and abroad. The plant technicians possess three years diploma in associate engineering after their Secondary School Certificate examination from various institutes of the country or have B.Sc. degrees from recognized universities. They are given one year Post Diploma Training (PDT) at CHASCENT. KINPOE also conducts Post Diploma Training for technicians.

The organization of the NPPs is such that all the managerial and supervisory positions are held by graduate engineers with a minimum of 6 to 10 years' experience in respective fields. The qualification requirement for shift supervisors and shift engineers is bachelor's degree in engineering along with minimum three years of requisite operation training before obtaining necessary licenses.

Qualification and training of operating personnel follow the regulatory requirements of PAK/913 and training program of the plant. PNRA conducts oral and operating examination for award of licenses to operating personnel. Main Control Room (MCR) engineers of CNPGS undergo mandatory training on a Full Scope Training Simulator (FSTS) for obtaining shift engineer and shift supervisor licence. The licensed operation engineers receive retraining on FSTS twice in a calendar year. The licensed personnel are re-examined internally every year. The field operators also undergo two months retraining every year.

While considering issuance of Fuel Load Permit or allowing commissioning, the availability of appropriate manpower is verified by PNRA. MCR operators including the shift supervisors are required to obtain licenses from PNRA prior to first fuel loading. The shift complement is also verified by PNRA resident inspectors during operation. It is ensured that the nuclear installations maintain a sufficient number of qualified and skilled manpower in all areas necessary for safe operation.

Operation Training Division (OTD) has contributed in development of skills & knowledge of Operation Manpower for existing and upcoming NPPs of PAEC. OTD has contributed to development of sufficient manpower for operation of CNPGS plants in six crews shift complement. It has met the requirements of PNRA Regulations PAK/913 for License renewal of Shift Engineers & Shift Supervisors of CNPGS. It has also resulted in the availability of qualified manpower as Turbine Operators, Electrical Operators & Local Area Operators.

OTD has completed the Joint Review on Detailed Functional Specification (DFS) of selected system for C-3/C-4 Full Scope Training Simulator (FSTS) through collective & coordinated response in the view of Operating Experience Feedback of C-1/C-2 FSTS.

It has made progress through all phases (Analysis, Design, Development, and Implementation & Evaluation) of Systematic Approach to Training (SAT) practices and consulted various international guidelines on SAT. It has developed sufficient Lesson Plans & related Training Material to ensure wide use in OTD.

Based on the feedback & risk assessment, OTD imparted Specialized Training Packages for Operation Manpower of CNPGS using simulator and class room training on Mid Loop Operation (Along with related WANO SOERs) & De-Graded Grid Conditions (along with related WANO SOERs) well before the Refueling Outages. Benefits of same were observed during the refueling outages at C-1/C-2.

Qualification and training of maintenance and technical personnel follow the FSAR requirements which are implemented through plant qualification and training procedures. Technical personnel undergo initial and refresher training on field related topics which is based on both in-class lectures as well as practical training. They are also continuously trained in Safety Culture, Industrial Safety, Radiation Protection, EPP, Plant systems, Plant Modifications, Plant events, Supervisory and Coaching Skills.

Besides basic operation, maintenance and technical training, PAEC has different management training programs to groom all the officers during different stages of their service to increase their capability and productivity which in turn will increase the overall safety as well as efficiency of PAEC.

Since Government of Pakistan plans to increase the nuclear power generation capacity to 8800 MWe by 2030, PAEC is enhancing the capacity of its training institutes such as PIEAS, KINPOE, CHASCENT, etc.

11.5 Resources for Decommissioning and Waste Management

PAEC is committed to carry out decommissioning of its nuclear facilities in a safe manner when it becomes necessary. PAEC is also committed to safe and secure management of radioactive waste generated from activities in its nuclear facilities according to National Policy on Control and Safe Management of Radioactive Waste. PAEC has also ensured provision of adequate financial resources for decommissioning and waste management at major nuclear facilities. National Policy on Control and Safe Management of Radioactive Waste requires that the producer of radioactive waste shall be responsible for safe and secure management of radioactive waste and shall bear the expense for its safe disposal.

KANUPP has described its decommissioning funding and waste management in Preliminary Decommissioning Plan. Decommissioning funding of KANUPP is managed from its own earning.

C-I and C-2 ensured provision of adequate financial resources for decommissioning activities through establishment of dedicated funds whose purpose is to manage disposal of operational as well as decommissioning waste and to carry out safe and environment friendly decommissioning. Deferred dismantling (safe storage) strategy is proposed for its decommissioning. Rad-waste Solidification Building will be used for solidification of liquid radioactive waste generated during decommissioning activities. With the passage of time, latest and advanced techniques involved in decommissioning activities will be adopted in a safe and cost-effective manner.

11.6 Human Resources, Training and Retraining at PNRA

Competency development of the regulatory staff is a top priority of PNRA. Therefore, right from its inception, PNRA has focused on the transfer of knowledge and skills of the experienced nuclear professionals to the younger generation. A number of steps have been taken over the last few years to strengthen professional capabilities of PNRA staff. These included in-house professional trainings, courses in local training institutes, foreign regulatory bodies and technical organizations. PNRA also arranged participation of its personnel in international workshops and fellowship programs of the IAEA in specialized fields, provided on-the-job trainings, and scientific visits to enhance the technical competencies for the regulation of nuclear power plants and radiation facilities in Pakistan

11.6.1 Human Resource Development at PNRA

Initially, PNRA established an Education and Training unit with the responsibility for inducting fresh technical staff and to arrange training for them. Later, the unit was transformed into a Human Resource Development Directorate (HRD).

PNRA attaches engineers with plant operation groups for a period up to four years. These engineers receive plant operation training and obtain licence for operating the plant. Afterwards, these engineers rejoin PNRA and assist in review and assessment, regulatory inspections and conducting the licensing examinations of plant operating personnel.

The total number of technical professionals currently at PNRA is around 300. However, in view of the Government’s plan for increasing nuclear power production to 8800 MWe by the year 2030, regulatory responsibilities of PNRA are also expected to increase in the coming years.

PNRA has adopted following processes for the competency development of its staff:

i. In-house training programs and

ii. Trainings arranged in external organizations.

In 2014, the 'School for Nuclear and Radiation Safety' (SNRS) and the 'Nuclear Security Training Centre' (NSTC) of the Nuclear Security Action Plan (NSAP) were merged to form the "National Institute of Safety and Security (NISAS)".

The NISAS faculty consists of experienced faculty members capable of imparting technical as well as regulatory knowledge at the national/international level. NISAS has produced a number of training manuals for various courses and possesses classrooms, well equipped with computers and multimedia systems. Other facilities at the institute include PWR simulator, physical models of plant major equipment, radiation protection laboratory, physical protection laboratory and various computer codes.

The institute is capable of assisting the international community in enhancing the competency of regulatory professionals. Faculty members of the NISAS participated as resource persons in a number of training courses arranged by IAEA in the areas of Basic Professional Training Course (BPTC) on Nuclear Safety, Human Resource Management, Competence Needs Assessment and Knowledge Management.

11.6.1.1 Trainings Arranged at External Organizations

During the reporting period, PNRA has arranged education and training of its employees at various national and international training institutes and continued to maintain training profiles of its workforce. HRD arranged training courses at local training institutes like Pakistan Institute of Management (PIM), Pakistan Welding Institute (PWI), National Center for Non Destructive Testing (NCNDT), Pakistan Atomic Energy Commission (PAEC), National University of Modern Languages (NUML), Research Society of International Law (RSIL), Secretariat Training Institute (STI), and Pakistan Manpower Institute (PMI).

PNRA also arranged a number of training courses and training fellowship schemes at international institutes as detailed below.

a) Training in Pakistan through expert missions from IAEA, NSC etc.

b) Fellowships at IAEA and other countries through TC projects

c) Placement at NNSA, NSC China and other Chinese organizations

11.6.2 Research and Development

Research and development activities remained in progress at the Center for Nuclear Safety and the Safety Analysis Center (SAC) of PNRA in collaboration with national academic and research institutions like Pakistan Institute of Engineering and Applied Sciences (PIEAS), Nuclear Institute of Agriculture and Biology (NIAB), and Pakistan Institute of Nuclear Science and Technology (PINSTECH) in the areas of nuclear and radiation safety. Moreover, PNRA maintains bilateral relationships with some international research institutions like Nuclear Safety Centre (NSC) Beijing, China Nuclear Power Operation Technology Corporation (CNPO) and the IAEA for research and exchange of safety related information.

PNRA officers are also encouraged to acquire higher education in the field of nuclear safety at reputed universities such as the Korea Institute of Nuclear Safety (KINS), etc.

Pakistan has, therefore, met the obligations of Article 11 of the Convention.

Article 12 – Human Factors

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

12 Human Factors

Pakistan has taken appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation. PNRA and PAEC recognize that human performance plays an important role in ensuring the safety of a nuclear installation during all phases, i.e. Siting, Design, Construction, Commissioning, Operation and Decommissioning. Accordingly, PNRA has set regulatory requirements for establishing management systems and procedures for taking into consideration limitations and human performance to ensure safe operation of nuclear installations. Subsequently, PAEC has established management systems and procedures for analyzing events resulting from human errors and to improve human performance for ensuring safe operation of nuclear installations.

12.1 Regulatory Requirements

PNRA Regulations PAK/911 require due consideration of human factors at the design stage. The design is required to be ‘’operator friendly’’ aiming at minimizing human errors and their effects. Systematic consideration of human factors and the man-machine interface must be included in design process at an early stage and should continue throughout the plant life. This would ensure an appropriate and clear distinction between the functions of operating personnel and those of automatic systems.

The aim of the design is to promote the success of operator actions with due regard to the time available for action, the physical environment to be expected and the psychological demands to be made on the operator. The need for intervention by the operator on a short time scale must be kept to a minimum. The necessity for such intervention is only acceptable when it can be demonstrated that the operator has sufficient time to make a decision and to act. The information necessary for the operator to make the decision to act should be simple, understandable and unambiguous. In addition, following an event, the physical environment in the main control room or in the supplementary control room and on the access route to that supplementary control room should be acceptable.

PNRA Regulations PAK/913 requires that the licensee defines the qualifications and experience necessary for personnel performing duties that may affect safety. Suitably qualified personnel are selected and are given necessary training and instruction enabling them to perform their duties correctly for different operational states of the plant and in the case of an incident/ accident, in accordance with the established procedures.

A high level of health and fitness is required for the personnel of nuclear installations. Accordingly, PAK/913 requires that all personnel of the operating organization (licensee) whose duty may affect safety shall be medically examined on their appointment and at subsequent intervals to ensure their fitness for duty and responsibilities assigned to them. Psychological examination is also required for licensed control room operating personnel. In addition, PAK/904 elaborates requirements for health surveillance program of radiation workers.

PNRA evaluates all elements of Human Factors Engineering (HFE) planning and analysis. HFE program management, operating experience review, function requirement analysis and function allocation, task analysis, staffing and qualification and human reliability analysis, human system interface design, procedure development, training program development, verification and validation, design implementation and operation are reviewed as per requirements of PAK/911, PAK/913, USNRC NUREG-0800, NUREG-0700, NUREG-0711 and NUREG-1764.

12.2 Steps Taken by PAEC to Ensure Consideration of Human Factors

KANUPP has made several design improvements to enhance human performance like implementation of Safety Parameters Display System (SPDS) and Critical Parameters Display System (CPDS). This facility is available in the Main Control Room (MCR), Emergency Control Center (ECC) and Alternate Emergency Control Center (AECC) so that the operator can monitor the plant status under accident and transient conditions more easily and can take corrective actions when required to bring the plant to a safe shutdown state. At KANUPP, SAMGs have been revised in the light of lessons learned from Fukushima NPP accident. Emergency Operating Procedures (EOPs) and Severe Accident Management Guidelines (SAMGs) have been revised as a result of FRAP-K1 modifications at the station. Revised EOPs and SAMGs are now part of regular training programs of operators and all relevant personnel. The online computation of entry condition to SAMGs is also incorporated in SPDS. Human reliability analysis is also regularly practiced to improve safety of the plant.

The design of the main control rooms (MCR) of CNPGS plants is based on a comprehensive and systematic task analysis and follows good human factors practices to facilitate the operators. It is compatible with human psychological and physical characteristics and enables the required tasks to be performed reliably and efficiently. In order to overcome human errors related to alarms, Alarm Response Procedures (ARP) have been implemented after verification & validation and simulator training.

In original design of MCRs, a number of alarms were lit undesirably thus causing undue burden on MCR operators. C-1 and C-2 accordingly initiated an Undesired Alarm Reduction Program to reduce all such alarms by changing the alarm logic. In this regard, a number of alarms were identified both in nuclear and conventional systems. The reduction of undesired alarms is in progress at C-1 and C-2 Full Scope Training Simulators.

At C-1 & C-2, Symptom Based Emergency Operating Procedures (SEOPs) have been developed, validation process of these procedures at C-2 FSTS was completed successfully and initial training was imparted to all MCR Engineers. At C-1, revision of SAMGs is in progress. For C-2, SEOPs were completely implemented in Aug 2014 while SAMGs, which have been developed, will be revised in line with C-1.

On the basis of HFE requirements, Bypass Inoperable Safety Indication System (CBI) has been included in the MCR of C-2. Several improvements have been made on the basis of requirements of HFE design standards and operating experience of C-1, in human system interface design of main control room, local control rooms, MCR alarm system and training programs of plant specific full scope training simulator.

Plant specific full scope training simulator is used for the training and qualification examination of operators. All activities at nuclear installations are carried out in accordance with approved procedures. The licensee ensures that technical content of the instructions is correct, and that

the design and presentation of instructions enable users to follow them accurately and reliably. This reduces the chances of human error. The procedures and instructions are subject to a process of verification and validation to ensure that they accurately represent operational requirements and are compatible with the design of plant and equipment. Suitable arrangements are made to implement these procedures and instructions. Nuclear installations have performed PSA including human factor events and their importance for different stages of the plant life. Through Human Reliability Analysis (HRA), human error probabilities are calculated for the errors that may be due to procedural lapses or operator errors. These inputs are used to improve procedures and operator training on simulator to minimize human errors.

KANUPP revised its full power PSA with internal fire event. On the basis of Fire PSA results, design improvements are being implemented that include passive and active fire suppression systems to prevent/control cable fire. KANUPP has also reviewed and revised its on-power internal initiating events PSA Level-1 report in 2015. At KANUPP, risk based operational decision making process is followed that considers human factors as well.

C-1 has performed PSA Level-1 (full power internal initiating event excluding internal fire and flood). C-1 is working on incorporation of IPSART recommendations (see Section 14.2.2). C-1 has performed an internal fire and flood PSA as well as low power and shutdown PSA which is under review at PNRA. The Human Reliability Analysis has also been carried out. The following HRA recommendations have been implemented at C-1 and C-2:

i. Stand by systems are now tested on staggered basis.
ii. I&C maintenance and calibration activities are performed on staggered basis.
iii. Important post-accident operator actions are incorporated in regular simulator training exercises.

C-1 and C-2 are implementing operating experience feedback program to collect, categorize, investigate and implement corrective actions plan. If human performance related issues are found, it is subject of further investigation to identify the corrective actions to prevent the recurrence.

In C-3 and C-4, Human Factor Engineering has been applied from the conceptual design phase to final detailed design. All elements of Human Factors are considered in the control room design in accordance with international practice and experience feedback from C-1 and C-2.

Following improvements have been made based on feedback from C-1 and C-2:

a. Provision of selector switch with separate current indicator for two auxiliary oil pumps for each Main Feed Water Pump for indication of running pump.
b. The design of Steam Generator Manhole cover studs of C-3/ C-4 has been modified to reduce worker's radiation dose and also outage duration.
c. At turbine floor, sound proof room has been provided for local operators along with communication arrangements with Main Control Room and Local Control Room turbine building.
d. Augmentation of communication facilities in emergency compressed air hall.
e. Improvements in control console in local control rooms.
f. Engraved tags (identification labels) are provided for keyboards in local control rooms.
g. Improvements (mimics, one-line diagrams etc.) in Plant Computer System (CPC).
h. Improvement in indication of switches in Main Control room.
i. Addition of new alarms in Main Control room.

12.3 Verification of Human Factors Considerations by PNRA

PNRA verifies that the human factors are considered throughout the life of a nuclear installation. Firstly, at the design stage, it is ensured that human factors are considered in the probabilistic safety assessment, design of main, emergency and local control rooms, safety parameter display system, safety system bypassed and inoperable status indication system, post accident monitoring system, alarm system, full scope training simulator, communication system, procedure development, training program development, technical support center and emergency control center. Secondly, during operation stage, regulatory inspections include various elements like checking of work conditions such as lighting, labeling, environmental and habitability issues, housekeeping, fitness for duty, etc.

PNRA Inspectors witness simulator exercises during training/re-training. They also carry out inspections of operation shift crews to verify compliance with procedures and to assess whether the operator actions are in accordance with the procedures and design intent. Human performance evaluation is also an essential element of safety culture. Inspections and reviews of unusual occurrence reports determine the contribution of human factors in initiation and progression of the event.

While reviewing PSA of all nuclear installations, it is verified that human factors have been adequately considered and all operator actions are modeled in accordance with actual design. Many improvements have been made in procedures and training material to minimize operator errors during normal operation, anticipated operational occurrences and design basis accidents as a result of review by PNRA.

12.4 Arrangements for Operating Experience Feedback in Relation to Human Factors Issues for Nuclear Power Plants (NPPs)

The main purpose of the operating experience feedback is to identify HFE related safety issues for improvement in the design (Human system interface), training and procedure development of NPPs. The issues and lessons learned regarding operating experience provide a basis for improving the plant design in a timely way that is at the beginning of the design process. NUREG 0711 specifies that the licensee should submit the result summary reports (RSR) of Operating Experience Feedback (OEF). Result summary reports consist of two parts result of reviewing NUREG-6400 operating experience feedback issues and feedback experience of reference plants. This OEF input is also used to contribute to other review elements of HFE for improvement to avoid the human errors by improving the design, training program and procedures.

PNRA collects data from C-1 and C-2. This feedback experience is collected by human factors engineers through activities including design review, walk-down of control rooms and simulator, review of C-1 and C-2 events reports, IRS events database and discussion with plant management, operators and maintenance staff.

PNRA identifies and analyzes HFE related issues of previous design that are similar to the current design, which will results in design improvements, reduction in human error and improvement in human performance.

On the basis of this operating experience feedback, C-3/C-4 made improvements in the Human System Interface design (HSI), training program and procedures.

During review of K-2 and K-3 PSAR, licensee has submitted the results summary report on the OEF. This report was reviewed and the licensee was asked to modify the human system interface design, training program and procedures.

Pakistan has, therefore, met the obligations of Article 12 of the Convention.

Article 13 – Quality Assurance

> *"Each contracting party shall take the appropriate steps to ensure that quality assurance programs are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation."*

13 Quality Assurance

Pakistan has taken appropriate steps to ensure that quality assurance programs are established and implemented with a view to providing confidence that specified requirements for activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

13.1 Regulatory Requirements

The regulatory requirements for the submission of quality assurance programs (QAPs) for site evaluation, construction and operation, at respective licensing stages, have been stipulated in PNRA Regulations PAK/909.

PNRA Regulations PAK/912 provides basic requirements for establishing and implementing quality assurance programs related to the safety of nuclear power plants. In addition, various IAEA safety standards are also being followed as part of requirements and guidance for the quality assurance program during various phases of licensing of nuclear installations. These basic requirements apply to overall quality assurance program of licensee/management, as well as to other separate quality assurance programs in each stage of the life of a nuclear installation. The licensee has to ensure safety in Siting, Design, Construction, Commissioning, Operation and Decommissioning of the nuclear installation. The regulations recognize that all work processes are planned, performed, assessed and improved. These basic requirements apply to all individuals and organizations, including designers, suppliers, constructors, manufacturers and operators of nuclear power plants.

QAP is required to provide an inter-disciplinary approach involving many organizational components and is not regarded as the sole domain of any single group. The QAP is to demonstrate the integration of following components:

a. Managers planning, resources and support to achieve the organization's objectives.

b. Staff performing the work to achieve quality; and

c. Management (at all levels) performing assessments to evaluate the effectiveness of management processes and work performance.

Graded approach based on the relative importance to nuclear safety of each item; service or process is being used.

13.2 Quality Assurance Activities at Nuclear Installations

PAEC has established an Overall Quality Assurance Program (OQAP) at each nuclear power plant in accordance with PAK/912 to achieve its safety objectives. OQAP includes quality policy statement, vision, mission, organizational structure with defined responsibilities, functions, interfaces, work processes & performance, monitoring & evaluation and process control procedures.

13.2.1 Quality Assurance at Corporate Level

Directorate of Quality Assurance (DQA) is established at corporate level at the PAEC HQ to coordinate QA activities in various PAEC establishments, and to have corporate oversight for QA matters. This directorate conducts QA audit of plants, provides guidance to the plants and the corporate management on quality issues and recommends actions for improvements. PAEC has formally issued its Nuclear Safety Policy which encompasses the quality assurance elements such as management's commitment for giving priority to safety over production objectives, compliance with safety regulations and industrial standards for achieving excellence in performance of all activities through highly professional and qualified manpower by utilizing all necessary financial and other resources. PAEC issued its quality policy to ensure safe, reliable and economical functioning of the facilities and work procedures.

13.2.2 Quality Assurance at Nuclear Installations

KANUPP updated its operational QAP in 2015 to address specific issues related to operation beyond design life.

The QAP of C-3 and C-4 during commissioning phase and the QAP of K-2 and K-3 for design and construction phases were reviewed and approved by PNRA during the reporting period.

The nuclear installations have established Quality Assurance Divisions (QADs) staffed with appropriately qualified personnel reporting directly to the highest level of the respective plant management. The QA personnel have been entrusted with necessary authority to ensure the implementation of QAP through surveillance, inspections and audits. Among other things, QADs have the authority to stop any work which is considered as not meeting the QA requirements. Assessment of QAP is carried out through self and independent assessments. This is done by performing internal and external audits, internal peer reviews, technical reviews, etc. The purpose of such assessments is to identify weak performance areas. Necessary corrective actions are taken to improve the identified weaknesses.

At KANUPP, Quality Assurance Division (QAD) conducts QA audits of Operation, Engineering Support, Chemistry Control, Health Physics, Maintenance, Procurement, Material Management and Training. All field activities related to areas mentioned in QA manual are routinely inspected following annual audit schedule. As per QA manual, QA audits of different plant areas were carried out during the reporting period. Necessary improvements were made on the basis of QA findings.

The QAD verifies that the work groups clearly understand management expectations to establish and maintain safety culture at KANUPP. Training and retraining of QA personnel including auditors is a regular activity to maintain and enhance their qualifications and skills. In 2016, QA audit of KANUPP was conducted by Directorate of Quality Assurance (DQA) on corporate level. Weaknesses identified during this audit are shared with Chairman (PAEC) as per policy. Improvements in documentation control, non-conformance control and training have been suggested by DQA team.

A number of spare parts for KANUPP are manufactured in-house by engineering support divisions which have also established QA/QC program as per ISO 9001:2008 quality management system.

QAP of C-1 and C-2 encompasses all items and activities important to safety and availability of the plant. The Quality Assurance Divisions are staffed with adequately qualified and skilled

manpower and report directly to respective Plant Managers (PMs). In all the activities, QADs emphasize the safety and quality culture. Through planned QA surveillance and audit programs, the QAD verifies compliance with the established requirements of QAP. Planned as well as general surveillances are carried out in all plant areas within the scope of QAP. Internal and external audits are performed according to the audit plans and applicable procedures.

During the reporting period, internal QA audits of different work units of C-1 and Technical Support Division (TS) were performed as per annual QA audit plans. External QA audits of contractors were conducted to comply with contractual requirements.

Through QA surveillance and audit programs, QAD verifies compliance with the established requirements of QAP. Planned as well as general surveillances are carried out of all plant areas within the scope of QAP. Corrective Actions Reports (CARs), Non-conformances Notices (NCNs) and Deficiency Reports (DFRs) are issued during planned / general surveillances and their follow-up is continued for the satisfactory resolution.

QAD also performs inspections and controls the activities of contractors through audits and surveillance. Detailed working procedures related to safety and quality undergoes a thorough QA review by QAD before approval.

Corporate level QA audit of C-1 and C-2 is also carried out by the Directorate of Quality Assurance (DQA) audit team. During DQA audit conducted in June 2015, recommendations were made in various areas such as revision of procurement procedures, improvement in storage conditions and documentation control.

The OQAP of C-3 and C-4 covers all activities related to design, construction and commissioning including management, performance and assessment and is being implemented during the commissioning phase.C-3 and C-4 perform QA audits of its contractors and sub-contractors to verify compliance with the OQAP.

K-2 and K-3 have established a “Management System/ Quality Assurance Program (QAP) for Design, Procurement, Construction and Commissioning of Karachi NPPs Unit-2 & 3” in accordance with the requirements of PNRA regulations. After review and necessary improvement in QAP, same has been implemented by K-2 and K-3 during the design and construction activities. The QAP covers all activities related to design, construction and commissioning including management, performance and assessment. Non-conformances are dealt according to the severity and safety implications as per procedure. Disposition actions are approved at different levels of the overall QA and regulatory system accordingly.

K-2 and K-3 have a Quality Assurance Department which assists the General Manager on QA matters. The QAP of project contractors and sub-contractors are required to be in line with the OQAP. K-2 and K-3 perform QA audits of the contractors and sub-contractors to verify compliance with the QAP.

13.3 Quality Assurance Activities of Equipment Manufacturing Facilities

“Regulations for Licensing of Nuclear Safety Class Equipment and Components Manufacturers” – PAK/907 provide the licensing requirements for manufacturers of Nuclear Safety Class Equipment and Components. The licensee is required to submit quality assurance manuals, process flow diagrams and manufacturing schedules so that control points for inspections may be selected. The manufacturing activities are performed according to quality plans which describe the processes, testing, examination, reviews and checks in

sequential order. Processes are required to be qualified according to the requirements of applicable codes and standards. Mock-ups are also required to be manufactured to qualify the processes. Manpower involved in manufacturing process and testing is qualified according to the requirements of relevant regulations, codes and standards.

PNRA performed numerous control point inspections of safety class equipment manufacturers during the equipment manufacturing of C-3 and C-4 projects to verify the compliance with the requirements of PNRA regulations and to assess the implementation and effectiveness of QAP in compliance with the applicable codes and standards.

NCNDT applied to PNRA for authorization of Non Destructive Examination (NDE) services in Nuclear Island of Nuclear Power Plants. Being the first of its kind of application, PNRA formulated the regulatory requirements taking into account the practices of authorization to NDE service providers in the world. The applicant was asked to submit the details of their facilities, capabilities, infrastructure, experience and others. Accordingly, Quality Assurance Program and other submissions were reviewed by PNRA. Special QA audit & factory inspections and mockup inspections were conducted to verify the capabilities and performance of organization to be authorized as NDE service providers. Upon fulfillment of the regulatory requirements, NCNDT has been authorized to perform NDE activities in Nuclear Island of Nuclear Power Plants.

13.4 Regulatory Surveillance of QA Activities

PNRA periodically performs regulatory inspections of overall QA activities of its licensees. During routine and non-routine inspection activities, surveillance of relevant aspects of QAP/QAM is also carried out. QA administrative inspections of licensees, contractors and subcontractors performing safety related activities are regularly performed while comprehensive inspections of specific areas of QA are performed as and when required. During these inspections, PNRA verifies compliance with the requirements of PNRA regulations and the license conditions. The routine inspections at the sites of nuclear installations are conducted by PNRA Regional Directorates at Karachi and Chashma, while the QA administrative inspections and inspections at the manufacturing facilities are conducted by PNRA HQ.

QA administrative inspection of licensee, main contractor and subcontractor of C-3, C-4, K-2 and K-3 projects performing safety related activities has been carried out by PNRA during the reporting period. During these inspections; PNRA verified the QAP of licensees, QAP of main contractor and sub-contractor for the fulfillment of its delegated responsibilities as per requirement of PAK/912 and IAEA relevant safety standards.

PNRA also verifies the implementation and effectiveness of QAP in compliance with the applicable codes and standards by participating in control point inspections during equipment manufacturing of C-3, C-4, K-2 and K-3 projects.

13.5 PNRA Integrated Management System

PNRA has established and implemented an integrated management system to carry out its activities in order to continuously improve its regulatory effectiveness. Management system of PNRA is in line with the requirements of the IAEA safety standard GS-R-3. The PNRA management system manual describes the establishment, implementation, assessment and continuous improvement of management systems. Based on the experience feedback, self-assessment and considering updated requirements of GSR Part 2 - Leadership and

Management for Safety, PNRA issued a revision of its Management System Manual in 2016. International experience feedback was also considered in the revision of the Management System Manual. The manual contains Policy statements, Vision, Mission, Core values, Objectives, Organizational structure, Responsibilities, Functions & Authorities, Management, Core, Support and Generic Processes, Monitoring & Evaluation, Assessment and Improvement practices, etc.

The Management System processes of PNRA are being regularly assessed through planning, control and effective supervision of its regulatory activities. All groups and Directorates conduct their self assessment on biennial basis. An internal audit of all PNRA directorates, groups and projects is also being conducted biennially.

Pakistan has, therefore, met the obligations of Article 13 of the Convention.

Article 14 –Assessment and Verification of Safety

“Each contracting party shall take the appropriate steps to ensure that:

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

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

14 Assessment and Verification of Safety

Pakistan has taken appropriate steps to ensure that comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life to verify the safety. Such assessments are well documented and subsequently updated in the light of operating experience and significant new safety information. Such assessments are reviewed by PNRA. Verification by analysis, surveillance, testing and inspections is carried out to ensure that the physical state and operation of a nuclear installation continue to be in accordance with its design objectives, and operational limits &conditions.

14.1 Regulatory Requirements

PNRA has a well-defined regulatory framework which ensures comprehensive safety assessment and verification before the commencement of operation of nuclear installations. PNRA Regulations PAK/909 prescribe a mechanism for licensing of nuclear installations in three stages, namely, Site registration, Construction licence and Operating licence. Regulation PAK/910 prescribes detailed site assessment requirements for site registration (for details refer to section 17.1 of the report).PNRA Regulations PAK/911 require that at the design stage of a nuclear installation, a comprehensive safety analysis shall be carried out to identify all sources of exposure and to evaluate radiation doses which could be received by workers and the public, as well as potential effects on the environment. The safety analysis shall take into consideration:

i. All planned normal operation modes of the plant.

ii. Plant performance in anticipated operational occurrences.

iii. Design Basis Accidents.

iv. Event sequences that may lead to a severe accident.

Through assessment of the above mentioned safety analysis, robustness of the engineering design to withstand postulated initiating events and accidents can be established, effectiveness of safety systems and safety related items or systems is demonstrated, and requirements for emergency response are established. PNRA regulations PAK/911 require that measures should be taken to ensure that radiological consequences are mitigated. Such measures include: engineered safety features; onsite accident management procedures established by the operating organization; and on-site and off-site emergency planning and preparedness measures to mitigate radiation exposure if an accident occurs.

A safety analysis of the plant needs to be conducted in which methods of both deterministic and probabilistic analyses are applied. These analyses establish and confirm the design basis for items important to safety. Applicant also needs to demonstrate that the plant as designed is capable of meeting prescribed limits for radioactive releases and acceptable limits for potential radiation doses for each category of plant states. The safety assessment is based on the results derived from the safety analysis, operating experience, results of supporting research and proven engineering practices. The applicant needs to ensure that an independent verification of the safety assessment is performed before the design is submitted for regulatory review and approval.

PNRA Regulation PAK/913 require the licensee to perform a systematic safety re-assessment of the plant for its entire operational lifetime. In such a re-assessment, operating experience and significant new safety information from all relevant sources also needs to be taken into account. The Regulations also include the assessment and verification requirements during operation phase, in particular, the assessment and verification of design modifications. It is emphasized that modifications involving plant configuration and the operational limits and conditions shall conform to the requirements set in the Regulations PAK/911. In particular, the capability of performing all safety functions adequately may not be degraded.

The requirements for safe management of radioactive waste in the country have been specified in Regulation PAK/915.

The applicant has to carry out safety assessments and the activities needed for Siting, Design, Construction, Operation and Closure, as well as the measures needed in the post-Closure phase of radioactive waste disposal. Additional requirements of Periodic Safety Review (PSR) for revalidation of Operating Licence and assessment for licensing beyond design life have also been stipulated in the PNRA regulations.

14.2 Assessment and Verification of Safety at Nuclear Installations

The safety of the plant is continuously assessed and verified during all phases of the plant life. This includes self assessments, reviews of plant safety performance by the plant operational safety committee, quality assurance division, engineering department, health physics division and relevant operation and maintenance departments. Independent reviews and assessments by corporate safety body and international reviews such as WANO Peer Review, OSART Mission, etc. are conducted. Nuclear installations have established effective systems for recording deficiencies identified during the assessment and verification activities, event analysis, corrective actions and maintaining records for authorization and control of temporary changes to the equipment, procedures, etc. In-Service Inspection (ISI) programs are implemented to assess and verify the condition of plant structures, systems and components important to safety at appropriate intervals. All these systems of safety verification take into account the requirements of applicable regulations, codes, standards and international practices.

In addition, all nuclear power plants underwent rigorous safety assessments after the Fukushima Daiichi Accident. Pakistan also adopted the IAEA Action Plan on Nuclear Safety to incorporate lessons learned from the Fukushima Daiichi Accident. (For details, please see Section 2.2)

14.2.1 Assessment and Verification of Safety at KANUPP

Safety of KANUPP is being assessed and verified through regulatory review, overall quality assurance program, periodic safety reviews, ageing management program, in-service inspection program, surveillance and testing program, preventive and corrective maintenance program, corporate review, safety performance indicator program and self assessment program. All safety related change approval cases are submitted to PNRA after deliberation by KANUPP Safety Committee for review and approval before implementation.

In the wake of Fukushima accident, KANUPP chalked out the Fukushima Response Action Plan (FRAP). KANUPP remained shut down for long outage during the year 2014 and most of the modifications as a result of assessments under FRAP were implemented during this period. Significant modifications include installation of water injection system by engine driven pumps and fire water system into spent fuel pool, reactor vault, building dousing spray, steam generators and reactor core. Diesel generators for continuous charging of station DC batteries in case of BDBA were installed. Passive Hydrogen Re-combiners (PARs) have been installed in the containment building.

KANUPP also completed its second Periodic Safety Review (PSR2) during the year 2015 as per licence condition. KANUPP submitted one hundred (100) safety reports covering thirteen (13) safety factors of PSR. These reports were reviewed at PNRA and corrective actions were agreed and included in PSR Corrective Action Plan. Based on the review of PSR reports and a global assessment report, PSR was accepted by PNRA. Following are the significant corrective actions against PSR:

i. Installation of seismically qualified metallic fire barrier between the two battery banks.
ii. Re-routing of cables of primary pressure control valves in order to eliminate the initiating event.
iii. Performance of periodic inspection and surveillance of feeder pipes to evaluate wall thinning and fretting with other components.
iv. Water lancing of steam generators and inspection of boiler tubes/ boiler internals.
v. Replacement of containment dampers.
vi. Fire protection system for cable tunnel and cable gallery.
vii. Reactor fuel channel inspection campaign to assess its end of life condition.
viii. Seismic qualification of emergency feed water room.
ix. Installation of environmental gamma monitors at various locations around the plant.

During the years 2015-2016, KANUPP performed Fire PSA and submitted the same to PNRA for review and approval. KANUPP also went under long shutdown during the period from Sept -October, 2015 for carrying out necessary maintenances and implementation of some design modifications.

During the reporting period, all safety related activities were performed under surveillance by QAD and regulatory oversight of PNRA.

14.2.2 Assessment and Verification of Safety at C-1

C-1 performs assessment and verification of safety under its Quality Assurance Program for Operation. Technical support from the designer and vendor was also sought when required. The plant has an Operational Safety Review Committee which performs review and assessment of the safety evaluation, modifications, events reports, plant operations, etc. Independent assessments are carried out in the form of audits, surveillance and internal / external peer reviews. All safety cases for modification are approved by Operational Safety Review Committee before submission to PNRA for approval.

At C-1, a comprehensive program is established for design modification control, which defines roles and responsibilities of the work units involved in the plant modification process. A set of procedures covering all aspects of design modifications, from the initial request, prioritization, safety screening, preparation of the design package, review and preparation of installation package to the evaluation of impact, testing/commissioning requirements, documentation revision and modification handover, etc. exists. Control of temporary modifications is done through a specific procedure which requires safety screening and evaluation similar to the one for permanent modifications. The activities related to verification of safety are stipulated under the Technical Specifications which include surveillance program, periodic testing, In-Service Inspection (ISI) Program, etc. to determine qualitative guidelines for ensuring safety while maintaining high availability and reliability of components.

A dedicated group for Ageing Management is in place at C-1 which has support from external organizations on Ageing Management activities.

Peer reviews are conducted by organizations such as Corporate Safety Review Committee (CSRC), IAEA OSART and WANO.

A WANO Follow up Peer Review Mission was conducted at C-1 in May, 2015. The status of actions against WANO Mission is mentioned in Annexure XII.

An OSART Mission was conducted in Nov- Dec, 2015. The scope of review covered operating practices in the areas of Leadership and Management for Safety; Training and Qualification of personnel; Operations; Maintenance; Technical Support; Operating Experience Feedback; Radiation Protection; Chemistry; Emergency Preparedness and Response; and Accident Management. Throughout the review, the exchange of information between the OSART experts and plant personnel was very open, professional and productive. Emphasis was given to assessing the effectiveness of operational safety rather than simply reviewing the content of programs. The conclusions of the OSART team were based on the plant performance against the requirements of the IAEA Safety Standards. The OSART team concluded that the managers of C-1 are committed to improving the operational safety and reliability of their plant. The areas of good performance include the following:

i. The Plant owns a fully equipped Personnel Decontamination Facility, adequately staffed and remains available 24 hours a day and 7 days a week throughout the year, and is prepared for dealing cases of injury and radioactive contamination.
ii. The plant adopted an approach to include daily operation logbooks screening in the retraining program of operators and to recreate operation events on simulator to improve training effectiveness.

iii. The plant developed an optimized shift working schedule to achieve a better distribution of workloads, ensure adequate time for training, and provide benefits to the operating personnel.

Plant received Good Practices in the areas of Qualification & Training of Personnel, Operational Organization & Function and Emergency Response.

14.2.3 Assessment and Verification of Safety at C-2

C-2 is operating safely since commencement of operation and recently completed its third refueling outage. All the routine inspection and tests are carried out for operability and safety margins verifications. C-2 has the modification process as that of C-1 and all safety cases for modification are approved by Operational Safety Review Committee before submission to PNRA for approval. The activities related to verification of safety are stipulated by the Technical Specifications which include the surveillance requirements, periodic testing and In-Service Test Program, etc.

A WANO Peer Review of C-2 was conducted in April -May, 2015. For details, please refer to Section 2.1.8.

14.2.4 Assessment and Verification of Safety at C-3 and C-4

The design of C-3 and C-4 was assessed at various levels for verification of safety. The designer performed detailed assessment at the first level and it was verified independently by the personnel who were not directly involved in the design. At the second level, the design was assessed and verified by C-3 & C-4 as owner. Modifications in the design followed the same course for approval as for the original design as required by the PNRA regulations PAK/913.

PNRA carried out inspections during installation and commissioning of C-3 components and systems. After completion of commissioning tests (stage A), acceptance of Final Safety Analysis Report and other documents stipulated by PNRA Regulations PAK/909, demonstration of implementation of emergency preparedness plan and completion of physical protection measures, fuel load permit was granted to C-3 by PNRA. The fuel has been loaded in C-3 and subsequent commissioning tests are in progress. Commissioning of C-4 is also in progress and application for fuel load permit is under review at PNRA. C-3 and C-4 are implementing design modification process similar to C-1 and C-2 for the safety related modifications. The activities related to verification of safety are stipulated by the Technical Specifications which include the surveillance requirements, periodic testing and In-Service Inspection Program, etc.

14.2.5 Assessment and Verification of Safety at K-2 and K-3

After completion of the review and acceptance of K-2 and K-3 SER, the sites of K-2 and K-3 were registered. K-2 and K-3 are third generation (Gen-III) PWR nuclear power plants with the design provision of double containment and passive safety features. Review of the construction licence application including necessary licensing submissions i.e., Preliminary Safety Analysis Report (PSAR), Probabilistic Safety Analysis (PSA) Report and Quality Assurance Program for Design and Construction Phases (OQAP) for K-2 and K-3 was completed in 2015 by PNRA. After satisfactory resolution of all relevant safety issues, construction licence was awarded to K-2 in August, 2015 and K-3 in November, 2015. The civil construction work of K-2 has started with first concrete pouring in August, 2015.

PNRA has developed inspection program for K-2 and K-3 which covers construction and manufacturing phases of the NPPs. PNRA has also performed the QA inspections of licensee, manufacturers, contractors and subcontractors as part of regulatory inspection program.

14.2.6 Safety Performance Indicators Program of Nuclear Installations

KANUPP has developed and implemented Safety Performance Indicators (SPI) program to monitor the performance trends and to take appropriate actions in a timely manner for performance improvement. The frame work of SPI program is in line with relevant IAEA guidelines. In this SPI framework, there are 89 SPIs which have different monitoring frequency depending on the nature of data. Analysis reports on these SPIs are issued after every six months and necessary actions are taken for SPIs which are found beyond working goal. These reports are also sent to corporate office as part of corporate oversight. KANUPP also participates in the WANO Performance Indicators Program and regularly provides performance indicators data to WANO on quarterly basis.

C-1 and C-2 have adopted WANO performance indicators program and share performance indicators data elements with WANO on a quarterly basis. The existing programs consist of collecting, trending, exchanging, and disseminating performance data for complete set of WANO performance indicators, covering critical safety and operational aspects of the plant. C-1 and C-2 have also developed safety performance indicators (SPIs) programs to monitor operational safety of station. The SPIs program is based on the guidelines of WANO and IAEA.

Safety performance indicators trends are reported in Technical Reports of the plant.

14.3 Regulatory Review Process

According to the procedure for licensing of nuclear installations in Pakistan, PNRA performs regulatory review of various licensee submittals such as Site Evaluation Report (SER), Preliminary Safety Analysis Report (PSAR), Final Safety Analysis Report (FSAR), Commissioning Program, Periodic Safety Review (PSR) Reports, PSA Report, etc., during various licensing stages. Earlier, the safety review was performed by PNRA staff with the help of consultants; however, PNRA has now established Centre for Nuclear Safety as its technical support organization to indigenously perform safety reviews and assessments for the licensing process of nuclear installations. Safety reviews are carried out in accordance with PNRA regulatory requirements for Siting, Design, Construction, Commissioning, Operation and Decommissioning of nuclear installations as referred in the Regulations PAK/909. Review meetings are held between the licensee and regulatory staff to address the queries raised during the review process. After completion of the regulatory review, safety evaluation report is issued that highlights all the major findings and licensee's compliance with the regulatory requirements. This report also indicates non-compliant situations which may form the licensing conditions attached with the regulatory authorizations issued at various stages of licensing process. Any change in the plant configuration or its operations that may have an effect on the licensing basis requires PNRA approval prior to implementation. PNRA reviews and approves the modifications. The design modification review process emphasizes that modifications, involving plant configuration and the operational limits and conditions, conform to the design requirements. The licensees are required to submit PSA submissions along with FSAR and PSAR at the construction stages, fuel load permit and PSR at licence revalidation stages.

PNRA reviewed the K-2 & K-3 SER, K-2 & K-3 PSAR, C-3 & C-4 FSAR and KANUPP PSR reports during the reporting period.

14.4 Verification of Safety by PNRA

Verification of safety of nuclear installations is carried out through regulatory inspections, review & assessment, analyses and audit calculations. The verification of safety is carried out during all phases of Siting, Design, Construction, Installation, Commissioning, Operation and Decommissioning. Safety analysis, carried out by the licensee to support the design, is reviewed and audit calculations are conducted on sampling basis using applicable computer codes. The underlying assumptions, modeling techniques, accident sequence quantification, results and uncertainties are verified against the acceptance criteria. Comparison of results with already approved design, where applicable is also considered. The inspection program of each phase is prepared in line with project schedule under intimation to the licensee. The inspection programs are focused on ensuring that plant construction, equipment manufacturing, installation and commissioning are in conformity with the design intent, and that the operation is within the approved limits and conditions. In addition to planned inspections, reactive/special inspections are also performed in situations requiring special attention or regulatory intervention. PNRA has included safety culture in its inspection program and has performed safety culture inspections at all operating NPPs. All activities of KANUPP, C-1 and C-2 , related to safe operation and maintenance of the plant, including engineering support, health physics, emergency preparedness, quality assurance, event analysis, operating experience feedback, radiological environmental surveillance, etc., are subject to PNRA regulatory oversight to verify compliance with the regulatory requirements.

C-3 and C-4 are at the commissioning stage whereas K-2 and K-3 are at the construction stage. PNRA verifies selected inspection points during commissioning, construction and manufacturing activities through its regulatory inspection programs. The inspection program is being executed in three types of inspections i.e. Hold “H”, Witness “W” and Record “R” point inspections according to the schedule agreed with the licensee.

14.5 Safety Reviews and Assessment through External Organizations

PAEC understands the importance of international evaluations and their benefits for enhancing safety and operational performance of the plant. This is done through benchmarking with plants having excellent performance in safety and availability.

KANUPP invited WANO Special Peer Review Follow up mission and a WANO Significant Operating Experience Reports (SOER) review in 2014. Four technical support missions (TSM) were conducted at KANUPP during the reporting period. These include:

[a] WANO Mission on Peer Review Standard Training (October, 2014)

[b] WANO Mission on Improvement in WANO Performance Indicators SP1, SP2 and SP5 (January, 2015)

[c] WANO Mission on Benchmarking visit on KANUPP Spent Fuel Dry Storage (October, 2015)

[d] WANO Mission on improvements in human factors in the wake of Fukushima disaster (February, 2016)

Following WANO missions are planned during 2016-2017:

i. WANO Peer Review of KANUPP

ii. TSM on contamination control and dose reduction at KANUPP
iii. TSM on good practices in self assessment
iv. TSM on effective transition methodology from time bases maintenance to condition based maintenance
v. Benchmarking visit on decommissioning

CNPGS also invited the following external missions during recent period.

[i] OSART Mission to C-1 (Nov - Dec, 2015)

[ii] WANO Follow -up Peer Review Mission to Chashma Unit-1(May, 2015)

[iii] WANO Peer Review of Chashma Unit-2 (April-May, 2015)

Improvements as a result of the above mentioned missions at KANUPP and CNPGS NPPs are reported in section 2.1.8 of this report.

Pakistan has, therefore, met the obligations of Article 14 of the Convention.

Article 15 - Radiation Protection

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

15 Radiation Protection

Pakistan has taken appropriate measures to ensure that during all stages of nuclear installations such as Operation, Maintenance, Refueling, Implementation of design modifications, etc., the exposure to plant personnel, public and environment is kept as low as reasonably achievable and that no individual is exposed to radiation which exceeds the prescribed national dose limits.

15.1 Regulatory Requirements

Pakistan Nuclear Regulatory Authority (PNRA) is responsible for controlling, regulating and supervising all matters related to radiation protection. PNRA Regulations PAK/909 require submission of a radiation protection program, radioactive waste management program and radiological environmental monitoring program as part of the pre-requisites for issuance of operating licence.

The radiation protection objective described in PNRA regulations PAK/911 states that, it is to be ensured that in all operational states, radiation exposure within the installation or due to any planned release of radioactive material from the installation is kept below prescribed limits and as low as reasonably achievable (ALARA), and to ensure mitigation of the radiological consequences. The safety objectives for design of nuclear installations require that nuclear installations shall be designed and operated so as to keep all sources of radiation exposure under strict technical and administrative control.

PNRA Regulations PAK/913 require that the licensee shall establish and implement a radiation protection program to meet the objective of PNRA Regulations PAK/911. The regulation also require that implementation of the radiation protection program shall be ensured by the appointment of qualified station Health Physicist who advises the plant management and shall have authority to participate in establishing and enforcing of safety procedures. PNRA does not accept an application for using and production of radioactive material if it is found that ALARA is compromised. The qualification of Station Health Physicist/ Manager Heath Physics is also defined in the regulations PAK/913. The dose limits for radiation workers and public during normal operation are given in PNRA Regulations PAK/904 and are reproduced in Annexure–VII.

15.2 Radiation Protection at Nuclear Installations

PAEC is committed to take all appropriate steps so that occupational radiation exposure to personnel working in its nuclear facilities is maintained as low as reasonably achievable (ALARA). Moreover, PAEC is committed to take all reasonably practical steps to achieve the following two safety objectives:

i. The risk of prompt fatality to an average individual in the vicinity (within 2 Km) of a PAEC nuclear facility, as a result of an accident in the facility, should not exceed 0.1%

of the sum of prompt fatalities due to other accidents to which the members of the public are generally exposed.

ii. The risk of cancer fatalities to population in the area of a PAEC nuclear facility (within 15 Km) that might result from the operation of the facility should not exceed 0.1 % of the sum of all cancer fatalities.

The nuclear installations have developed policies and procedures, for the protection of workers, public and environment from the harmful effects of radiation, in conformance with the PNRA regulatory requirements. It is ensured that in all operational states radiation exposure within the installation or due to any planned release of radioactive material from the installation is kept below prescribed limits and as low as reasonably achievable (ALARA), and that the measures to mitigate the radiological consequences arising from any design basis accidents are in place.

At nuclear installations, monitoring and surveillance of doses to radiation workers is conducted and records maintained. For environmental monitoring, continuous air sampling and ambient dose level monitoring are performed. Environmental samples of air, water, soil, vegetables, fruits, milk, meat, etc., are collected and analyzed for estimation of radionuclide content at frequencies prescribed in the radiological environmental monitoring programs. On-site and Off-site environmental monitoring points are selected at different locations. Environmental TLD dosimetry is also performed to record the cumulative dose level on quarterly basis. PNRA normally reviews the records of sampling and analysis of the licensees, however, independent verification of plant monitoring samples may also be conducted. PNRA has also established its own environmental monitoring laboratory for verification of assessments submitted by the licensee.

At all nuclear installation sites, radiological environmental monitoring is conducted during pre-operational phase, operational phase and emergency phase. The records are maintained and reports generated on quarterly and annual basis. During plant operation, radiological environmental monitoring is performed for the following:

a) To determine ambient gamma radiation dose rate in pre-operational phase, operational phase and emergency phase and to assess the public doses contributed by NPP operation.

b) To determine level of activity in air, soil, water, vegetables, crops and milk etc. during the three phases and to assess the internal gamma doses to public attributed by NPP operation.

c) To meet the surveillance requirement of standard/codes and to consolidate the basis for enhancing public confidence in NPPs safe operation.

15.2.1 Radiation Protection at KANUPP

At KANUPP, radiation exposure is controlled by means of job planning, pre-job briefing, frequent radiation surveys, radioactive contamination control, and regular training to keep the doses well below the regulatory limits. In addition, a Radiation Control Officer (RCO) is designated for radiation intensive jobs with prime responsibility of participating in each activity right from planning to execution. Internal radiation dose is controlled by providing suitable respiratory protection equipment, reducing the airborne contamination level. Internal uptake limits have been defined, which are followed strictly.

Radiation exposure to the public is kept as low as reasonably achievable by controlling the release of radioactive effluents from the plant. This is done by on-line monitoring of the releases, removing the Tritium contents from containment building atmosphere, filtration of gaseous effluent before releasing to the environment, decay and dilution of liquid effluent before its release, collection, processing and safe storage of solid radioactive waste, etc. As a result, both the gaseous and liquid effluent radioactive releases from the plant are well below the Derived Release Limits for KANUPP.

An environmental monitoring program is in place that includes regular radiation ambient dose rate monitoring at plant periphery and in different areas of Karachi city. This is done by placing TLDs and high volume air sampling system away from the plant. Environmental samples from the vicinity of plant are collected and analyzed. The records show no appreciable change in ambient background dose levels and environmental sampling analysis data.

Annual collective doses to the workers during 2013, 2014 and 2015 at KANUPP were 1.684 man-Sv, 2.013 man-Sv and 1.844 man-Sv respectively. Average individual dose for these years were 2.54 mSv, 2.85 mSv and 2.71 mSv respectively. The graphical representation of these doses is shown in Annexure– VIII.

Tritium released through gaseous radioactive effluents during 2013, 2014 and 2015 were 60.320 TBq, 97.889 TBq and 129.215 TBq respectively. Whereas, Noble gases released through gaseous effluents during 2013, 2014 and 2015 were 0.012TBq, 0.043 TBq and 0.177 TBq respectively. On the average, the cumulative gaseous releases remained less than 1% of annual release limits.

Tritium released through liquid effluents to sea during 2013, 2014 and 2015 (up to June) contained, 55.379 TBq, 31.019TBq and 195.103 TBq of Tritium respectively. Generally, these were less than 0.01 % of annual release limit for Tritium. Gross beta-gamma radioactivity released to sea during 2013, 2014 and 2015 was 0.028 TBq, 0.004 TBq and 0.006 TBq respectively which are less than 0.028 % of annual derived release limit for gross beta-gamma radioactivity. The effluent releases of KANUPP are shown graphically in Annexure–IX.

The ambient dose levels for KANUPP for the years 2013, 2014 and 2015 are 104, 102 and 100 nGy/hr respectively.

15.2.2 Radiation Protection at C-1 & C-2

In order to implement the radiation protection program, C-1 & C-2 has established the necessary organizational setup headed by Manager Health Physics Division. Health Physicists are responsible for implementing the radiation protection program for handling and monitoring radioactive materials, including sources and secondary source materials. This program conforms to PNRA Regulations and includes:

a. Conformance to working procedures for implementing the radiation protection program.

b. Survey of all incoming and outgoing shipments that may contain radioactive material.

c. Investigation and documentation of any radiological incident to minimize the potential for recurrence and for reporting these incidents to PNRA in accordance with the regulations.

d. Periodic surveys of radiation, contamination and airborne activity.

e. Record keeping of occupational radiation exposures and reporting to the PNRA.

f. Provision of personnel and other radiation monitoring equipment and their periodic calibration.

g. Establishment of access control points to separate potentially contaminated areas from uncontaminated areas and survey of tools and equipment before removal from a controlled area.

h. Issuance of Radiation Work Permits (RWP) in accordance with the station radiation control procedures.

i. Bioassay program including whole body counting and / or a urinalysis sampling to measure the uptake of radioactive material.

j. An environmental radiological monitoring program to measure any effect of the installation on surrounding environment.

Annual collective dose for C-1 during 2013, 2014 and 2015 was 474.9 man-mSv, 405 man-mSv and 462.57 man-mSv respectively. Average individual dose for these years remained 0.301 mSv/man, 0.27 mSv/man and 0.249 mSv/man respectively. Similarly, maximum individual doses for C-1 during 2013, 2014 and 2015 was 7.495 mSv , 8.56 mSv and 5.45 mSv respectively. The graphical representation of these doses is shown in Annexure–VIII.

Annual collective dose for C-2 during 2013, 2014 and 2015 was 575.837 man-mSv, 789.777 man-mSv and 724.84 man-mSv. However, annual average individual dose during 2013, 2014 and 2015 was 0.330 mSv/man, 0.524 mSv/man and 0.483 mSv/man respectively. Similarly, maximum individual dose for C-2 during 2013, 2014 and 2015 was 6.483 mSv, 7.032 mSv and 7.201 mSv respectively.

At C-1 & C-2, all liquid and gaseous effluents are monitored before release to the environment. Liquid effluents are released from C-1 & C-2 into the discharge canal, which falls into the Indus river. For C-1, gaseous effluents released during 2013, 2014 and 2015 were 0.28 TBq, 0.136 TBq and 10.9 TBq respectively. On the average these releases remained less than 1% of annual release limit. Liquid effluent releases for C-1 during the years 2013, 2014 and 2015 were 2.9 TBq, 2.23 TBq and 2.71 TBq respectively. These releases were less than 1% of annual release limit. C-1 effluent releases are shown graphically in Annexure–IX.

Gaseous effluent releases from C-2 during 2013, 2014 and 2015 were 0.000265 TBq, 0.0109 TBq and 0.00639 TBq respectively. Liquid effluent releases from C-2 during 2013, 2014 and 2015 were 7.46 TBq, 3.02 TBq and 1.01 TBq respectively. The releases were less than 1% of annual release limits.

It has been noted that the ambient dose levels at the boundary of KANUPP and CNPGS were generally close to the level of natural background during the reporting period. The ambient dose levels at Chashma site during the years 2013, 2014 and 2015 were 100.2n Gy/hr, 124.4 nGy/hr and 128.8 nGy/hr respectively. The ambient dose levels at KANUPP and Chashma site are summarized in Annexure X.

15.3 National Environmental Monitoring Program (NEMP)

According to PNRA Ordinance 2001, PNRA has the responsibility to ensure that the public is protected from any buildup of environmental radioactivity in the country. PNRA is implementing National Environmental Monitoring Program (NEMP) with the aim of enhancing PNRA's capabilities for monitoring environmental radioactivity, evaluating any buildups of radiation, assessing the doses being received by the public, and verifying the environmental data

provided by NPPs. Radioactivity monitoring under NEMP is not only focusing the global environment but is also focusing environment around NPPs with the aim of independent verification of the environmental monitoring results of NPPs submitted to PNRA. Three state of the art Environmental Monitoring laboratories have been established at Islamabad, Chashma and Karachi under NEMP. At this time, two laboratories at Karachi and Chashma are established and operational. The construction work of Islamabad laboratory is in the final stages of completion.

The NEMP generally covers measurement of radioactivity in sand/soil, air, water, flora/fauna in the whole country. Under this program, various samples have been analyzed around NPPs and environmental data provided by the licensees has been verified. This program also assesses the radiation survey and analysis of Naturally Occurring Radioactive Material (NORM) related activities at National level.

15.4 National Dosimetry & Protection Level Calibration Laboratory (NDCL)

In order to facilitate and verify the implementation of radiation protection at nuclear installations, PNRA has established Internal and External Dosimetry Laboratories and Protection level Calibration Laboratory.

The Internal Dosimetry laboratories have been established at Islamabad, Karachi and Chashma. Each center is equipped with a state of the art Whole Body Counter to assess internal contamination of radiation workers of licensed facilities. The internal dosimetry labs at Karachi and Chashma are equipped with high throughput whole body counters so that the radiation assessment of large number of radiation workers may be performed.

The External Dosimetry Laboratories of PNRA consists of new state-of-the-art Thermo Luminescent Dosimeter (TLD) reader systems. Three TLD readers have been installed so far, two at Islamabad and one at Karachi center respectively. The External Dosimetry Lab verifies the dosimetry data provided by the NPPs.

The protection level calibration laboratory is established at Chashma center. It is equipped with a Gamma Irradiator. It has three radiation sources which are used for verification and performing of calibration of radiation protection equipment like radiation survey meters and personal dosimeters.

15.5 Classification of Areas and Radiation Zones

According to the requirements of PNRA Regulations PAK/904, the radiation areas are classified into two parts i.e. Supervised and Controlled areas for the purpose of controlling the occupational exposure. At KANUPP, Controlled area is divided into 4 zones on the basis of dose rates. Zone 1 and Zone 2 contain no radioactive equipment and is kept free of contamination at all times. Zone 3 includes service area for active equipment and materials that are potential sources of contamination. Zone 4 is Radiation Controlled Area (RCA) which is further classified into 3 radiation areas.

C-1 & C-2 Radiation Controlled Area (RCA) is classified into 5 radiation Zones based on dose rates.

- Zone R1 includes the areas that do not contain radiation sources and their adjacent areas.

- Zone R2 includes some operating rooms for equipment containing radiation sources, corridors, operating hall in the refueling and storage building, and some equipment rooms with very low activity, etc.
- Zone R3 includes the areas outside the personnel hatch, emergency hatch and equipment hatch, cable penetration area, and equipment rooms containing lower activity. The thickness of shielding wall between two neighboring equipment is designed to satisfy the dose rate limit of this zone.
- Zone R4 includes limited entrance areas. Application for permission is required to enter these areas requires application for permission in advance.
- Zone R5 are normal prohibited areas. Only personnel having Radiation Work Permit (RWP) with prior approval can enter these areas if it is extremely necessary under accident conditions, and they are required to have a careful and approved plan in advance.

ZONE	**Zone-I**	**Zone-II**	**Zone-III**	**Zone-IV**	**Zone-V**
COLOR CODE	GREEN	YELLOW	ORANGE	BROWN	RED
	Dose Rate(μSv/hr)				
C-1/ C-2	≤8	8<DR≤25	25<DR≤100	100<DR≤1000	>1000

15.6 Dose Constraint

For KANUPP, dose constraint limit is set as 0.3 mSv/yr. For CNPGS, dose constraint limit is set as 0.26 mSv/year for normal operation taking into account effluent releases from each unit.

15.7 Verification of Implementation of Radiation Protection Program

Performance of the nuclear installations is continuously monitored to verify compliance with radiation protection requirements. In this regard, PNRA performs regulatory inspections and reviews various reports of the licensees to verify compliance with radiation protection and radiological environmental monitoring programs. The regulatory inspections are an essential part of annual inspection plan of PNRA Regional Directorates for nuclear installations. During these regulatory activities, various aspects of implementation of radiation protection program are considered. These include development and implementation of ALARA plans for activities involving radiation exposures, compliance with the procedures, provision of personal protective gear to workers, availability and accuracy of personal and area monitoring equipment, radiation dose records for radiation workers and records of radioactive releases from nuclear installations. It has been observed during the reporting period, that the doses to radiation workers remained well below the radiation dose limits and the average dose received by an individual remains less than a fraction of the annual dose limit. Similarly, in the entire operating history of nuclear installations in Pakistan the gaseous and liquid effluent releases have been well below the derived release limits. The licensees report the ambient dose levels at nuclear installations to PNRA quarterly and annually. PNRA has observed that the ambient dose levels at the boundary of KANUPP, C-1 and C-2 are generally close to the level of natural background.

Pakistan has, therefore, met the obligations of Article 15 of the Convention.

Article 16 - Emergency Preparedness

"1. Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.

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

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

16 Emergency Preparedness

Pakistan has taken appropriate steps to ensure that there are on-site and off-site emergency plans for nuclear installations, which are routinely tested and cover almost all the activities to be carried out in the event of an emergency. For new nuclear installations, emergency plans are prepared and reviewed before the commencement of operation. In addition, appropriate steps have been taken to ensure that the surrounding population is provided with appropriate information for emergency planning and response.

16.1 Regulatory Requirements

The PNRA Regulations PAK/909 set the requirement for establishing an emergency preparedness and response plan prior to introduction of nuclear material into the facility. PNRA Regulations PAK/913 requires the licensee to establish appropriate emergency arrangements from the time the nuclear fuel is brought to the site and to put in place emergency preparedness plans before the commencement of operation of the installation. Emergency preparedness plans are required to maintain the capability for managing accidents, mitigating their consequences if they do occur, protecting the site personnel, public and the environment. These plans are to be submitted to PNRA for approval and implemented in the event of an emergency. In addition, emergency plans are required to be tested through emergency exercises before the commencement of operation of the installations and at periodic intervals thereafter. Some of these exercises shall be integrated and shall include the participation of all concerned organizations. The plans shall be subject to review and updating in the light of experience gained from the exercises.

Further, the PNRA Regulations PAK/914 "Regulations on Management of a Nuclear or Radiological Emergency" require that licensee shall develop, test, and put in place an infrastructure according to the hazard category as defined in the Regulations. In addition, the licensee shall ensure a timely, well-managed, controlled, coordinated and effective response at the installation, in the emergency planning zones anticipated to be affected by the nuclear or radiological emergencies. Implementation of these requirements are aimed to minimize the radiological consequences for the public, property and the environment arising from such an

emergency. In case of severe emergencies, the response at national level is also required by these regulations.

The regulations require maintaining preparedness for emergency response actions both within and outside facilities, for sources under the control of licensee including action to be taken both in and after an emergency. As per regulatory requirements, licensees have to coordinate, in advance, with local response organizations for management of interventions in emergency situations and with the National Disaster Management Authority, Provincial Disaster Management Authority or District Disaster Management Authority for the provision of necessary support in case the consequences are expected to be beyond the control of licensee and local response organizations. The responsibilities of all the parties including decision makers are defined in respective emergency plans and a coordination mechanism is established for implementing the decisions both at onsite and offsite areas. PNRA reviews and approves the emergency plans and ensures that the plans are demonstrated regularly through emergency exercises.

The PNRA regulations require a comprehensive safety analysis to identify all sources of exposure and to evaluate radiation doses that could be received by workers at the facility and the public as well as potential effects on the environment. Full range of postulated events need to be considered, including emergencies involving a combination of a nuclear or radiological emergency with a conventional emergency such as an earthquake, tsunami, fire etc. This also includes consideration of simultaneous accidents at multi-units site. It is required that the nature and extent of emergency arrangements for preparedness and response shall be commensurate with the potential magnitude and nature of the hazard associated with the facility or activity. PNRA has defined criteria for hazard categorizations of facilities and activities in PNRA regulations which are in line with IAEA requirements and guides. The assessment of the hazard is described in safety analysis reports and emergency plans of the facilities which are reviewed by PNRA.

The regulations require that on-site and off-site emergency response need to be effectively managed and coordinated. A clear command and control system for the response to nuclear or radiological emergencies both at onsite and offsite need to be in place and tested regularly. As per regulatory requirement and for effective coordination in response to a nuclear emergency, Onsite and Offsite Emergency Control Centers have been established at facility and head office of district/provincial government department. Organizational interfaces among all major response organizations have been defined.

The regulations require the licensee to take, all appropriate measures to save lives. The arrangements need to be made for taking appropriate actions for the protection of emergency workers; alerting permanent, transient and special population groups; taking urgent protective actions; protecting supplies of food and water; imposing restrictions on the immediate consumption of products from farms or gardens and of locally produced milk; monitoring and decontaminating evacuees; caring for evacuees; alerting special facilities; the control of access and the restriction of traffic. It is required to identify Emergency Planning Zones (EPZs) for which arrangements shall be made for taking urgent protective action. The intervention levels for taking urgent protective actions are defined in the regulations.

PNRA Regulations require providing a prompt warning and instructions to permanent, transient and special population groups and to special facilities in EPZs upon declaration of emergency. These instructions are required to be provided in local languages. Accordingly,

predefined statements in national and local languages are prepared and made part of emergency plans.

PNRA regulatory requirements are in line with IAEA safety standards which demonstrate an effort to harmonize the local emergency preparedness and response arrangements with international arrangements.

16.2 National Emergency Management Infrastructure

West Pakistan National Calamities (Prevention and Relief) Act of 1958 provides for the maintenance and restoration of order in areas affected by calamities, and relief against such calamities. The Calamities Act 1958 was mainly focused on organizing emergency response.

The institutional and policy arrangements were further strengthened by promulgation of the National Disaster Management Ordinance 2007 (NDMO) in the aftermath of the 2005 earthquake. Under NDMO, Government of Pakistan established a National Disaster Management Commission (NDMC) headed by the Prime Minister under National Disaster Management Act, 2010.

The National Disaster Management Act, 2010 also established a National Disaster Management Authority (NDMA) to serve as the focal point and coordinating body to facilitate implementation of disaster management. All stake-holders including government departments / agencies and armed forces work through and form a part of NDMA in all stages of Disaster Risk Management.

Pakistan Nuclear Regulatory Authority (PNRA) under the PNRA Ordinance No. III of 2001 has the mandate to ensure, co-ordinate and enforce preparation of emergency plans for actions to be taken following foreseeable types of radiation emergencies that might affect the public.

Provincial Disaster Management Authorities (PDMAs) and District Disaster Management Authorities (DDMAs) have been established at the provincial and district levels of the country. The National Disaster Management Authority has formulated a National Disaster Response Plan (NDRP) after extensive cross-sectored consultations. NDRP seeks to upgrade the country's ability to cope with all conceivable disasters. To achieve this purpose, complete range of disaster management activities from preparedness to response have been addressed. The formulation outlines a framework for emergency response at different levels of the government structure; identifies roles and responsibilities of various stakeholders, and lays down coordination mechanism for activities involving the United Nations, Non Governmental Organizations (NGOs), civil society organizations, public & private sector and media to harness the full national potential for efficient disaster management. Details on functions and responsibilities of NDMA/PDMAs/DDMAs and other stake holders are given in the NDRP.

In case of a nuclear or radiological emergency, the licensee is responsible to implement response actions at the site while local government will implement the protective measures in offsite areas. The responsibilities of the licensees with respect to nuclear or radiological emergencies and District/Provincial Government are defined in onsite and offsite emergency plans respectively.

NDMA is supported by organizational set-ups at provincial and district levels by Provincial Disaster Management Authority (PDMA) and District Disaster Management Authority (DDMA) respectively. At the district level, the District Coordination Officer (DCO), the leading officer of the DDMA has the right to take decisions in consultation with the Site Emergency Director of the facility.

Under the National Command Authority (NCA) Act 2010 , the existing emergency management system has been strengthened with the establishment of National Nuclear Emergency Management System (NEMS). The objective of the NEMS is to coordinate all off-site emergency preparedness and response activities related to nuclear or radiological emergencies, provide technical support to offsite response organization through radiological assistance groups of PNRA and PAEC, and assistance from other organizations. NEMS seamlessly dovetails with NDMA plans in case the nuclear emergencies begin to have off-site consequences. Additionally, necessary coordination and liaison is continuously maintained with all stakeholders. Major stakeholders are as given below:-

a. Strategic Plans Division (SPD)
b. Pakistan Nuclear Regulatory Authority (PNRA)
c. Pakistan Atomic Energy Commission (PAEC)
d. National / Provincial / District Disaster Management Authority (NDMA / PDMA / DDMA).
e. Federal / Provincial Ministries / Local response organizations
f. Armed Forces

In order to retain centralized control of off-site coordination activities and direct countrywide resources to the place of accident, a center of operations called "Nuclear and Radiological Emergency Support Center" (NURESC) has been established at SPD to act as the focal Emergency Preparedness & Response Centre to coordinate and facilitate all consequence management / mitigation activities of offsite response organizations in case of nuclear and radiological emergencies. On occurrence of an accident / incident, emergency management plans will be implemented by respective NPPs while keeping NURESC informed. The functions of NURESC are as follows:-

i. Act as the focal point for receipt of information on any nuclear or radiological emergency and oversee off-site consequence management activities at national level.
ii. In case of nuclear emergencies arising at NPPs, NURESC would augment the capabilities of response organizations by providing advanced radiation detection system and arrange additional support for implementing offsite protective measures.
iii. Coordination with the nuclear facilities to ensure communication of requirements of offsite assistance to concerned DDMA / PDMA. Also arrange assistance which is required to come forth from the armed forces.
iv. Augments the resources of other stakeholders in managing nuclear emergencies.
v. Render technical expertise and assistance to other national agencies through PAEC and PNRA, especially NDMA in managing nuclear and radiological emergencies.
vi. Provides advice and necessary guidance to Emergency Management Oversight Committee for Public communication related to nuclear and radiological incidents/accidents.
vii. Maintains close contact with NDMA and act as liaison point for off-site emergencies.

The emergency management at NURESC is being overseen by Nuclear & Radiological Emergency Management Oversight Committee comprising senior decision makers and

technical experts from different stakeholders. This committee facilitates critical decisions related to Emergency Preparedness and Response including the recovery/restoration phase of an emergency.

For validating the NEMS concept, and to continuously affect improvements, the following national level exercises were conducted involving all relevant stakeholders in addition to participation in the national and ConvEx exercises (Please see Annexure XI):-

[a] Air Time Exercise at Lahore & surrounding areas (Nov, 2012)

[b] Ex-Swift Horse Exercise at CNPGS (Sep, 2013).

[c] Air Time Exercise at Lahore & surrounding areas (Jan, 2014).

[d] Air Time Exercise at Rawalpindi & surrounding areas (May, 2015).

16.3 Emergency Plans of Nuclear Installations

The operating nuclear installations (KANUPP, C-1 and C-2) have developed on-site and off-site emergency plans. These emergency plans describe on-site and off-site response organizational setups, classification of emergencies, assessment and declaration of emergencies, emergency facilities, on-site and off-site notification systems, emergency planning zones, intervention and derived intervention levels, environmental dose measurement and assessment facilities, application of protective measures, recovery operations, termination of emergency, public information, records and reports pertaining to exercises and drills, etc. Emergency plans also give brief details of plant systems, demography and regional climatology. The on-site and off-site emergency response organizations of all nuclear installations are described in the emergency plans covering the role of each responsible person during an emergency situation. Emergency facilities like emergency control center, auxiliary emergency control center, communication facilities, radiation monitoring system, post accident monitoring system, medical facilities, decontamination facilities, etc. are described in the respective emergency plans.

Moreover, PAEC Emergency Response Coordination Center (PERCC) has been established at PAEC HQs. This center operates round the clock. PERCC coordinates response activities in case of emergencies at nuclear installations of PAEC. PERCC is a focal point where notification of emergency at PAEC facilities is received, processed and forwarded to the relevant authorities. Under the NEMS, PERCC coordinates with NURESC for activities to limit the consequences of accident and to minimize risk to the general public and the environment. This Center is equipped with state of the art facilities; including high quality diverse communication channels.

The effectiveness of emergency plan is demonstrated in an integrated exercise before the commencement of operation of a nuclear installation and periodically with a pre-defined frequency during the operation phase. During the period from 2014-2016, the emergency exercises at KANUPP, C-1 and C-2 have been conducted as per schedule. The frequency of the exercises is given in Annexure–XI. Emergency exercises performed at KANUPP, C-1, C-2 and NRECC from January, 2014 to June, 2016 are also shown in Annexure–XI. PNRA inspectors and representatives of PAEC Corporate office witnessed the exercises and made recommendations to the licensee for further improvements. The plans are updated in the light of experience gained from the exercises and drills. In order to ensure an appropriate response, emergencies are classified according to the severity of an event or accident. Emergencies have been categorized into four classes in increasing order of severity as

standby alert, plant emergency, site emergency and general emergency. The details of the initiating conditions and actions to be taken during these emergencies are defined in the emergency plans.

There are two types of response organizations called onsite emergency response organization and offsite emergency response organization. The onsite response organization consists of Site Emergency Director (SED) and different type of emergency support and advisory groups. Offsite response organization consists of Head of local government and all supporting departments. Roles and functions of these response organizations are defined in emergency plans. Positions have been assigned to all those who will perform response functions in case of a nuclear accident or radiological emergency. Organizational coordination and interfaces among all major response organizations have been established.

The initial assessment of the accidents and determination of associated emergency class is specified in relevant plant procedures to be exercised by the on duty Shift Supervisor (SS) under intimation to the SED. After the situation comes under control and the plant is brought to a safer mode, SS terminates the emergency with the authorization of SED.

According to On-site Emergency Plan of C-1 and C-2, 'CHASNUPP Emergency Response Organization' (CERO) is responsible for initiation and completion of recovery operation and is regarded as Recovery Organization while Technical Support Centre (TSC) is meant to provide technical support to the MCR crew in case of emergency. Both CERO and TSC are activated by SS in case of emergency.

C-1, C-2, C-3 and C-4 have separate onsite emergency plans and a common offsite emergency plan. All units have developed a joint procedure for interface during radiological emergency defining communication links between Emergency Control Centers (ECCs) and MCRs in case of emergency at C-1, C-2, C-3 and C-4. In case of emergency at any one unit, the respective MCR Shift Supervisor will notify to other units that the same class of emergency be declared at the sister units to ensure the implementation of protective measures for safety of all personnel on the whole site. Consequently, all the units will perform actions in accordance with their respective emergency plans and procedures. CNPGS Off-Site Emergency Plan is endorsed both by the district as well as provincial Governments.

For the period from 2013 to 2016, CNPGS has conducted Integrated Emergency Exercise and Partial Emergency Exercises to evaluate the effectiveness of approved emergency plan. In March 2015, CNPGS conducted 2nd Off-site Partial Emergency Exercise (Tabletop) with full involvement of District Administration. During this exercise, detailed discussions were held among all district officers under supervision of DCO/DC and senior police officials for arrangement of resources needed to implement the public safety measures during emergency like evacuation, sheltering, re-habilitation, etc., and were witnessed by PNRA. In April 2016, an 8th Integrated Emergency Exercise of CNPGS was conducted to test the On-site and Off-site emergency plan before first fuel load of C-3.

At KANUPP, there is KANUPP Onsite Radiological Emergency Plan (KONREP) and KANUPP Offsite Radiological Emergency Plan (KOFREP). Radiological Emergency Procedures (REPs) are also available which provide detailed guidance on respective response in accordance with On-site emergency plan. KANUPP has submitted revised KONREP to PNRA for review and approval. This revision incorporates NEMS concept and further necessary improvements.

The off-site emergency plan KOFREP is duly approved by Provincial Disaster Management Authority (PDMA) Sindh. KOFREP contains Off-site response actions required to be taken to protect public in case of emergency at KANUPP requiring off-site response. PDMA Sindh has constituted and notified Karachi Radiological Emergency Response Committee (KRERC) for timely implementation of off-site response measures to protect public. Standard Operating Procedures (SOPs) are also in place on respective response actions in line with KOFREP. In addition, KOFREP plan is being revised to incorporate NEMS role.

EPZ for KANUPP which was initially 3 km has been enlarged to 5 km following re-assessment after Fukushima Daiichi Accident. Currently, stock of 100,000 Potassium Iodide (KI) tablets is available. This inventory has been maintained keeping in view enlarged EPZ in case of any severe accident. At present, PDMA ,Sindh will provide necessary assistance as per KOFREP. SOPs for sheltering, KI tablets distribution and evacuation have already been prepared and approved. Population data is also updated up to 16km.

At KANUPP and CNPGS, a team of multi discipline reserve force (Operation, Maintenance, Health physics, etc.) has been formed for assistance during any severe accident. Radiological Assistance Groups (RAGs) have been formed in different parts of the country under NEMS. These groups will provide support to affected plant in case of emergency in the area of environmental monitoring and to some extent radiological protection. A database for other organizations in the country which have these capabilities has been compiled.

16.4 Verification of Emergency Plans by PNRA

PNRA has developed a specific mechanism to regulate emergency preparedness and response arrangements at nuclear installations. This mechanism is based on review and evaluation of emergency plans and regulatory inspections including evaluation of emergency drills and exercises.

16.4.1 Review of Emergency Plans

PNRA regulations require submission of various documents during different stages of authorization and licensing processes. The regulations require licensee to submit emergency preparedness plans, prior to introducing nuclear material into the nuclear installation. PNRA performs safety review and assessment of the emergency plans starting from initial stage of licensing. Initially, the emergency plans are submitted as part of preliminary safety analysis report of a nuclear facility to ensure the compatibility of proposed emergency plans for both onsite areas and the emergency planning zones, with facility design features, site layout, and site location, access routes, surrounding population distributions, land use, etc. Later on, detailed plans are submitted to the PNRA at the stage of submission of final safety analysis report as separate documents. PNRA reviews and approves the plans against regulatory requirements prior to issuance of fuel load permit, subject to fulfillment of applicable regulatory requirements. The commencement of operation of the facility is allowed only after successful demonstration of complete emergency preparedness and response arrangements in an emergency exercise. During the reporting period, onsite emergency plan of C-3 has been reviewed and approved. During 2014 and 2015, PNRA reviewed contents of K-2 and K-3 On-site and Off-site emergency plans, submitted to PNRA as part of application for issuance of construction licence.

16.4.2 Regulatory Inspection Program

The inspection program of PNRA for nuclear installations comprises various types of inspections like planned and unplanned inspections, periodic inspections, reactive inspections etc. These regulatory inspections are conducted by regional offices of the PNRA established at sites of nuclear installations. Relevant regulatory staff from PNRA headquarters also participate in periodic and special regulatory inspections. Such inspections are conducted to verify compliance with regulatory requirements which include verifying that the implementing procedures are developed, on-site emergency response organizations are equipped with necessary means, and response personnel have adequate qualifications and training.

16.4.3 Evaluation of Emergency Exercises

PNRA evaluates the conduct of periodic emergency drills / exercises and record of trainings as part of regulatory oversight. During this evaluation, it is ensured that the licensee has demonstrated arrangements in place to cope with or minimize radiological consequences in case of an emergency. At least one month prior to the conduct of an exercise, licensee submits emergency exercise scenario for review and approval of PNRA. A team comprising evaluators from PNRA headquarters and respective regional office witnesses the exercise.

On the basis of the results of drills and exercises, a report is prepared describing the actions to be taken for improvement of emergency plans and procedures. The exercise evaluated by PNRA during the reported period are mentioned in Annexure XI.

16.5 National Radiological Emergency Coordination Centre (NRECC)

Pakistan is a State Party to the Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the case of a Nuclear Accident or Radiological Emergency. In Pakistan, PNRA is the National Competent Authority { NCA (D) and NCA (A), about an accident situation happening domestically (D) or abroad (A)} respectively as well as point of contact for notification and coordination with IAEA and/or with other State Parties under the both Conventions. For fulfillment of obligations under these Conventions and the Ordinance, PNRA has established National Radiological Emergency Coordination Centre (NRECC) at its Headquarters in Islamabad which acts as national warning point and remains available round the clock for receipt/dissemination of emergency notifications and initiation/coordination of emergency response at national and international level. NRECC works in coordination with NURESC for sharing of information in case of nuclear or radiological emergencies at national and international level. NRECC also coordinates with NURESC regarding provision of advice to the government for initiating actions related to implementation of protective measures at the national level, if required.

The main functions of NRECC are to:

i. Receive and disseminate notification and information concerning the nature of the emergency (national as well as transnational).
ii. Authenticate and verify notifications or information of a nuclear accident or radiological emergency.
i. Inform forthwith, after being notified of an event, the NRECC Chain of Command and relevant authorities about the received notification.
ii. Communicate received information (consistent with confidentiality limitations) promptly to licensee, public authorities or relevant international organizations.

iii. Facilitate and/or co-ordinate the provision of assistance at the national/international level, if it is requested for.
iv. Assist the national competent authority on recommendations to Government of Pakistan for protective actions like sheltering, evacuation or supply of prophylactics, etc.
v. Use its best endeavors to promote, facilitate and support the cooperation and coordination between PNRA, licensees, public authorities and relevant international organizations.
vi. Ensure that there are timely, accurate and reliable releases of information to the media, as appropriate, through other relevant directorate of PNRA.

NRECC is supported and equipped with communication, radiation detection equipment, personal protective equipment, mobile radiological monitoring labs and technical support team comprising of experts from various directorates of PNRA. A network of six mobile radiological monitoring labs (MRMLs) with field response teams comprising trained scientists and technicians has been established by PNRA which are geographically located in major cities and NPP sites across the country. These include Islamabad, Chashma, Karachi, Peshawar, Multan and Quetta. The purpose of these teams is to provide technical assistance to local and national response authorities and to perform independent assessment of any situation involving accidental radiation exposures, if needed. In addition, PAEC has its own MRMLs at sites.

During emergencies, the decision for implementation of protective measures is the responsibility of the licensee on the basis of intervention levels, reference levels, etc., defined in the licensee emergency plans which are approved by PNRA. However, the licensee keeps NRECC informed about any protective measures taken. PNRA is consulted in case of any unforeseen situation. PNRA also coordinates with the response and law enforcing agencies to familiarize them with their role during a nuclear accident or radiological emergency.

NRECC conducts various emergency exercises to test its own preparedness and response arrangements during different types of emergency situations. These exercises include; Communication Test Exercise (COMTEX) and Mobile Radiological Monitoring Laboratory (MRML) field exercise. COMTEX exercises are conducted, thrice a year, to check availability and reliability of communication channels established with licensees and other relevant national organizations whereas, MRML field exercises are conducted, biannually, to test the procedures and operation of field response teams in hypothetical emergency situations. Such field exercises are sometimes conducted in different cities, in coordination with and support of regional directorates of PNRA and by involving regional field response teams. These exercises are listed in Annexure XI.

In line with the decision of the Government of Pakistan to increase share of nuclear power in electricity generation, National Radiological Emergency Coordination Centre (NRECC) is being upgraded. In this regard, PNRA has pursued a project for up-gradation of NRECC with the Government of Pakistan under Public Sector Development Program (PSDP). Under this project, NRECC would have online access to safety parameters of all the nuclear installations and environmental radiation monitoring system during normal operations as well as in emergency situations. The project will also help to improve the technical capabilities of NRECC in order to effectively advise to the Government and relevant organizations who shall implement protective measures in case of a nuclear accident or radiological emergency.

NRECC receives information on radiation incidents and emergencies occurring worldwide through IAEA. These events are usually related to, events at nuclear facilities, overexposure of workers/members of the public, theft/loss of radiation sources, contamination/spill of radioactive material, malfunction of equipment, etc. NRECC analyzes the information received, identifies the lessons learnt and implement these lessons for improvement of radiation safety in the country. PNRA also shares the information with the licensees regarding information on radiation incidents in the world.

16.6 Training of First Responders

In case of an emergency, the rescue person is always one of the first responder reaching at the scene of the accident. The trained rescuers can play an important role to avoid spreading of contamination and overexposure to the personnel. In order to train the first responders, PNRA and NURESC contribute towards capacity building of the stakeholders through provision of necessary detection equipment and arranging trainings at various levels.

In 2014, PNRA arranged a national workshop for medical community on medical response to a nuclear or radiological emergency in coordination with International Atomic Energy Agency (IAEA). The workshop was attended by more than sixty participants from different medical centers throughout the country. The international experts from IAEA shared their experiences with the participants for handling of overexposed and contaminated individuals due to a nuclear accident or radiological emergency. During 2015, PNRA organized four training courses on emergency preparedness and response including one with the assistance of IAEA. PNRA has also provided technical support to other national organizations in conducting training courses on emergency preparedness and response. More than two hundred participants of various organizations including personnel from different facilities, Rescue Services, Police, Customs, Doctors and Paramedical Staff were provided training on different aspects of handling radiation emergencies.

In 2015, a workshop on decision making for implementation and termination of protective measures in case of nuclear accident or radiological emergency was also arranged for the operators and responders at national level.

16.7 Training of Medical Professionals in Handling of Radiation Injuries

Overexposure to radiation or radioactive contamination may cause radiation injuries in case of a nuclear or radiological emergency. It is obvious that medical professionals would be among the first responders in such accidents. In this regard, NURESC has played a central role in providing necessary resources at the national level for the capacity building and training of medical professionals.

PNRA is working towards coordinating the development of national capability for the management and treatment of radiation injuries with licensees, other national organizations and hospitals. PNRA pays special attention to the training of the medical personnel to ensure that adequate level of such competency exists among medical doctors and paramedical staff. In this regard, short courses have been arranged in different hospitals for medical doctors and paramedical staff. These courses are based on basic medical techniques for treatment of overexposed and contaminated individuals at the site and in isolated rooms in hospitals in case of a nuclear or radiological emergency.

16.8 Public Awareness

A two pronged strategy for implementation of public awareness program has been adopted. First, as part of implementation of offsite emergency plans, the licensees are implementing site specific public awareness programs in areas around nuclear installations. Assistance from other local organizations such as local governments, educational institutions, etc., is being sought for providing awareness about emergencies and response of the public.

During the reporting period, PNRA participated in different national level Disaster Management Exhibitions, for the awareness of general public, students, responders and other organizations. Radiation detection equipment, personal protective equipment, brochures and pamphlets were displayed for the interest of the visitors. The exhibitions were attended by hundreds of visitors together with general public and students of various universities and educational institutions.

For the use and awareness of first responders and public, PNRA has prepared, printed and distributed pamphlets and booklets regarding nuclear and radiation emergencies which, among others, include "Instructions for Radiation Workers during Radiological Emergencies", "Guide for First responders" "Instructions for General Public during Radiation Emergencies" and "How to Use TLDs" The brochures are prepared both in English and national languages.

During the reporting period, PNRA conducted 66 lectures and seminars (till June, 2016) involving around 10,000 participants for public awareness in Islamabad, Lahore, and Peshawar. These seminars were conducted at hospitals, medical centres, law enforcement agencies, schools, colleges, and universities.

16.9 International Cooperation in Emergency Planning and Preparedness

Pakistan is participating in a number of international activities under the auspices of IAEA in the area of emergency preparedness and response. Pakistan participates in IAEA ConvEx exercises which are conducted to test the accuracy, availability and accessibility of contact points, adequacy of response time and capability to exchange information through USIE website. These exercises, especially the large scale ones like ConvEx-3, helped in testing the planning and preparedness. As a lesson learnt from ConvEx-3 (2013) exercise and Fukushima accident, PNRA has identified and trained a team consisting of members from its technical directorates for ensuring smooth long term operation of NRECC.

As a Contracting Party to the Convention on Early Notification of a Nuclear Accident, and to the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, Pakistan is committed to exchange information or consider provision of assistance in case of a nuclear accident or radiological emergency in line with the provisions of the Conventions. The contact points for IAEA are Permanent Mission of Pakistan to the IAEA whereas; PNRA is National Warning Point and National Competent Authority.

16.9.1 Response and Assistance Network of the IAEA (RANET)

IAEA Response and Assistance Network (RANET) is an integrated system established under the International Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and is meant to provide international assistance to Member States to minimize the radiological consequences of accidents. Being the State Party to the Convention, Pakistan has registered National Assistance Capabilities (NAC) in the RANET at IAEA. NURESC plays central role in coordinating all the organizations for provision of resources to be offered by

Pakistan under RANET, whereas, PNRA is the national contact point under this network. Recently, IAEA revised the scope and areas of assistance under RANET. Considering the revised functional areas of assistance, PNRA has also identified various experts from different fields to contribute in RANET. Pakistan also participated in RANET workshop conducted by IAEA in Fukushima, Japan in November 2014 by deploying equipment and resources to test the compatibility and harmonization of arrangements at international level.

PNRA participated in IAEA RANET related workshops/meetings to review the areas of RANET, preparation of RANET documentations and proposals to broaden the areas of assistance in RANET.

Pakistan has, therefore, met the obligations of Article 16 of the Convention.

Article 17 – Siting

"The Contracting Parties shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

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

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

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

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

17 Siting

The objective of siting and site evaluation for nuclear installation is to ensure protection of the public and the environment from the consequences of radioactive releases during normal operation and accident conditions. Characteristics of the natural environment in the region that may be affected by potential radiological impacts during normal operational states and accident conditions are observed and monitored throughout the lifetime of the installation. In evaluation of suitability of a site for a nuclear installation, the following main aspects are considered:

i. Effects of external events (natural or human induced) occurring in the region of a particular site

ii. The characteristics of a site and its environment that could influence the transfer of radioactive material to public & the environment

iii. Population density, population distribution and the possibility of implementing emergency measures.

Pakistan Nuclear Regulatory Authority Ordinance 2001 clearly stipulates "no person shall commence construction of any nuclear installation without first obtaining an authorization for the purpose from the authority as may be prescribed by regulations". PNRA regulatory framework ensures that licensees have developed and implemented adequate procedures for evaluating all relevant site related factors.

It is ensured that licensees have developed and implemented adequate procedures for evaluating all relevant site related factors likely to affect the safety of a nuclear installation for its projected lifetime, and for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment. The continued safety acceptability of the nuclear installations has been ensured by re-evaluating all relevant site related factors likely to affect the safety of a nuclear installation for its projected lifetime.

17.1 Regulatory Requirements

Requirements for the Siting of a nuclear power plant are provided in PNRA Regulations named “Regulations on the Safety of Nuclear Installations – Site Evaluation (PAK/910)”.

Before site registration, the applicant has to submit an Environmental Impact Assessment report approved by the Pakistan Environmental Protection Agency (PEPA). Subsequently, a Site Evaluation Report (SER) is submitted to PNRA for site registration in order to ensure that the plant complies with the national rules and regulations regarding environment protection, land and water use, etc. In the evaluation of the suitability of a site for a nuclear installation, various aspects are considered such as external events (natural origin or human induced) occurring in the region of the particular site, the characteristics of the site and its environment that could influence the transfer to persons and the environment of radioactive material to be released, population density, population distribution and other characteristics of the external zone in so far as they may affect the possibility of implementing emergency measures and the need to evaluate the risks to individuals and the population.

In addition, Regulations for Licensing of Nuclear Installation(s) in Pakistan – PAK/909 also require provision of “No Objection Certificates” from local, provincial and other federal agencies.

"Regulations on the Safety of Nuclear Installations-Site Evaluation"; PAK/910 are currently under consideration for revision to incorporate requirement for periodic re-evaluation and re-assessment of all hazards (natural or man-made) in line with the revision of IAEA requirements on siting and commitment made in the Vienna Declaration on Nuclear Safety.

17.1.1 Specific Requirements for Evaluation of External Events

The characteristics of the natural and human induced hazards as well as the demographic, meteorological and hydrological conditions of the nuclear installation site are monitored over the lifetime of the nuclear installation. The site characteristics are assessed on the basis of historical evidences, recorded data, site surveys, detailed investigations and analyses in line with international practices and proven engineering techniques. Generally, site specific data (recorded data) are used. Where site specific data is not available, data derived from historical information and /or data of similar site is used. The site is evaluated against natural hazards as well as man-made hazards (storage, transportation, etc.).

In the evaluation of the suitability of a site for a nuclear installation, the following external events (natural origin) occurring in the region are:

i. Earthquakes
ii. Surface Faulting
iii. Meteorological Phenomena
iv. Flooding
v. Geotechnical Hazards

These evaluations are used to establish design bases for nuclear installations. Seismic activities, ground water, meteorological conditions are continuously monitored and instruments are installed at proposed sites.

17.1.2 External Human Induced Events

Human induced events (i.e. fire, explosion, aircraft crash) are also assessed at proposed sites. The potential for aircraft crashes on the site is assessed with account taken, to the extent practicable, of characteristics of future air traffic and aircrafts to be used. Activities in the region that involve the handling, processing, transport and storage of chemicals having a potential for explosions or for the production of gas clouds capable of deflagration or detonation are identified and considered in the design.

17.1.3 Site Characteristics and the Potential Effects of the Nuclear Installation in the Region

The site and the design for the nuclear installation is examined in conjunction to ensure that the radiological risk to the public and the environment associated with radioactive releases is acceptably low. Suitability of the site for nuclear installation mainly considers:

i. the characteristics of the site and its environment that could influence the transfer to persons and the environment of radioactive material that has been released;
ii. the population density and population distribution;
iii. other characteristics of the external zone in so far as they may affect the possibility of implementing emergency measures;
iv. the need to evaluate the risks to individuals and the population.

Programs for meteorological measurements at appropriate elevations and programs for investigation/measurements of the surface hydrology to determine the dilution and dispersion characteristics for water bodies are conducted at NPP sites. Following studies are carried out to determine the dispersion of radioactive material to the population.

a. Atmospheric Dispersion of Radioactive Material
b. Dispersion of Radioactive Material through Surface Water
c. Dispersion of Radioactive Material through Groundwater
d. Population Distribution

17.2 Environmental Monitoring Program

According to the PNRA Regulations on Licensing of Nuclear Installations PAK/909, licensee has to submit Environmental Impact Assessment (EIA) report duly approved by Environmental Protection Agency (EPA). The Environmental Protection Agency is responsible for the prevention and control of environmental issues. A Nuclear Power Plant is covered by Pakistan Environmental Protection Act. Under this Act, the proponent of the Plant is to submit an Impact Assessment Report to the concerned Environment Protection Agency. The Nuclear Power Plants are designed, installed and operated with such stringent standards that the adverse impacts are taken care of in an inherent way.

During the consideration of Nuclear Power Plants at Karachi and Chashma sites, the environmental assessments were integrated with feasibility studies of respective designs to avoid any major adverse impact on the environment. To fulfill the requirements of the environmental act, the information about the site, project development, plant features and operation was provided in Impact Assessment Report. The guidelines regarding air emissions, liquid effluents and solid wastes are to be followed by the licensee.

17.3 Nuclear Installation Sites

Pakistan has two NPPs sites i.e. Karachi and Chashma. Karachi site has three nuclear power plants, one unit KANUPP is in operation and two units (K-2 and K-3) are under construction. Chashma site has two operating nuclear power plants namely; C-1, C-2 and two other NPPs C-3 and C-4 are under construction. The design and operation of these NPPs have ensured that integrity of all SSCs is ensured against all potential hazards considered in siting. PAEC is in process of identifying new NPPs sites in line with the Government of Pakistan Energy Security Plan to increase nuclear energy share up to 8800 MWe by the year 2030.

17.3.1 Site Evaluation of Karachi Site

Karachi site is located along the coastline of the Arabian Sea. It is about 22 km North-West of Karachi port and 1155 Km in South-West of Islamabad. The regulatory requirements regarding size of the exclusion area, low population zone and population center distance have been fulfilled with respect to each plant individually. The licensee is committed to demonstrate that the simultaneous operation of multiple reactors at site will not result in cumulative radioactive effluent releases beyond the allowable limits. The impact of all relevant site related factors on plant and the impact of plant on individuals, society and the environment has been evaluated and reassessed.

Karachi site was reevaluated in 2012 to find any potential hazard including earthquake, Tsunami, flooding, etc. by following the IAEA safety guide SSG-9, various structural elements present in the region were critically studied and PGA was re-estimated. Safety and safety related SSCs of KANUPP are assessed against 0.2g instead of the original design basis of 0.1g.

PNRA also directed the licensee to re-evaluate the seismic potential of Murray Ridge situated about 75 km from the site. Licensee submitted a report regarding seismic potential and Tsunami analysis of Murray Ridge and historic instrumental seismicity along with other geophysical and drilling data which indicates that no tsunami event occurred along Murray ridge in recent and distant past. Whereas, other potential sources related to Karachi site i.e. Makran subduction zone and triple junction are identified and also evaluated with special emphasis. It can be concluded that site is safe against earthquake and Tsunami hazards.

KANUPP has been enlisted with Tsunami Early Warning System (TEWS) of Pakistan Meteorological Department (PMD) for dissemination of Tsunami warnings. A recent study to analyze the Seismic Hazard along with Tsunami potential, as per new IAEA guidelines, for Karachi site has now been completed. The results are similar to those obtained from earlier studies conducted for earthquake and Tsunami potential. Since the Karachi site is not close to any forest or fire source therefore possibility of external fire is ruled out.

K-2 and K-3 site is about 1.5 km in the North-West of existing Karachi Nuclear Power Plant (KANUPP). The site was evaluated against Tsunami, earthquake and all relevant natural and manmade hazards. K-2 and K-3 have been designed for 0.3g. Factors, such as population distribution in the area, future growth and industrial development, have also been given special attention. Comprehensive technical reports for all siting factors such as Tsunami hazard analysis from potential sources were provided. Licensee has performed preliminary studies by using Next Generation Attenuation (NGA-2008) relationships to determine PGA values for K-2

and K-3 site. Considering Fukushima experience, licensee has been asked to perform Probabilistic Seismic Hazard Analysis (PSHA) for the site to take all possible earthquake scenarios for the site. PSHA for Karachi site isin progress and is planned to be submitted to PNRA by the end of 2016.

17.3.2 Site Evaluation of Chashma Site

Chashma site is situated on the left bank of the Indus River about 32 km South of Mianwali district and 280 km south-west of Islamabad. There are four nuclear power plants at Chashma site; two (C-1 and C-2) are in operation while the other two (C-3 and C-4) are under commissioning phases. The major site studies include demographic and geographic studies, nearby industrial transportation and military facilities, Meteorological hazards, hydrological, geological, seismo-tectonics and geotechnical evaluations as per regulatory requirements. The requirements for size of the exclusion area, low population zone and population center distance have been fulfilled with respect to each plant. Furthermore, the licensee is committed to demonstrate that the simultaneous operation of multiple reactors at site will not result in total radioactive effluent releases beyond the allowable limits.

Design basis Safe Shutdown Earthquake (SSE) value of 0.25g has been adopted for all units at the site. Similarly meteorological parameters and flooding have been taken into consideration in the design which provide sufficient margin against these hazards. The phenomena of surge & seiche flooding, and Tsunami are not relevant for the Chashma site. The floods due to other natural causes as well as those due to multiple failure of upstream dams have also been analyzed and the site has been evaluated as safe against peak flood level. The maximum possible water level expected at the CHASNUPP site is 201.03 meters MSL, whereas the minimum finished ground level in the plant area is more than 201.30 meters and 203 meters around the safety related structures to cater for wind induced effects during flooding, free board, etc.

17.3.3 Re-evaluation of Site Related Factors

The operating licence for a nuclear installation is granted for ten years. For the licence renewal, comprehensive re-assessments of site related factors and the effects of external events on the safety of the facility are carried out in the light of national and international standards. In this regard, periodic safety review (PSR) is performed by the licensee according to the guidance provided by PNRA. The assessment of safety factor relating to the siting covers meteorology, hydrology, geology, seismology, population and use of land. Karachi site was re-evaluated after Fukushima Daiichi Accident to find any potential hazard including earthquake, Tsunami, flooding, etc. KANUPP again re-evaluated both external and internal hazards as part of its second PSR during 2013-15.

In light of lessons learned from Fukushima accident and international experience feedback, PNRA required licensee to update and re-evaluate relevant site related factors like earthquake potential, Tsunami potential and other hydrological and meteorological factors etc. Licensee has performed PSHA for Chashma site as part of site re-evaluation studies and submitted its report to PNRA. In addition, PSHA for K-2 and K-3 is in progress and its report will be submitted to PNRA by the end of 2016. PNRA has also asked licensee to verify the current status of potential earthquake sources around the plant site. Licensee has developed a work plan to full fill this regulatory requirement and PNRA will be apprised accordingly.

The safe shutdown earthquake (SSE) for KANUPP site has been re-evaluated based on new IAEA methodology, and found as 0.2g. The same has now been set as the design base earthquake (DBE) for KANUPP site and all the important buildings and systems have been evaluated for new DBE. Seismic retrofits where necessary, have been provided. Design basis Tsunami height using Japan Nuclear Energy Safety (JNES) organization code in worst hypothetical case is found as 2.84m, while Pump House (P/H) is at 2.74m. However, none of the equipment installed at pump house has been credited for usage during severe accident / natural hazard. The expected landslide generated Tsunami height has also been calculated and found as 3.24m whereas the ground level of KANUPP site is 12m above MSL. KANUPP site is safe against submarine landslide generated Tsunami. Water recession during Tsunami has been analyzed and found maximum probable water recession (net depression) is -4.80m from MSL in worst case scenario with 10% safety margin at the Hawks bay coast near KANUPP site. The safety of KANUPP intake structure could be compromised if the worst case scenario of wave recession occurred but the probability is very low. As per topographic survey and hydrologic study carried out for KANUPP site, the existing drains are more than sufficient. However, refurbishment work of existing rain drainage system is underway and completion is expected by the end of 2016.

17.4 Verification by PNRA

The details of site verifications of C-1, C-2 and KANUPP performed at the time of construction have been reported in the previous reports.

17.5 Trans-boundary Effects

Pakistan is signatory of the Convention on “Early Notification of a Nuclear Accident” and the Convention on “Assistance in the Case of a Nuclear Accident or Radiological Emergency”. The nuclear plant sites are far away from the national borders, which rules out the possibility of any trans-boundary implications. However, in case of an accident, Pakistan will respond according to the obligations under these Conventions with the international community.

17.6 Monitoring at Sites

Mechanisms of hazard monitoring are in place which includes seismic instrumentation and meteorological instrumentation station for monitoring of wind and temperature distribution. Furthermore, there is close interaction with the national authorities regarding information on tsunami, flooding and precipitation. The sites are declared as no fly zones and close interaction exists with the concerned aviation authorities for implementation of such arrangements.

Radiological environmental monitoring programs are in place both at KANUPP and CNPGS to analyze the effect of controlled radioactive discharges in the environment during plants operation. Environmental TLDs have been installed for ambient dose rate measurement. Soil, water, milk, grass and fish sampling is done and analyzed from the surroundings of sites. In addition, air borne samples are also collected and analyzed. The analysis result shows no significant impact of operation of C-1, C-2 and KANUPP on the respective environments. KANUPP, C-1 and C-2 also submit yearly reports on environmental monitoring to PNRA.

Pakistan has, therefore, met the obligations of Article 17 of the Convention.

Article 18 - Design and Construction

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

(i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence-in-depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;

(ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;

(iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface."

18 Design and Construction

Pakistan has taken appropriate steps to ensure that the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in-depth) against the release of radioactive materials, with a view to prevent the occurrence of accidents and mitigate their radiological consequences should they occur; and that the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis.

18.1 Regulatory Requirements

The regulations PAK/911 specify regulatory requirements for the design of nuclear installations. In addition, PAK/904, PAK/909, PAK/910, PAK/912, PAK/913 and PAK/915 also cover various aspects of design and construction of nuclear installations. The obligations of Article 18 are met through conformance to relevant regulatory requirements.

18.2 Implementation of Defence-in-Depth Concept

In striving to realize the objectives of its Nuclear Safety Policy, PAEC is committed to design, construct, operate and decommission its nuclear installations with appropriate barriers and engineered safety features to prevent or minimize potential radioactive releases. In order to ensure the safety of nuclear installations, a multi-barrier concept is applied based on the Defence-in-Depth (DiD) principle in the design and operation of nuclear installations. All structures, systems and components of nuclear installations are designed in consideration of internal and external hazards.

During first PSR of C-1, re-evaluation of plant design in relation to application of defense in depth was carried out as per IAEA Safety Report Series 46 "Assessment of Defence-in-Depth for Nuclear Power Plants".. In this regard, following improvements were made:

i. Development of symptom based emergency operating procedures.

ii. Installation of loose parts monitoring system.

iii. Provision of fuel assemblies with anti-debris filters.

A number of safety improvements are being implemented after Fukushima Daiichi Accident to enhance defense-in-depth. Details are given in Section 2.2 - Fukushima Response Action Plan.

Indigenous efforts and in-house resources are being utilized for installation of the passive hydrogen re-combiners, whereas, compensatory measures are being looked into in lieu of cavity flooding system and reactor coolant system fast de-pressurization valve for mitigating severe accidents.

KANUPP has given due consideration to the concept of defense-in-depth (DiD), in implementing actions to meet challenges from severe accident. As an example, to meet the challenges of prolonged SBO at site, an additional 300 KW diesel generator has been installed at a separate location in addition to the existing three emergency diesel generators (EDGs) by taking into account seismic and flood protection considerations. Provision has been made to connect plant essential buses from the already available diesel generator of medium pressure emergency injection water system. Moreover, provision has also been made to connect any remote / portable diesel generator with plant essential buses in case of failure of all the on-site diesel generators. Portable equipment have been made available and stored at seismically qualified and flood-protected building, for arranging diesel from remote location and also for filling sea-water into Fire Tender and ultimately providing to the newly installed Emergency Water Injection (EWI) system. This system may be used to provide cooling water to reactor core, boilers, vault, containment dousing, and spent fuel bay, in case of prolonged SBO.

The design of C-2 has given due consideration to the DiD principle including features for prevention and mitigation of severe accidents such as cavity flooding system, fast depressurization valve and passive hydrogen recombiners. Provision of these features in C-2 is primarily based on the severe accident analysis, PSA and international experience feedback.

18.2.1 Prevention and Mitigation of Accidents

Nuclear installations are adequately designed and constructed for preventing, controlling and mitigating the consequences of anticipated operational occurrences, faulted conditions and design and beyond design basis accidents. Following features have been considered:

a. The reactor coolant pressure boundary is designed to have an extremely low probability of abnormal leakage and gross rupture. If any leakage of the reactor coolant takes place, it is promptly detected and isolated to prevent an accidental situation. It is also designed to permit periodic inspection and testing to assess the pressure boundary integrity and leak-tightness.

b. The reactor core is designed to assure that power oscillations, which can result in conditions exceeding specified acceptable design limits, are not possible or can be readily suppressed.

c. The emergency core cooling system is designed to provide adequate emergency core cooling following any loss of reactor coolant at a rate such that any fuel damage that could impair continued effective core cooling is prevented.

d. In case of loss of offsite power, there is provision of house load operation. Cooling through natural circulation up to certain level is also considered. Redundant emergency power sources are also available to accomplish safety functions in case of loss of offsite power. Consideration of station black out (complete loss of power scenario) for prolonged period is also taken into account.

e. The reactor containment is designed so that if any accident occurs, the radioactive material released from the reactor coolant pressure boundary is confined and reduced over a long period. A system is installed in the containment to control the

concentration of any combustible gas as it accumulates inside the containment. The safety features including the containment spray system are considered to lower the pressure inside the reactor containment and to remove radioactivity from containment atmosphere.

f. The reactor protection system is designed to sense abnormal conditions and maintain the reactor in a safe state by automatically initiating the operation of the reactor shutdown system and the engineered safety features. The reactor protection system is designed with redundancy, diversity, and independence to assure that no single failure of any equipment or channel of the system results in loss of the intended safety functions.

g. The Safety Parameter Display System (SPDS) is installed in the Main Control Room so that challenge to major safety parameters/functions is promptly recognized. The Main Control Room is designed so that even if any accident occurs, the operator can safely remain inside the Main Control Room to take the necessary post-accident actions. It is also possible in the separate Emergency Control Room to monitor the essential operating parameters, the radioactivity inside and outside the reactor containment, the radiation releasing passage, and the radioactivity around the nuclear installation in order to sense the accident conditions and to take appropriate actions.

h. Mitigating features for severe accidents such as cavity flooding system, passive hydrogen recombiners, fast depressurization of containment, large dry containment, thickened containment base-mat, etc., are provided at all nuclear installations.

i. Provision of alternate water and power sources for long term removal of decay heat has been ensured.

j. The Emergency Control Centers are established to assess, coordinate and respond to any radiological emergencies including release of radioactive material.

18.2.2 Application of Proven Technologies

For all nuclear installations, it is ensured that technologies incorporated in design are proven by experience or qualified by testing or analysis.

Technologies used in design of nuclear installations are proven based analyses, testing and operation experiences. Both C-3 & C-4 and K-2 & K-3 designers have proven nuclear safety codes, advanced 3-D designs, simulation systems, validated state-of-the-art computer codes which are used to evolve PWR nuclear design. Different tests have been performed to ensure higher levels of nuclear safety in the design which include, reactor hydraulic integral test, CRDM seismic test, cavity injection system test, digital instrumentation and control equipment, etc.

18.3 Improvement in Design of Nuclear Installations

As part of relicensing, plant life extension and Fukushima Response Action Plan (FRAP), improvements are being made/in progress/planned in the design of KANUPP. These include the following:

i. Installation of Accident Monitoring Instrumentation (AMI)

ii. Installation of active and passive fire protection system in auxiliary area and cable tunnel area

iii. Installation of Emergency Water Injection (EWI) system to inject water into the reactor core, reactor vault, steam generators, containment dousing spray system, spent fuel pool via diesel engine driven pumps, fire water/fire engine in case prolonged SBO.

iv. Provision of quick connection facility for 300 kW diesel generators with plant essential bus.

v. Installation and commissioning of two 80 KWe diesel generators in tank area at 34 ft elevation from ground level to provide alternate power supply to 220V AC UPS/ 24V DC UPS and continuous charging of batteries.

vi. Solid improvements in onsite/offsite radiation emergency plans.

vii. Installation of flood gates on critical buildings.

viii. Revision of EOPs and SAMGs.

ix. Revision of Final Safety Analysis Report

x. Installation of 12 units of Passive Auto-catalytic Recombiners (PARs) in containment building.

xi. Increase in onsite diesel storage capacity from 3 days to 9 days of continued operation of EDGs without external support

xii. A submersible pump (FLEX Equipment) along with a dedicated 15KVA diesel generator have been procured to fill fire tender with sea water in case of any emergency.

The designs of CNPGS NPPs are similar to other PWRs operating elsewhere in the world and meet the current safety requirements. However, as a result of operating experience feedback, modification in alarm suppression of SRC LOOP AB level high was made in C-2 and installation of Passive Autocatalytic Hydrogen Recombiners (PARs) and modification to revert EEG001DG as IE power source for train-A (EMA) are being made in C-1. The following design modifications were completed at C-1 during the reporting period:

a. Replacement of the Control System & Human Machine Interface (HMI) of Turbine Emergency Trip System.

b. Replacement of PC based Reheat Temperature Control System with PLC & HMI based System.

c. Replacement of Main Generator Excitation system

d. Replacement of PC based In Core Neutron Flux Monitoring System with PLC & HMI based System.

e. Replacement of Generator Transformer Protection System.

f. Replacement of obsolete Data Acquisition Instruments and related control program in Reactor Vessel Level Monitoring System.

g. Replacement of obsolete MCR Data Acquisition System.

h. Up gradation of IAEA Safeguard Surveillance System at Reactor Building & Fuel Building.

The following modifications are planned at C-1:-

a) Replacement of Reciprocating Type Main Air Compressors with Screw Type Compressors in Compressed Air System.

b) Replacement of 220kV GIS Compressors.

c) Up gradation of Plant Computer System.

d) Up-Gradation of Ventilation Micro Computer Monitoring System.

e) Up gradation of Turbine Digital Electro-hydraulic Control System.

At C-2, the following modifications were implemented during the reporting period:

[i] Replacement of Main Feed Water Control Valves along with pneumatic circuit accessories to avoid tripping problems
[ii] Provision of redundant power supplies to travelling filter control panels
[iii] Installation of Fire / smoke detectors in Generators Hood.
[iv] Reduction in mesh size of Chemical and Volume Control System (SCV) filters to reduce Reactor coolant system (SRC) radioactivity
[v] Starting logic of Emergency Compressed Air Systems dryer was changed for it to start on buffer tank pressure instead of compressor startup
[vi] Power supply of Domestic Water Pumps of Raw Water Purification System (WRP) was changed from C-1 to C-2 to reduce dependency on C-1.
[vii] Power supply to Channel Gates at Circulating Cooling Water Intake (WCI) was changed from C-1 to C-2 to reduce dependency on C-1.
[viii] Suppression of eight alarms in Main Control Room to minimize the alarm window lit in MCR (Dark window concept)
[ix] Provision of manual parallel operation for auxiliary oil pumps of Main Feed Water Pumps to facilitate duty change over
[x] To reduce the operator burden by improvising the configuration of interlocks for testing of AAC

K-2 and K-3 are advanced 1100 MWe NPPs, designed on the basis of rich design experiences, construction, commissioning and operation of existing NPPs. This is a standard design 3-loop PWR with improved passive safety features. The safety assessment of the design mainly uses combination of deterministic and probabilistic approaches and engineering judgment by taking into account experience feedback and PSA results as reference. Improvements are made to increase the safety of the plant like, double shell containment design, seismic safety through standard design of 0.3g, passive technologies for residual heat removal and containment heat removal, specific features to cope with severe accident, etc, habitability of main control room has been enhanced by ventilation system.

Fukushima experience feedback has been considered in the design of K-2 and K-3 to ensure that; under emergency situation, temporary on-site electric power supply has been provided to facilitate valves of passive systems and emergency lighting of main control room and emergency water makeup from on site or off site water resources have been considered.

18.4 Construction / Commissioning Activities at Site

The activities related to construction and installations of C-3/C-4 are described below.

18.4.1 Chashma Nuclear Power Plants (C-3 and C-4):

The construction of Chashma Nuclear Power Plants (unit 3 & 4) of 340 MWe gross capacity have been completed. The installation of all systems and components has been completed. Commissioning activities of C-3 and C-4 are in progress. Commissioning is aimed to verify the design intent of the installed/constructed structures, systems and equipment as per commitments made during safety review along with verification and validation of operating procedures. Fuel has been loaded at C-3 after successful completion of applicable commissioning tests whereas commissioning activities of C-4 are in progress. PNRA performed regulatory oversight activities during the commissioning and PNRA inspectors are performing control point inspections at C-3 and C-4 to ensure compliance of regulatory requirements. PNRA performs pre-requisites inspections, test witness inspections and close down inspections during performance of a commissioning test and issue inspection reports to communicate regulatory findings to the licensee. As a result of regulatory oversight several corrective actions have been taken by the licensee to ensure compliance of applicable code and standards and commitments made during review and assessment process.

The licensee submitted Final Safety Analysis Report (FSAR) of C-3 and C-4 to PNRA in December 2014 and the regulatory review has been completed. C-3/C-4 FSAR includes Level-1 PSA report, severe accident analysis and certain design improvements as per commitment made in PSAR. The regulatory review is aimed to verify compliance of licensee commitments as well as conformance to the requirements of PNRA regulations and committed standards.

The FSAR review team is also interacting with the resident inspectors and witnessing the important commissioning tests in order to verify licensee commitments regarding improvement in plant safety. Based on compliance to regulatory requirements as per PNRA Regulations, agreed codes & standards and fulfillment of commitments made during PSAR & FSAR, Fuel load permit has been granted to C-3.

18.4.2 Karachi Nuclear Power Plants (K-2 and K-3):

PAEC submitted the Site Evaluation Report (SER) of Karachi Nuclear Power Plant (Unit-2 & 3) to PNRA for safety review. K-2 and K-3 site was registered for Karachi Nuclear Power Plants (Unit-2 & 3) on May 6, 2014. After site registration, K-2 and K-3 applied for construction license along with applicable submissions as per Regulations PAK/909 which includes PSAR, QAP and PSA reports, etc.

These submissions have been reviewed at PNRA and queries raised during review have been resolved to the satisfaction of PNRA. After successful safety review of licensing submissions pertaining to the construction license, PNRA awarded the construction licenses to K-2/K-3 on August, 2015 & November, 2015 respectively. Casting of Pre-stress concrete gallery below the raft of Nuclear Building (NB) of K-2 has been completed. The construction activities in nuclear island and Conventional island of K-2 and K-3 are in progress.

PNRA is performing regulatory inspections to assure that activities important to safety are being performed in accordance with agreed code and standards, regulatory requirements and PSAR commitments. Any deficiencies raised by PNRA inspectors are being resolved through timely corrective measures taken by K-2 and K-3 management under intimation to PNRA.

18.4.3 Manufacturing in Pakistan

Heavy Mechanical Complex-3 (HMC-3) Taxila is one of the largest projects in the heavy engineering sector of Pakistan which is manufacturing safety class 1, class-2 and safety class-3 mechanical components for NPPs. PNRA has licensed HMC-3 for manufacturing of safety class 1, safety class-2 and safety class-3 mechanical components. All the manufacturing activities are performed according to quality plans which describe the processes, testing, examination, reviews and checks in sequential order. Processes are required to be qualified according to the requirements of applicable codes and standards, and the standards of the client. Mock-ups are also prepared to qualify the processes. Manpower involved in manufacturing and testing is qualified based on the requirements of relevant regulations, codes and standards. HMC-3 has manufactured various equipment for C-3 and C-4 such as SG Blow Down Sampling Cooler, Essential Chilled Water Expansion Tank, Inlet Pipe Filter of Auxiliary Feedwater, SCW Surge Tank and Volume Control Tank.

PNRA maintains effective regulatory oversight during manufacturing of these equipment and PNRA inspectors performed regulatory inspections based on selection of control points including QA inspections from the Quality Plans submitted by HMC-3. PNRA conducted around fifty (50) regulatory inspections related to manufacturing, fabrication, testing and qualification of different components of C-3 &C-4 and K-2 & K-3 during the reporting period.

18.4.4 Manufacturing in China

Most of safety related equipment for nuclear installations have been manufactured in China. The manufacturers were selected by the main contractor according to the procurement control requirements of its QAP. The QAP of main contractor has been developed on the basis of Overall Quality Assurance Program of C-3 & C-4 and K-2 & K-3 which is approved by PNRA. PNRA conducted inspections and QA audits of the manufacturing facilities. PNRA maintains effective regulatory oversight during manufacturing of equipment and PNRA inspectors perform regulatory inspections based on selection of control points including QA inspections from the Quality Plans.

During the reporting period, PNRA conducted around twenty five (25) regulatory inspections related to manufacturing, fabrication, testing and qualification of different safety significant components of C-3 & C-4 and K-2 & K-3.

18.5 Design Consideration of Human Factors and Man-Machine Interface for Operation

In order to maximize the safety and efficiency of nuclear installations, the main control room, the SPDS, the auxiliary control room and emergency control center are designed so that the results of analysis and evaluation of human factors are reflected therein. (Please see Article 12 for details).

Pakistan has, therefore, met the obligations of Article 18 of the Convention.

Article 19 - Operation

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

(i) the initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning program demonstrating that the installation, as constructed, is consistent with design and safety requirements;

(ii) operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;

(iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;

(iv) procedures are established for responding to anticipated operational occurrences and to accidents;

(v) necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;

(vi) incidents significant to safety are reported in a timely manner by the holder of the relevant license to the regulatory body;

(vii) programs to collect and analyze operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies;

(viii) the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal."

19 Operation

Pakistan has taken appropriate steps to meet the intent of Article 19 of the Convention. Authorization for initial operation is issued based on appropriate safety analysis, commissioning program and other documents demonstrating that the plant construction, installation and commissioning is consistent with design and safety requirements. Operational limits and conditions are derived from safety analysis, commissioning tests and operational experience to identify safe boundary for operation, and are updated as necessary. All activities are performed according to approved procedures.

Technical assistance on safety matters remained available for KANUPP from Canada under the auspices of IAEA. Designer and vendor support is also available for C-1 and C-2. Engineering and technical support is available at all the plants and from sister organizations within PAEC. Operating experience feedback process remained in place to collect and analyze operating

experience and to take appropriate actions. Experience was also shared with the international community at various fora such as IAEA OSART, NEWS, WANO, COG, etc.

The generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable, both in activity and in volume.

19.1 Regulatory Requirements

PNRA issues licences to nuclear installations according to Regulations PAK/909. The licensing process has three stages, namely, site registration, issuance of construction licence and operating licence. PAK/909 enlists the documents to be submitted for each licensing stage. As required by the regulations, a nuclear installation can be operated only after a licence is issued by PNRA. The issuance of licence is based upon an appropriate safety analysis and a commissioning program demonstrating that the installation, as constructed, is consistent with design and safety requirements.

The PNRA Regulations PAK/913 establishes regulatory requirements for safety of nuclear installations during operation. These include requirements such as organization & staffing, quality assurance, emergency preparedness, fire safety, physical protection, operating experience feedback, qualification & training of personnel, commissioning program, plant operation (technical specifications), licensee event reporting system, notification of emergency & non-emergency events to the regulatory authority, radiation protection &waste management, testing & surveillance program and criteria for appointment to significant posts, etc.

PNRA Regulations PAK/912 set the requirements for quality assurance during operation. The licensee is required to establish a comprehensive quality assurance program that covers safety related activities during operation.

19.2 Initial Authorization to Operate

Permission to operate a nuclear installation is granted by PNRA in steps. After construction and equipment installation, commissioning program is reviewed and approved on the basis that it encompasses a systematic and integrated testing of systems and components in line with the design and safety requirements. This allows the licensee to start cold commissioning. During this phase, Final Safety Analysis Report (FSAR) is submitted, which demonstrates that the plant conforms to the safety requirements and the design is according to safety standards. If the safety review of FSAR is also satisfactory and other requirements of PAK/909 are fulfilled, the licensee is allowed to load fuel, perform low power tests, raise power and perform other tests as specified in the commissioning program. Upon satisfactory completion of commissioning, trial operation after attaining full power and submission of updated FSAR and other documents, an operating licence is issued. The operating licence is valid for a period of ten years subject to certain conditions. For the case of relicensing beyond design life, PAK/909 prescribes detailed requirements. The required documentation for the purpose include updated PSR report, revised FSAR, PSA (Level-1 plus) report, decommissioning program, emergency preparedness program, etc.

During the long shutdown of KANUPP in 2014-15, several design modifications related to Fukushima Response Action Plan (FRAP) were implemented. The major modifications included installation of post accident monitoring instrumentation display panels, etc. KANUPP again underwent long shutdown in September, 2015. During this long shutdown, major design modifications were implemented e.g. installations of Passive Autocatalytic Re-combiners,

replacement of containment dampers and fire protection of cables trays in critical areas. After long shutdown of 2015, KANUPP was re-started in October, 2015.

The existing licence of KANUPP is valid till December 2016 and the decision for further operation will be made after execution of safety measures as agreed in 2nd PSR Global Assessment Report and implementation of regulatory directives.

For information regarding commissioning of C-3 and C-4 NPPs, please refer to section 6.4.

19.3 Operational Limits and Conditions

The operational limits and conditions are developed to ensure that plant is operated in accordance with design assumptions and intent. KANUPP has developed operating policies and principles (OPPs) based on Canadian practice, that set operational limits and conditions derived from the safety analyses, tests, and operational experience.C-1 and C-2 developed technical specifications based on Standard Technical Specifications i.e. NUREG-0452 and NUREG-1431 respectively.

The OPPs of KANUPP have been revised on the basis of design modifications carried out in response to re-licensing beyond design life and implementation of FRAP. These are under review at PNRA for approval. Furthermore, as a result of other Fukushima related re-assessments and PSR, the OPP may be updated (if required).

Technical Specifications (TS) of C-1 and C-2 are classified as, safety limits; limits on safety system settings; limits and conditions for normal operation & transient operational states and surveillance requirements. The Technical Specifications are based on actual plant design, safety analysis as well as operational experience.

In the event, where the operation of the plant deviates from the established operational limits and conditions, the appropriate remedial actions are also defined with the timeline. The licensee is required to undertake review and evaluation of safety limit violations and notify to the Authority in accordance with the established event reporting system. These operational limits and conditions are revised as and when required, based on changes in safety analysis, changes in regulatory requirements or implementation of design modifications in safety systems or limits. External Modification in TS may also be made based on operating experience feedback, if accepted by PNRA.

19.4 Operating Plant Procedures

All operation, maintenance, inspection and testing activities at nuclear installations are carried out in accordance with written, validated and approved procedures. The revision and updating of plant procedures is a continuous process at KANUPP, C-1 and C-2, and any revisions of these documents is made known to the operating personnel and other relevant entities.

19.4.1 Procedures for Operation

Procedures for normal operation of the plant are kept updated to reflect as built conditions of the plants. These procedures ensure that the plant is operated within the design envelope. The procedures for C-3 and C-4 were validated during the commissioning tests with the involvement of plant operating staff. Plant personnel engaged in operation are trained and re-trained in the use of these procedures. Mechanism for continuous improvement of procedures on the basis of operating experience feedback is in place.

19.4.2 Procedures for Maintenance and Inspections

Maintenance, testing, surveillance and inspection programs are in place since the commencement of operation. The procedures are developed in line with the programs taking into consideration the design data, equipment specifications, quality assurance requirements, human factors considerations and ALARA principle. The procedures are subject to revision within the time period specified in each document or as and when needed.

19.4.3 Procedures for Modification Management

Approved procedures are in place to manage and control modifications in the plant's structures, systems and components. Both permanent and temporary modifications are controlled through these procedures. All the plants have established administrative procedures for updating documents within the stipulated time after modification, installation and testing. Responsibilities for the revision of all documents (such as drawings, procedures, safety analysis report, operational limits &conditions, system description, training material including simulator training, vendor equipment manuals and spare parts lists) are clearly identified to ensure that up-to date procedures are used during operation, maintenance and testing of the equipment and systems.

19.4.4 Emergency Operating Procedures

At KANUPP, Emergency Operating Procedures (EOPs) have been reviewed and validated through Table Top and Walk Through exercises after Fukushima Daiichi Accident and were revised using revised safety analysis results. EOP for Spent Fuel Cooling has been issued. Revised EOP for earthquake has also been issued. For extreme weather condition, guidelines in the form of TechMan have been issued.

Background analyses for development of Severe Accident Management Guidelines (SAMGs) are completed. SAMGs have been revised in the light of lessons learned from Fukushima NPP accident. Validation process of sample procedures as per SAMGs is in progress.

At C-1 and C-2, Emergency Operating Procedures (EOPs) are available to mitigate the consequences of failures and to limit the core damage and radiation dose to the plant personnel and the public. C-1 and C-2 initially received Event Based EOPs from the vendor. According to the licensing requirement and international practice, complete set of Symptom Based EOPs (SEOPs) to deal with DBAs and BDBAs has been developed and are in place at both plants C-1 & C-2. C-2 has developed SAMGs based on generic SAMGs which are being made plant specific based on additional background analysis and set-point calculations.

At C-1, revision of SAMGs is in progress and C-2 SAMGs will also be revised in line with C-1 if deemed applicable.

19.5 Reporting of Emergencies and Events

Requirements for reporting emergency conditions and abnormal events to the regulatory body are specified in PNRA Regulations PAK/913 which requires immediate notification of emergencies and significant events. Detailed event report in a prescribed format is required to be submitted by the licensee within 60 days of the events. These reports are analyzed by PNRA to review event details and to identify any additional corrective action which needs to be taken by the licensee. Root Cause Analysis (RCA) is normally an essential part of the detailed event reports.

19.6 Engineering and Technical Support

Nuclear Installations have their own engineering departments for technical support, whereas, engineering support is also available from other organizations within PAEC and the designer. Efforts are also made at all installations to acquire necessary engineering and technical support from national and international organizations.

Technical assistance on safety matters remained available for KANUPP from Canada under the auspices of IAEA in certain areas.

KANUPP core assessment was performed by CANDU Energy Inc., Canada in 2013-2014 using FCIA 2011 inspection data. This core assessment (fitness-for-service evaluation) was performed in accordance with CSA Standard N285.4 to demonstrate acceptance of KANUPP fuel channels. Stress analysis of the feeder pipes was also performed by AMEC NSS, Canada in 2013-14 to evaluate the Minimum Acceptable Wall Thickness (MAWT) as per the requirements of latest CSA Standard N 285.4 and ASME B&PV NB-3600 code 2001 Edition. The purpose of this analysis was to establish the Minimum Acceptable Wall Thickness (MWAT) values applicable to each individual feeder at the first elbow / bend downstream of the feeder Grayloc coupling as well as the bounding thickness for the entire feeder length. These tasks were carried out through a contract with Candu Energy Incorporated and AMEC NSS, Canada under an IAEA Technical Cooperation Project on “Long Term Operation of KANUPP (LTSK) Phase II”.

Engineering support of vendor and designer is available for C-1 and C-2 under lifetime support agreement. In addition, support from vendor country organizations for maintenance, in-service inspection, refueling operations, etc., are also available. CNPO has signed an agreement with CNPGS to provide technical support regarding development of an effective ageing management program and training of plant personnel. At Chashma site, a Directorate of Technical Support has been established which supports all operating plants at site in the areas of engineering, maintenance, radioactive waste, procurement, etc. This Directorate will also provide support to all future plants at the site i.e. C-3 and C-4.

For indigenous development of review and assessment of licensees’ submittals, PNRA has established its own technical support organizations "Center for Nuclear Safety" and "Safety Analyses Center". The TSOs are equipped with technical competencies in areas of review and assessment, probabilistic safety analysis (PSA), accident analysis, system & structural analysis, materials & plant systems, etc. PNRA has also signed various Memorandum of Understanding (MOUs) and training agreements with various national and international technical organizations such as PSQCA, NSC, NNSA, CHASCENT, etc. for technical support and personnel training.

19.7 Program to Collect and Analyze Operating Experience

KANUPP interacts with COG, WANO and IAEA networks to exchange Operating Experience (OPEX) Feedback information. Information received from these networks is screened for relevancy and applicability at KANUPP by OEF Section and disseminated to relevant Divisions/Sections for review and follow-up actions. If the information is found applicable, it is incorporated through changes in procedures, systems or equipment, etc., in order to prevent recurrence of event. Important OEF is discussed in weekly management meeting and actions are recommended for their implementation at KANUPP. A number of changes in plant systems and procedures have been carried out on the basis of operating experiences. In the areas, where it has experience and expertise, KANUPP responds to the queries raised by other NPPs.

To deal with internal low level and significant events, KANUPP has internal operating experience program (EIICA). This program is internationally known as Corrective Action Program (CAP). Low level and significant events are recorded/ evaluated/ investigated under the umbrella of EIICA program and necessary corrective actions are formulated and implemented to prevent recurrence. Annual & bi-annual trending of events is carried out to identify areas for improvement. Lesson learned are retrieved and disseminated to OEF coordinators.

C-1 and C-2 have developed Internal Operating Experience Program (IOEP). C-1 and C-2 are using LAN based "CHASNUPP Operating Experience Report" (COER) for the collection of information about all types of events, suggestions and lessons learned. Significant events are evaluated for reporting to PNRA and IAEA/WANO. The criteria of reporting to PNRA are as per requirements of “Regulations on the Safety of Nuclear Power Plants Operation (PAK/913)” and “Regulations on Radioactive Waste Management (PAK/915)”. The Prompt Reportable events are reported to PNRA through Event Notification Sheet (ENS) within stipulated time (1hr, 4hrs or 8hrs) and Non-Prompt Reportable events are notified within 3 days. Licensee Event Report (LER) for all reportable events is submitted within 60 days. The criteria of reporting to IAEA are as per requirements of “IAEA Service Series No. 19, IRS Guidelines” and to WANO are as per requirement of “Operating Experience Program Reference Manual (Dec, 2014)”. Operability/Functionality issues are identified and assessment is made by Main Control Room. All COERs are categorized according to their significance in the fields of nuclear, radiological, industrial safety, economic impact, etc. Depending on significance, Apparent Cause Analysis (ACA) or Root Cause Analysis (RCA) is initiated to find causes and corrective actions to prevent recurrences. All events are coded for trending to identify adverse trend. Internal operating experience information is disseminated to all relevant work units within the plants for effective utilization of information.

Plant has strengthened Operating Experience Training (In-House & International) during Licensing & Re-Training Program and enhanced the training on Human Performance Improvement / Error reduction tools & Operator’s Fundamentals in Operation Training Division (OTD) for rigorous use and evaluation. It has reinforced the use of same through Lesson Plans on various training areas. Initiatives have been taken for Periodic screening meeting for Operating Experience reports and their utilization to update training material.

C-1 and C-2 have a system of analyzing national and international operating experience feedback which includes analysis of events at national level and events reported through the IAEA, WANO, QNPC, SNERDI, CNPO, etc. on various safety related issues as well as best practices. In addition, plants have access to the IAEA International Reporting System on Operating Experience (IRS) and NEWS. Technical divisions of the plants are responsible for collecting and analyzing the operating experience from within the installations while Directorate of Technical Support (DTS) is responsible for OEF from other installations(including non-nuclear installations) operating in the country. DTS also utilizes international experience feedback to identify necessary actions. As a member of WANO, C-1 and C-2 share plant operating experiences with other members. C-1 was using PCR system (Plant Condition Reports) for collection of information about low level events. The information collected was screened and trended for identification of vulnerable areas of the plant. For significant events, “Event Notification and Reporting (ENR) system is in place which requires event analysis to find causes and formulate corrective actions to prevent recurrences. Under revised Internal Operating Experience Program (IOEP) PCR and ENR systems have been integrated.

The operating experience of management issues, unexpected degradation, design weaknesses, external hazards not considered earlier, etc., is shared through peer reviews conducted within and outside Pakistan under auspices of IAEA, WANO, COG, etc.

PNRA verifies the licensee's programs to collect and analyze operating experience through reviews of licensee event reports and by inspections. PNRA is the contact point to the IAEA International Reporting System (IRS) on Operating Experience Feedback and NEWS and the licensee's relevant personnel have access to these systems. PNRA encourages the licensee to benefit from relevant international operating experience at other nuclear installations to enhance safety and reliability.

PNRA feels that effective use of OEF is essential to maintain and improve safety of nuclear installations. Along with licensee, the same activity has to be performed by PNRA to support its functions, responsibilities and missions. The theme and intentions of learning and implementation of lessons extracted from previous events are to adopt a safety conscious approach so that recurrence of such events is controlled. Working on this theme, PNRA started a formal program of evaluation of international OEF received at PNRA from nuclear industry around the globe including INES, IRS and information received from other regulatory bodies of the world. The program comprises evaluation of international OEF and issuance of reports on biannual basis along with its dissemination to relevant stakeholders including operators of nuclear installations in Pakistan for their consideration.

19.8 Reporting to INES and IRS

Safety significant reportable events occurring at nuclear installations are reported to INES and IRS. From 2014-16, no event exceeding INES Level 1 rating occurred at KANUPP. Ten plant events were shared with WANO during 2013 to 2015, and these were rated INES Level 0.

One event related to Exposure to Worker in Excess of Administrative Limit at C-1 was reported to INES in 2014-15. The event was rated at Level 1.

19.9 Safety Performance Evaluation

Please see Section 14.2.6 “Performance Indicators Program of Nuclear Installations".

19.10 Radioactive Waste Management

According to PNRA Regulations PAK/915, licensee is required to keep the generation of both activity and volume of radioactive waste to the minimum practicable by suitable design, operation and while opting decommissioning strategy for its facilities.

Installations have developed their own radioactive waste management programs and the waste is managed accordingly. Waste generation at nuclear installations is kept to a minimum by appropriate classification, segregation, treatment, conditioning and reuse and recycling of material. Treatment and conditioning of radioactive waste is carried out in accordance with the waste acceptance criteria. Procedures are in place for processing of radioactive waste so that the resulting waste, packaged or unpackaged, can be safely stored and retrieved from the storage facility for disposal. Discharges to the environment are kept minimum possible and environmental monitoring is performed according to established monitoring program and procedures.

Radioactive Waste Storage Facility (RAWSA) at KANUPP is designated for collection of radioactive waste from radiation and nuclear facilities operational in southern part of Pakistan.

The facility is covered under general license of KANUPP. However, in 2012, KANUPP extended its site to increase the available storage capacity for its solid radioactive waste. Upon PNRA recommendation, KANUPP submitted the safety assessment of RAWSA to PNRA which has been approved upon satisfactory resolution of review queries during the reported period.

In the original design of C-1, spent resin was stored in holdup tanks which had capacity for 10 years resin generation. The process has been modified to solidify the stored resin resulting in enhancement of storage capacity of spent resin. On the basis of C-1 experience feedback, some modification will be implemented for conditioning/ treatment of spent resin at C-2. This conditioning/ treatment of spent resin will help in providing space for spent resin storage tank which is a regulatory requirement.

CNPGS is establishing modular extended storage building at Chashma site for Low Level Waste (LLW) storage within the plant boundary which has been completed in 2016. This design envisages over packed LLW solidified drums in concrete containers with concrete grouting, which will then be stored in extended storage building. The storage buildings will cater for storage needs of C-1 and C-2 at Chashma site.

The national policy on control and safe management of radioactive waste is being implemented in Pakistan. The policy covers control and management of all radioactive wastes generated in the country irrespective of its origin. The policy serves as national commitment to address country's radioactive waste control and management issues in a well-coordinated manner.

19.11 Spent Fuel Storage

Currently, the spent fuel of all nuclear power plants is kept in on site storage pools for a certain period of time for cooling. Spent fuel of KANUPP is stored in the spent fuel storage pool located inside the service building. The Spent fuel storage bay is designed to store spent fuel safely until it is removed for interim storage outside spent fuel bay. After 43 years of operational life, spent fuel storage bay is approaching its capacity limit. Due to good chemistry in spent fuel storage bay and low oxidation rates, no ageing is visible on the structural material used in stacking the fuel bundles and the spent fuel under water which appears to be in good physical condition. To handle the storage problem, storage capacity of existing spent fuel storage bay was increased via a seismically qualified High Density Tray Racking (HDTR) System to operate the plant till first quarter of 2019. Due to limitations of further storage capacity, KANUPP has opted for dry storage technology to store the spent fuel safely till any further policy shift. The spent fuel dry storage facility is being established within the plant premises. This dry storage facility will not only provide additional storage capacity for new incoming spent fuel beyond March, 2019 but this would also provide interim storage solution for approximately fifty (50) years. Development and engineering work of underwater handling tools, tilter and basket assemblies are in-progress. The design, manufacture, testing and qualification of concrete cask for storage is also in progress. The Preliminary Safety Analysis Report (PSAR) on spent fuel storage cask has been prepared and submitted to PNRA for review and approval.

At C-1 and C-2, spent fuel storage facilities are integral parts of each plant to meet under water storage requirement for fifteen reloads plus one full core. Similar provision of spent fuel storage is included in design of C-3 and C-4. Due to limited storage capacity, PAEC has started efforts to build a dry storage facility for storage of spent nuclear fuel at reactor site and submitted letter of intent for licensing of spent nuclear fuel dry storage facility. Preliminary design/ scheme is completed.

PNRA has established regulatory framework for the licensing of spent nuclear fuel storage facilities under PNRA Regulations PAK/909 “Licensing of Nuclear Installation(s) in Pakistan’. Whereas, regulatory process for the certification of spent nuclear fuel storage casks has been established and regulations for safe management of spent nuclear fuel are being developed.

Pakistan has, therefore, met the obligations of Article 19 of the Convention.

Annexure–I: Existing Nuclear Installations

	KANUPP	C-1	C-2	C-3	C-4	K-2	K-3
Status	Operating	Operating	Operating	Under Construction	Under Construction	Under Construction	Under Construction
Location	Karachi, Sindh	Chashma, Punjab	Chashma, Punjab	Chashma, Punjab	Chashma, Punjab	Karachi, Sindh	Karachi, Sindh
Type	CANDU	PWR	PWR	PWR	PWR	PWR	PWR
Capacity (gross)	137 MWe	325 MWe	340 MWe	340 MWe	340 MWe	1100 MWe	1100 MWe
First fuel loading	July, 1971	November, 1999	February, 2011	May, 2016	January, 2017 (expected)	-	-
Connection to Grid	1971	June 13, 2000	March 14, 2011	Sept, 2016 (expected)	July, 2017 (expected)	2020 (expected)	2021 (expected)

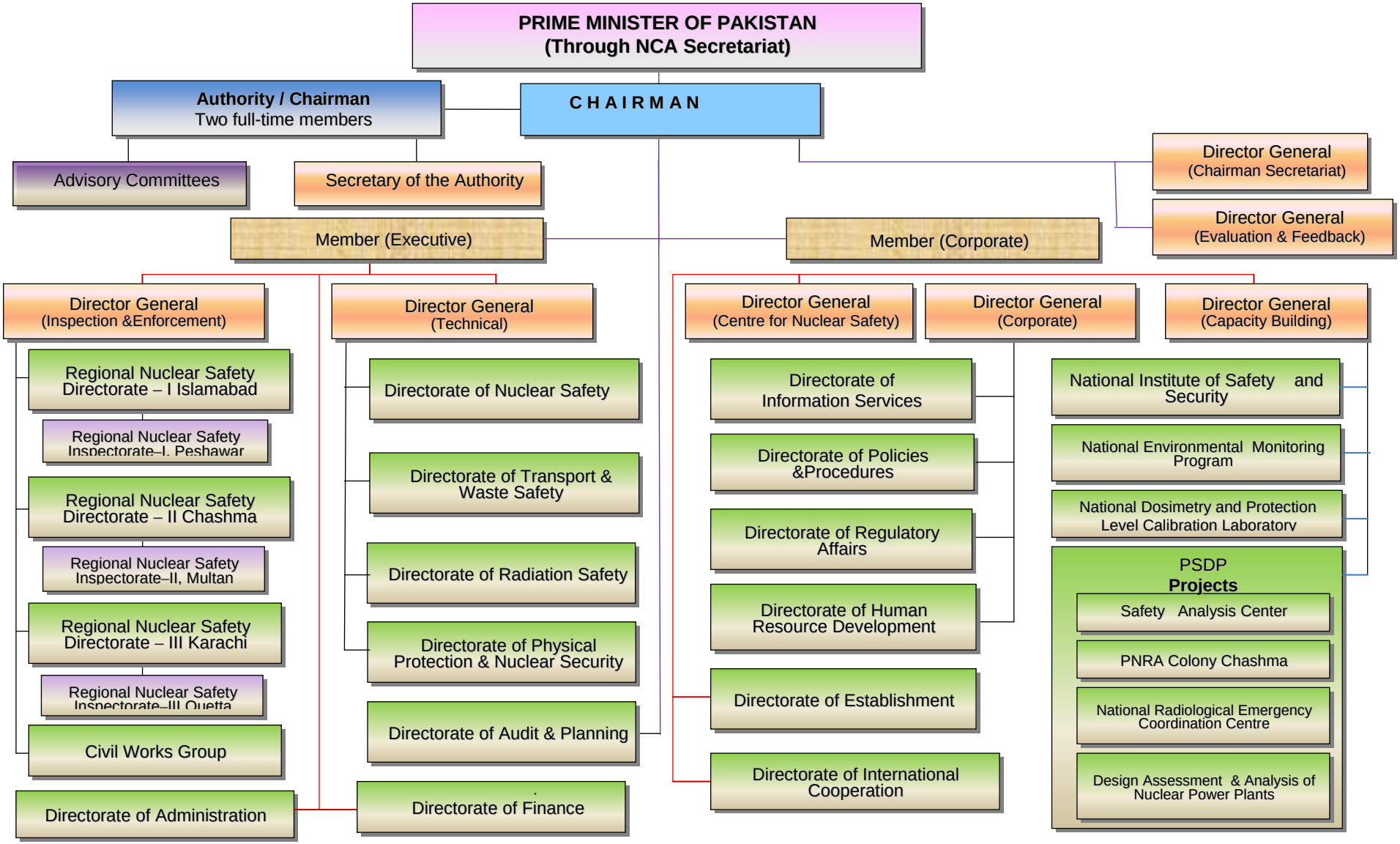
Annexure–II: K-2 and K-3 Design Parameters

Gross Electrical Output	1100 MWe
Number of Primary Loops	3
Reactor Type	PWR
Fuel	Enriched uranium
Containment Building	The annular space between the inner containment and the outer containment is 1.8m wide. Both the cylindrical wall and the dome are pre-stressed concrete structures. The internal surface of the structure is covered entirely by a leak tight steel liner.
Containment Building Diameter	46.8 m (inner)
Containment Design Pressure	0.520 MPa(abs)
Coolant Design Pressure	17.23 MPa
Design Temperature of Coolant	343^{o} C
Coolant Flow Rate (Best Estimate)	23790 X 3 m^3/h
Fuel Assemblies	177
RPV Material	RCC-M M2111
Height of RPV	13.228 m
Active Core Height	3.660 m
Coolant Operating Pressure	15.5 MPa
Control Rod Assemblies	-------
Steam Generators	3
Reactor Coolant Pumps	3
Turbine Type	Horizontal Tandem Machine

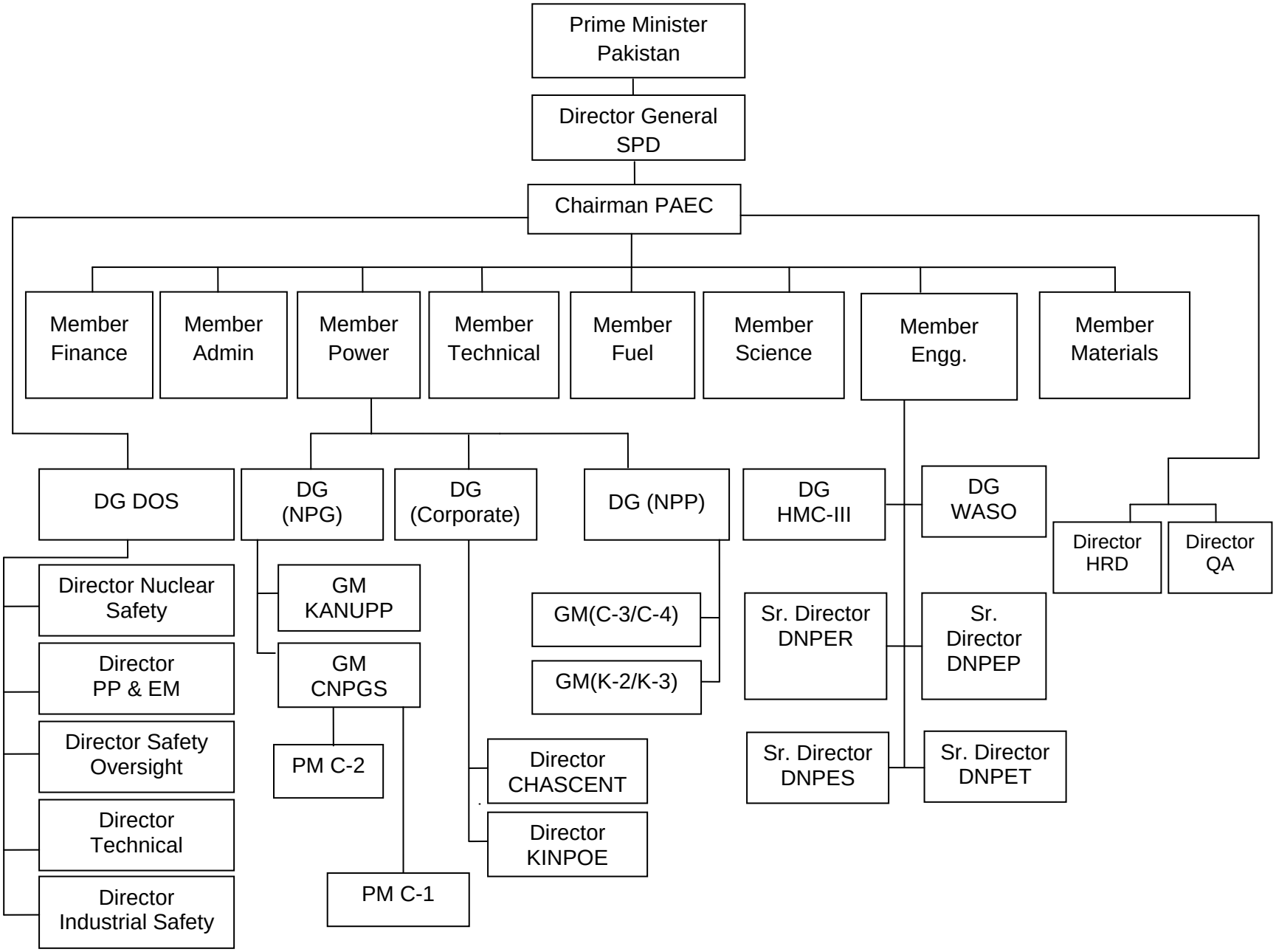
Annexure–III: List of Issued Regulations

S. No	Title	Latest version
1.	Pakistan Nuclear Safety & Radiation Protection Regulations 1990	March 01, 2012
2.	PNSRP (Treatment of Food by Ionizing Radiation) Regulations 1996	March 7, 1996
3.	Regulations on Licensing Fee by Pakistan Nuclear Regulatory Authority – (PAK/900)	Feb 13, 2015
4.	Regulations on Transaction of Business of Pakistan Nuclear Regulatory Authority - (PAK/901)	Sep 10, 2012
5.	Regulations on Radiation Protection (PAK/904)	March 28, 2012
6.	Regulations for Licensing of Nuclear Safety Class Equipment and Components Manufacturers – (PAK/907)	Sept 01, 2008
7.	Regulations for the Licensing of Radiation Facilities other than Nuclear Installations (PAK/908)	Oct 05, 2004
8.	Regulation for Licensing of Nuclear Installation(s) in Pakistan (PAK/909) revision 1	June 29, 2012
9.	Regulations on the Safety of Nuclear Installations – Site Evaluation (PAK/910)	Sept 01, 2008
10.	Regulation on the Safety of Nuclear Power Plant Design (PAK/911)	Dec 16, 2014
11.	Regulations on the Safety of Nuclear Power Plants-Quality Assurance (PAK/912)	Dec 16, 2014
12.	Regulations on Safety of Nuclear Power Plants-Operation (PAK/913)	Dec31, 2015
13.	Regulations on Management of a Nuclear or Radiological Emergency - (PAK/914)	Sept 01, 2008
14.	Regulations on Radioactive Waste Management (PAK/915)	March 8, 2010
15.	Regulations for the Safe Transport of Radioactive Material - (PAK/916)	April 20, 2007
16.	Regulations on the Safety of Nuclear Research Reactor(s) Operation (PAK/923)	Dec 31 , 2015
17.	Pakistan Nuclear Regulatory Authority Enforcement Regulation (PAK/950)	Dec 23, 2010

Annexure–IV: Organization Chart of Pakistan Nuclear Regulatory Authority



Annexure–V: Organization Chart of Pakistan Atomic Energy Commission



Annexure–VI: PNRA Performance Indicators

Indicator 1. Acceptable level of safety being maintained by licensees

Indicator 2. Regulations and procedures in position and understood by licensees

Indicator 3. Continuous improvement of performance

Indicator 4. Appropriate actions taken to prevent degradation of safety and to promote safety improvements

Indicator 5. Human resource development, and competent and certified regulatory staff

Indicator 6. Legal provisions for enforcement, i.e., dealing with non-compliance or licence conditions violations

Indicator 7. Performance of functions in a timely and cost-effective manner

Indicator 8. Well established Quality Management System

Indicator 9. Availability of adequate resources for performing the functions

Indicator 10. Confidence of the operating organization

Indicator 11. Confidence of the general public

Indicator 12. Confidence of the Government.

Grading Scale for Performance Indicators

Green	Satisfactory
White	Minimally acceptable
Yellow	Needs improvement
Red	Unsatisfactory
Pink	Not acceptable

Annexure–VII: Dose Limits for Exposures Incurred From Practices

ANNUAL DOSE LIMITS FOR RADIATION WORKERS

Organ or Tissue	Dose Quantity	Dose Limit (mSv)
Whole body	Effective dose	20*
Lens of the eye	Equivalent dose	150
Extremities (hands and feet) or Skin (average dose over 1 cm^2 of the most highly irradiated area).	Equivalent dose	500

* In special circumstances, an effective dose of up to 50mSv in a single year provided that the average dose over five consecutive years does not exceed 20mSv/year.

ANNUAL DOSE LIMITS FOR APPRENTICES/STUDENTS (16 to 18 years of age)

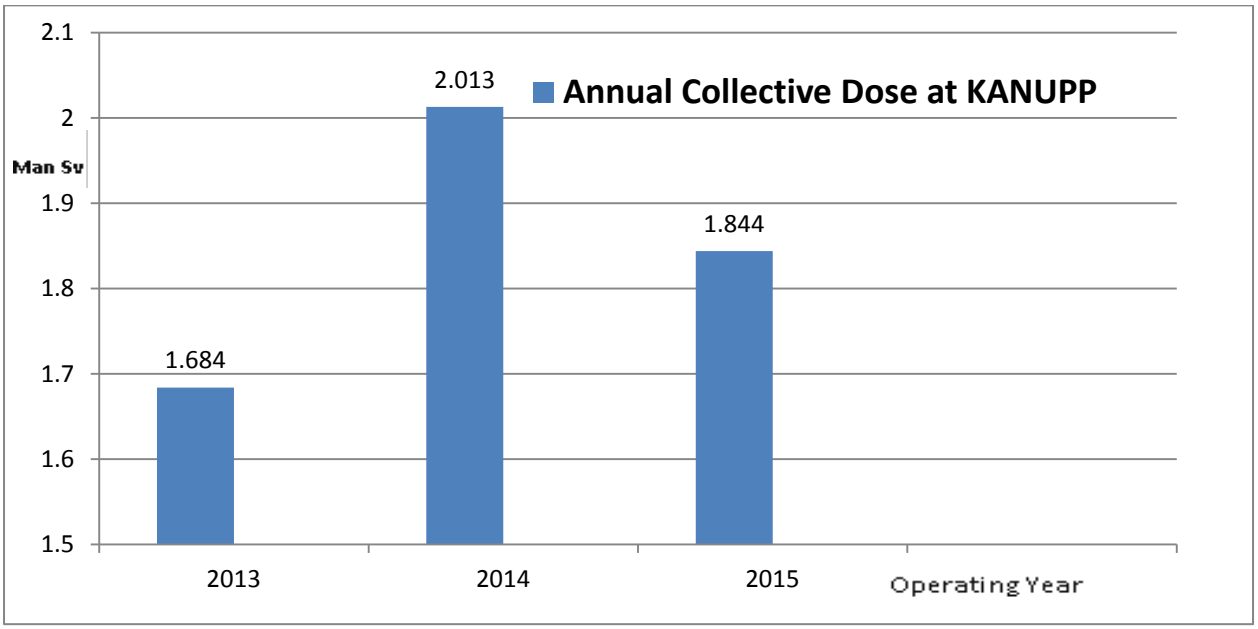
Organ or Tissue	Dose Quantity	Dose Limit (mSv)
Whole body	Effective dose	6
Lens of the eye	Equivalent dose	50
Extremities (hands and feet) or skin (average dose over 1 cm^2 of the most highly irradiated area).	Equivalent dose	150

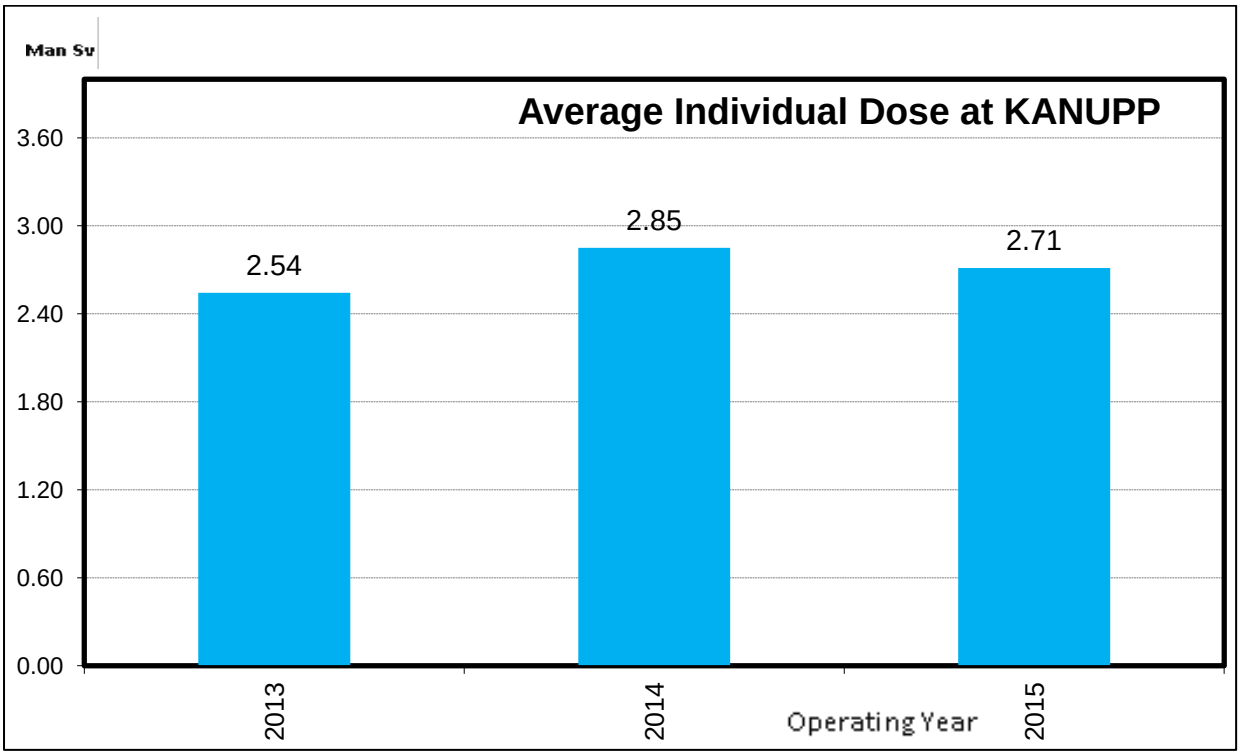
ANNUAL DOSE LIMITS FOR PUBLIC

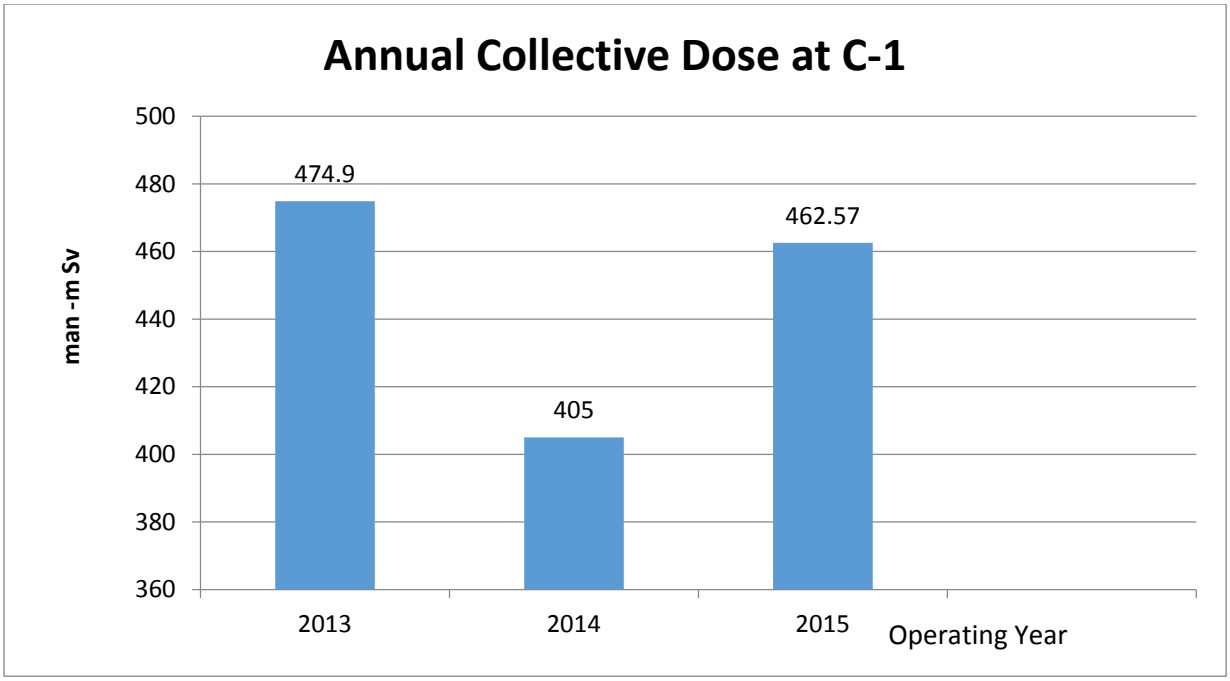
Organ or Tissue	Dose Quantity	Dose Limit (mSv)
Whole body	Effective dose	1*
Lens of the eye	Equivalent dose	15
Skin	Equivalent dose	50

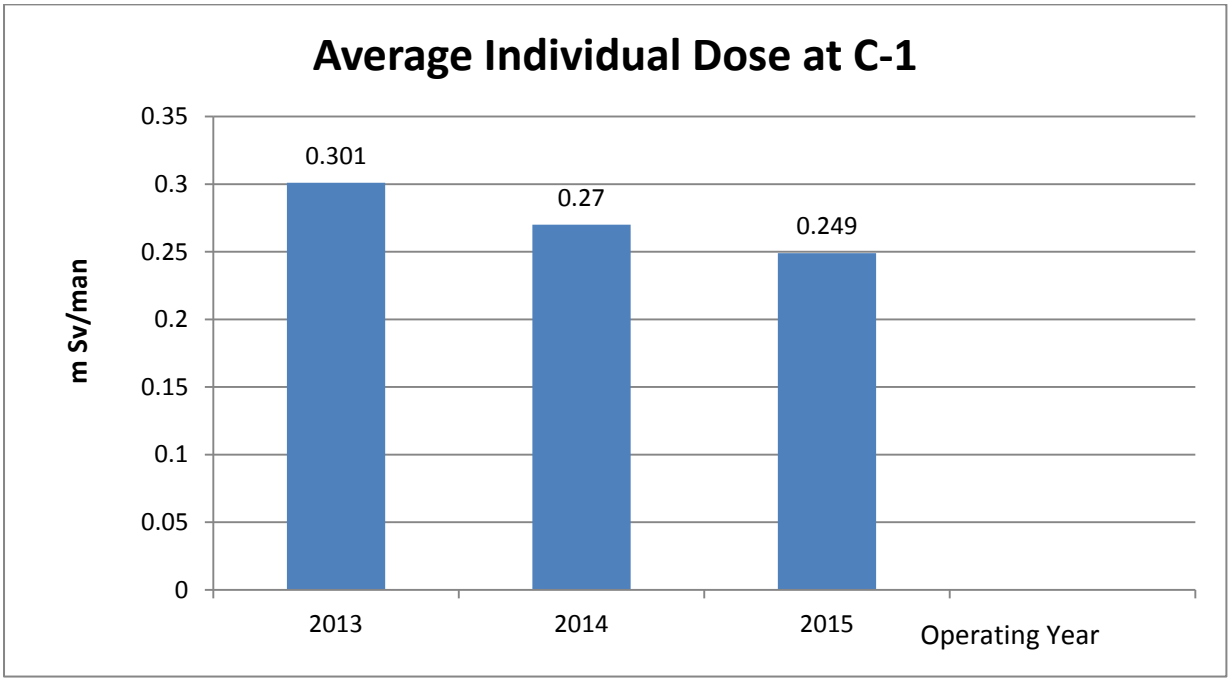
* In special circumstances, an effective dose of up to 5mSv in a single year provided that the average dose over five consecutive years does not exceed 1mSv/year.

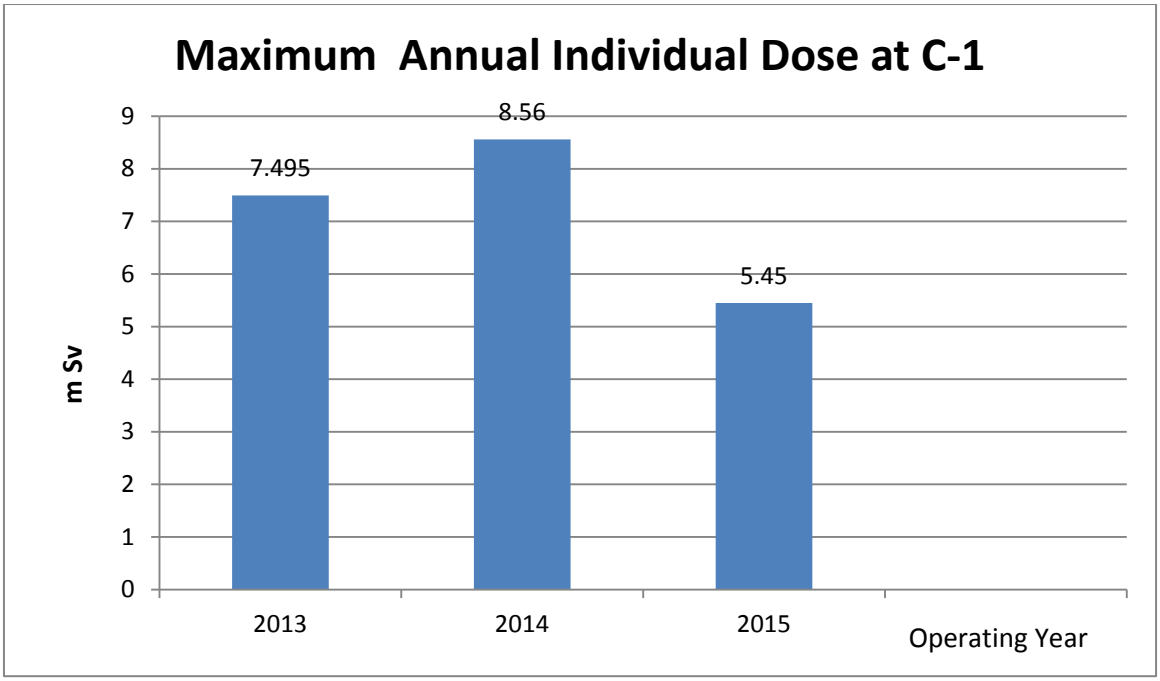
Annexure–VIII: Occupational Exposures at Nuclear Installations (2013-15)

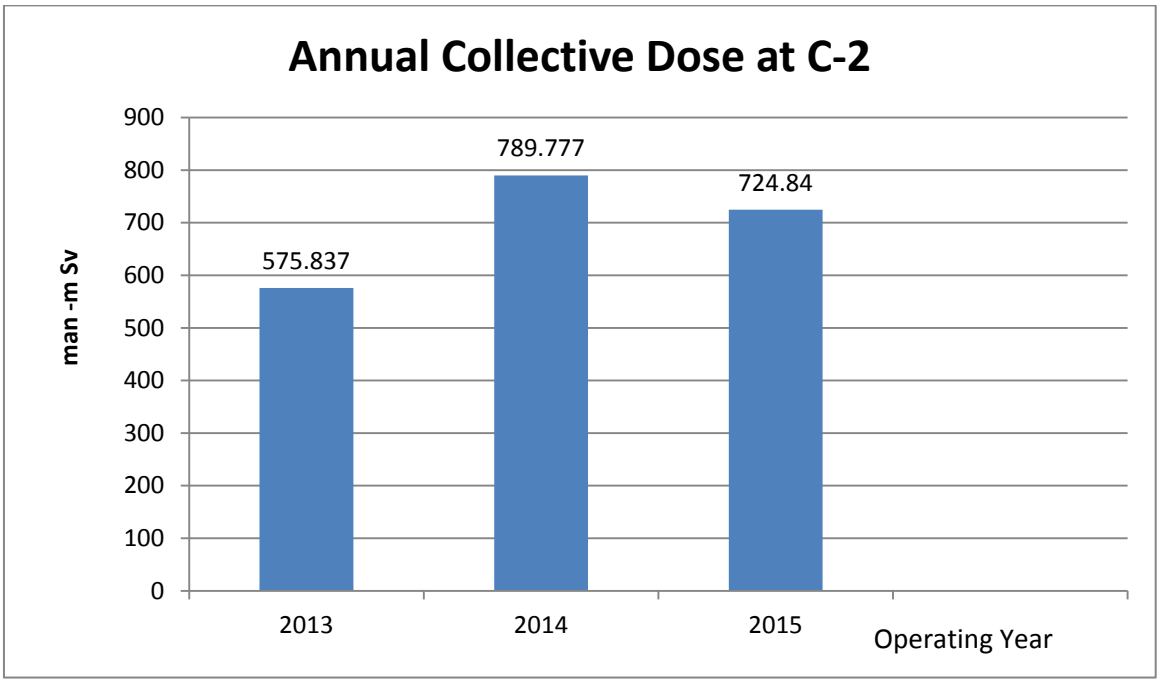


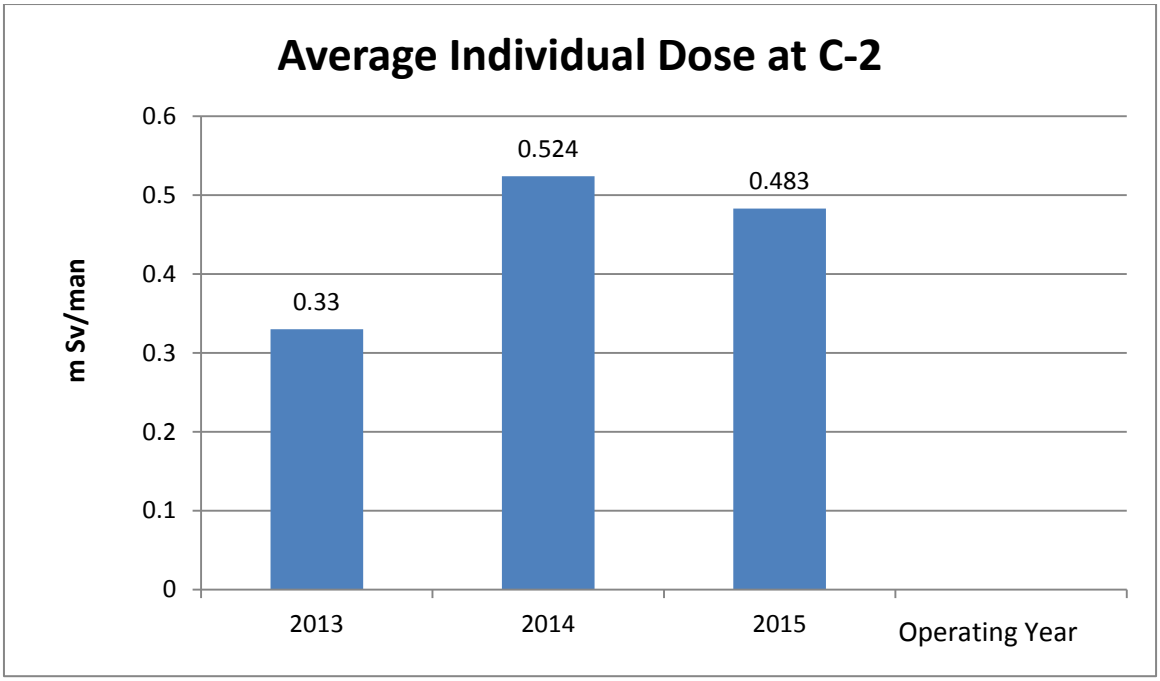


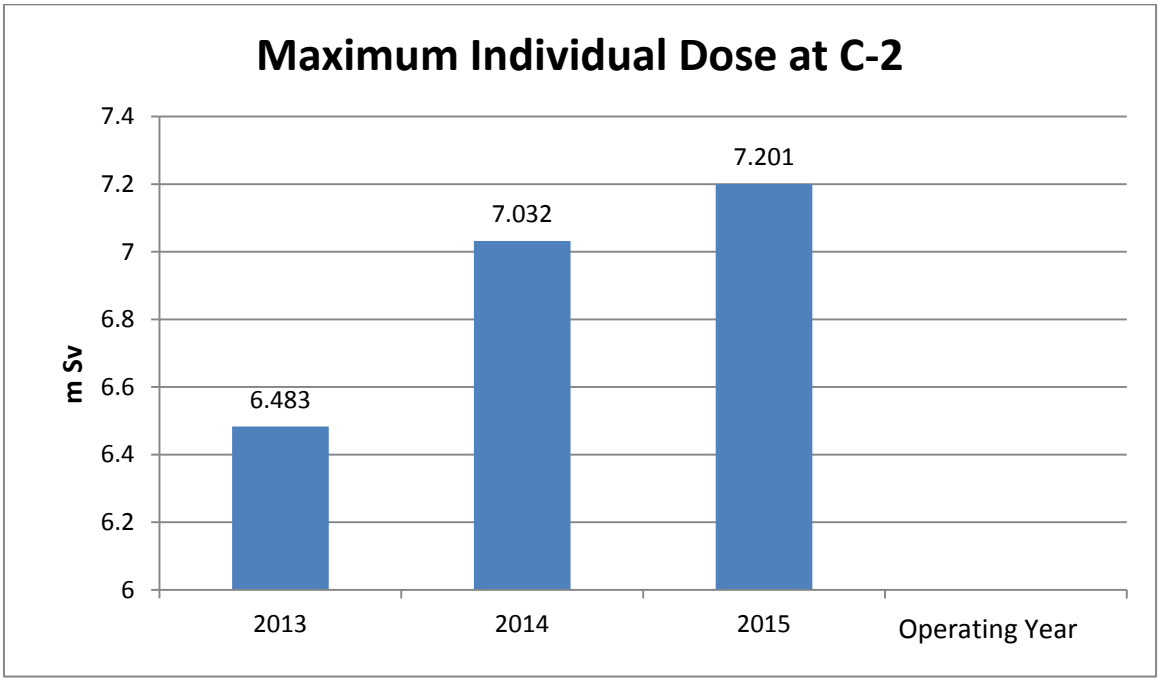

Annual Collective Dose at C-1
man -m Sv
500
480
460
440
420
400
380
360
474.9
405
462.57
2013
2014
2015
Operating Year


Average Individual Dose at C-1
m Sv/man
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.301
0.27
0.249
2013
2014
2015
Operating Year


Maximum Annual Individual Dose at C-1
m Sv
9
8
7
6
5
4
3
2
1
0
7.495
8.56
5.45
2013
2014
2015
Operating Year

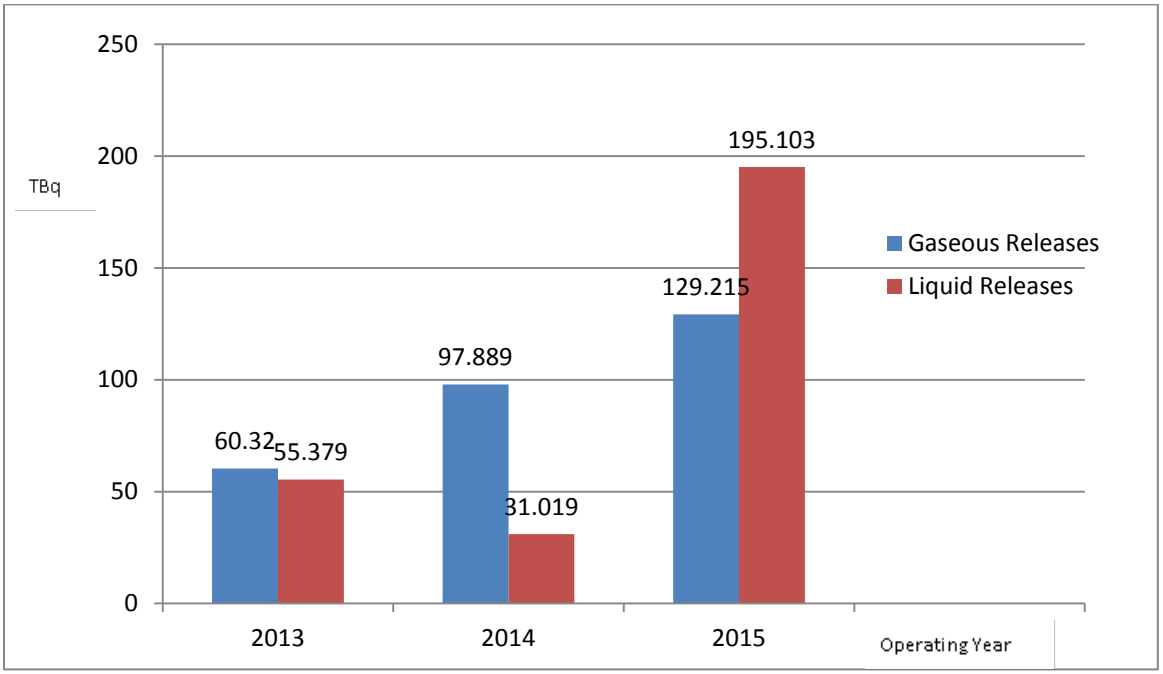

Annual Collective Dose at C-2
man -m Sv
900
800
700
600
500
400
300
200
100
0
575.837
789.777
724.84
2013
2014
2015
Operating Year


Average Individual Dose at C-2
m Sv/man
0.6
0.5
0.4
0.3
0.2
0.1
0
0.33
0.524
0.483
2013
2014
2015
Operating Year

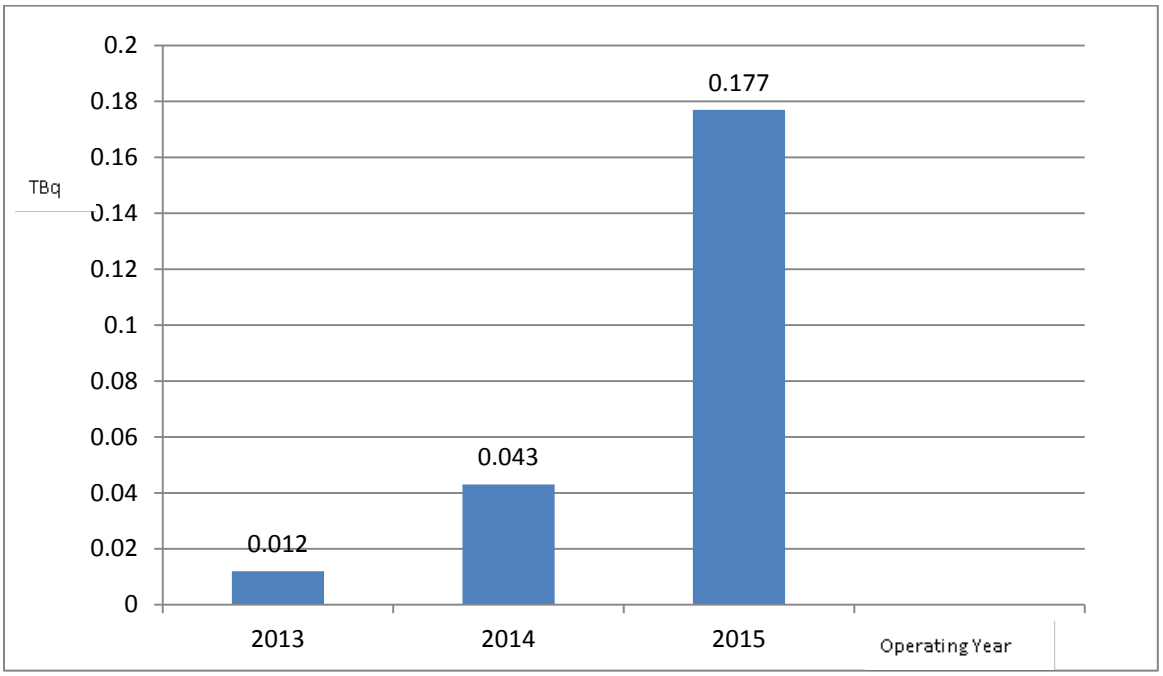

Maximum Individual Dose at C-2
m Sv
7.4
7.2
7
6.8
6.6
6.4
6.2
6
6.483
7.032
7.201
2013
2014
2015
Operating Year

Annexure–IX: Effluent Releases from KANUPP, C-1and C-2 (2013–15)

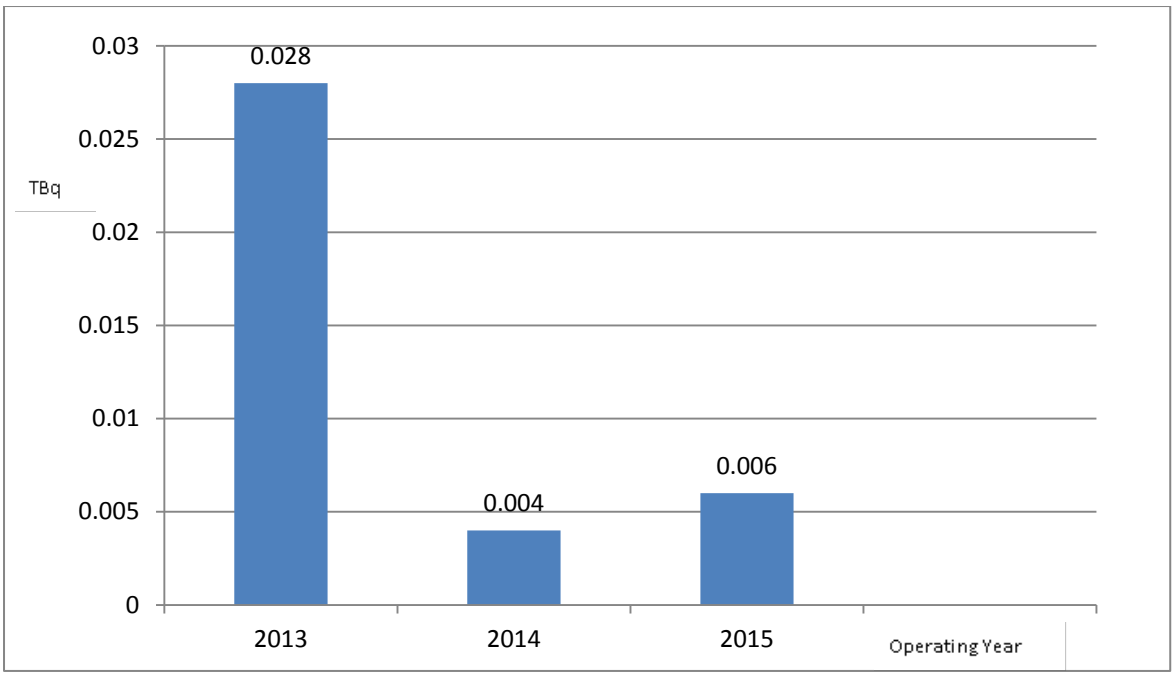
Tritium Released through Gaseous and Liquid Effluents at KANUPP



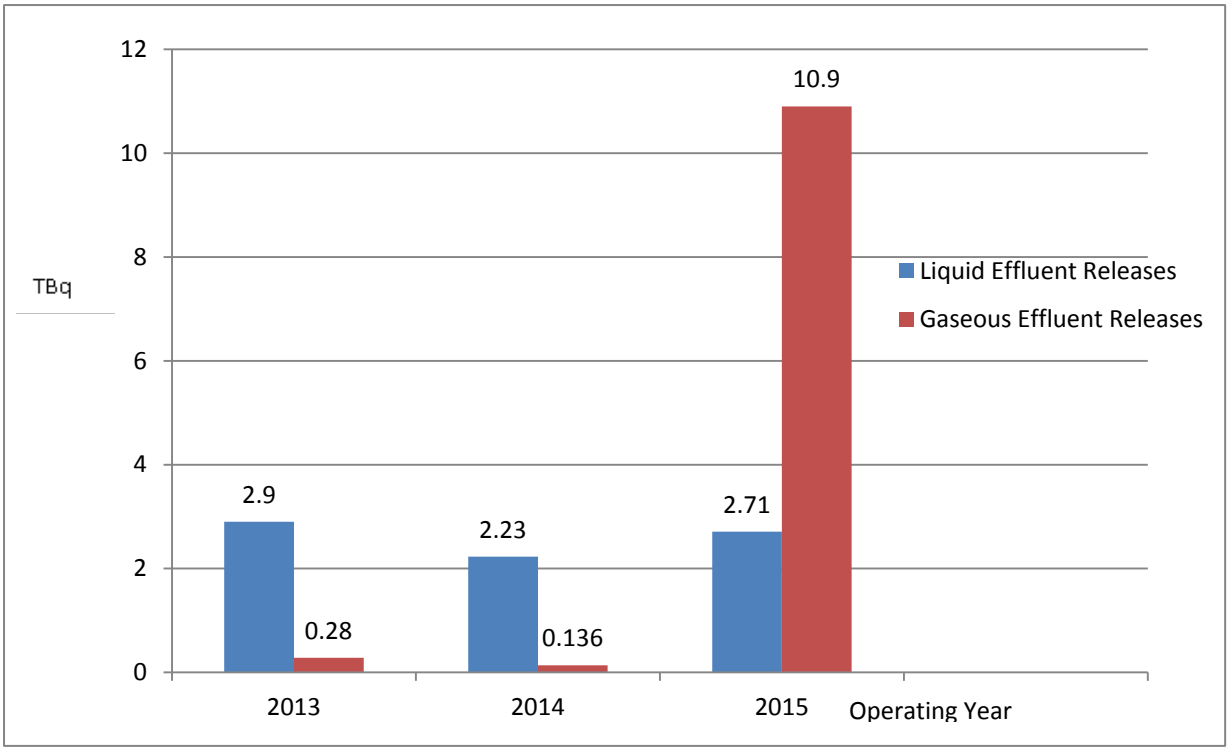
Nobel Gases Release Through Gaseous Effluents at KANUPP



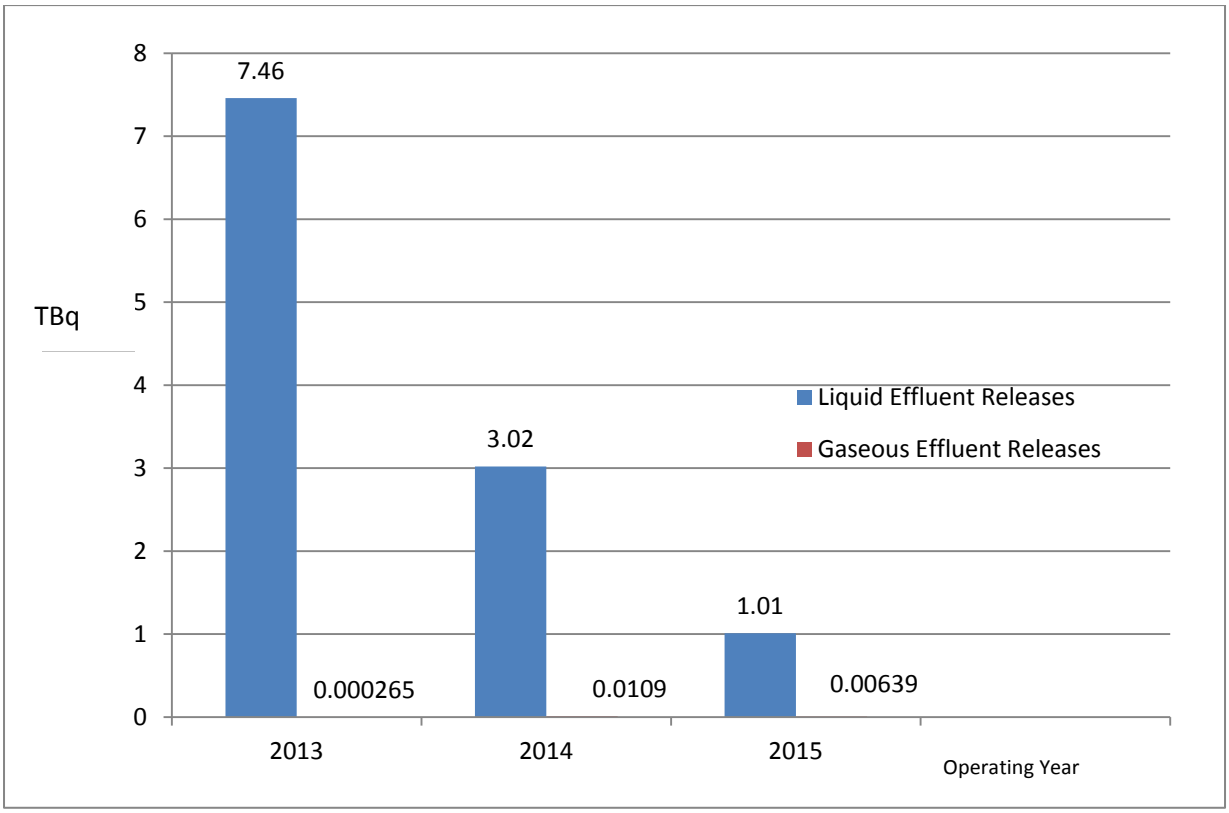
Gross Beta Gamma Released Through Liquid Effluents at KANUPP



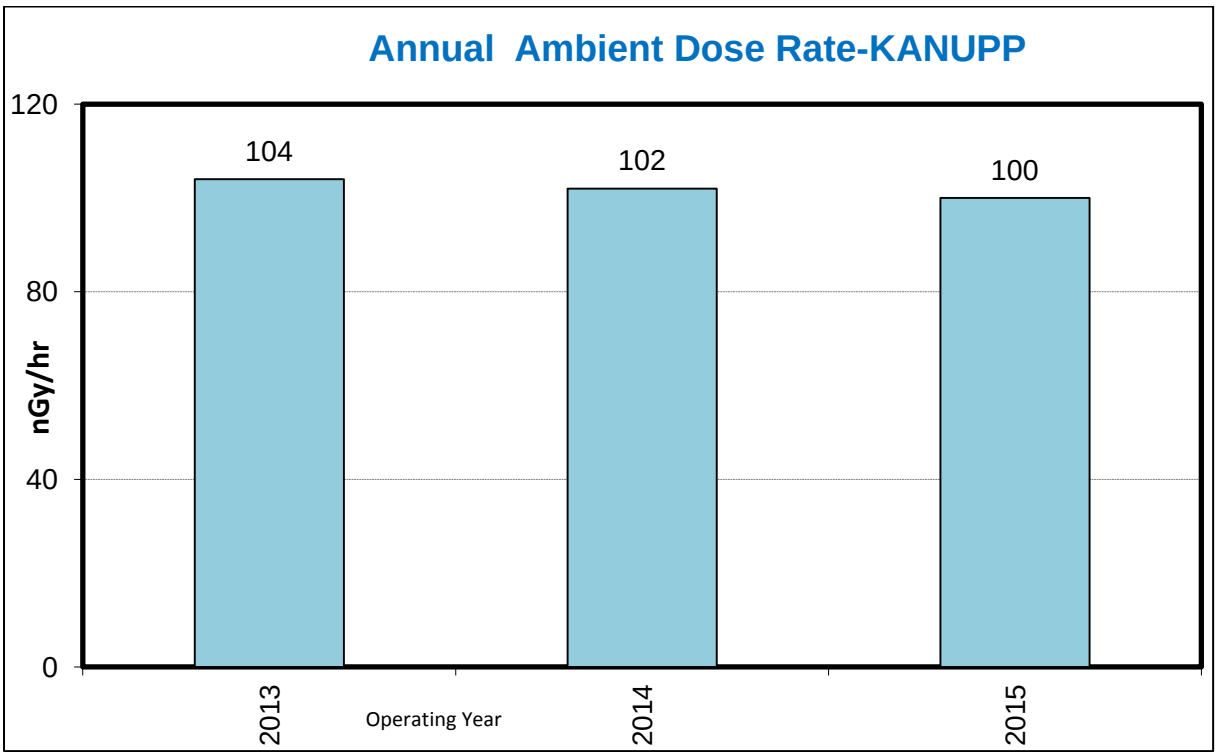
Effluent Releases at C-1

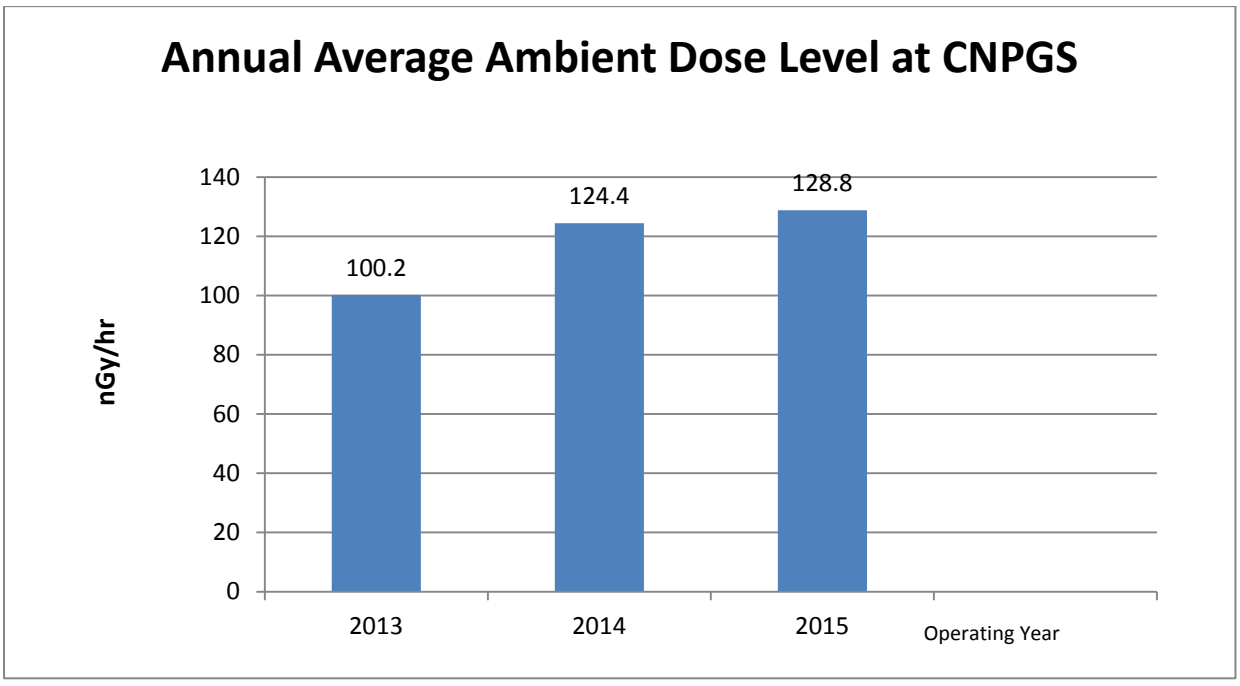


Effluent Releases at C-2



Annexure–X: Annual Average Ambient Dose Levels Around Nuclear Installations, (2013-15)





Annexure–XI: Frequency of Various Drills/Exercises and Emergency Exercises Performed

Type of Drill/Exercise at KANUPP		**Frequency**
1.	Decontamination of contaminated injured person	Half yearly
2.	Assembly area air sampling	Quarterly
3.	Emergency class announcement	Quarterly
4.	Notification of emergency to KANUPP Emergency Response Organization (KERO)	Yearly
5.	Healthiness of VHF communication sets and response of relevant personnel at emergency facilities	Quarterly
6.	Assembly Emergency Response Team (ERT)	Yearly
7.	Environmental monitoring and sampling activities	Quarterly
8.	Emergency assembly drill	Yearly
9.	Onsite Emergency Exercise	Yearly
10.	Integrated (onsite and offsite) emergency Exercise	Once in two years
Type of Drill/Exercise at C-1 and C-2		**Frequency**
1.	Communication drill	Quarterly
2.	Off-site projected dose assessment drill	Bi-Annual
3.	Search and rescue operation drill	Bi-Annual
4.	Medical treatment and personnel decontamination drill	Bi-Annual
5.	Firefighting drill	Annual (with on-site PEE/IEE)
6.	On-site Partial Emergency Exercise	Year next to year of IEE (2011/2014/2017/2020/2023/2026)
7.	Off-site Partial Emergency Exercise	Year next to year of On-site PEE (2012/2015/2018/2021/2024/2027)
8.	Integrated emergency exercise	Once in every three years (2010/2013/2016/2019/2022/2025)
9.	Environmental radiation monitoring drill	Bi-Annual
10.	Emergency class assessment drill	Quarterly
11.	Post accident sampling and analyses drill	Bi-Annual

Emergency Exercises Performed at KANUPP, CNPGS and NRECC

1. Emergency Exercises Performed at KANUPP

Sr. No.	Date of Exercise	Type of Exercise
1.	June, 2013	Site Emergency Exercise
2.	December, 2013	Security Emergency Exercise
3.	May, 2014	Integrated Emergency Exercise
4.	December, 2015	Site Emergency Exercise

2. Emergency Exercises Performed at CNPGS (C-1 and C-2)

Sr. No.	Date of Exercise	Type of Exercise
1.	November, 2013	C-1/C-2 7th Integrated Emergency Exercise
2.	May, 2014	C-1/C-2 7th Partial Emergency Exercise
3.	March, 2015	CNPGS Partial Off Site Exercise (Tabletop)
4.	April, 2016	8th Integrated Emergency Exercise

3. Participation of Pakistan in IAEA ConvEx Exercises

Sr. No.	Date of Exercise	Type of Exercise
1.	March, 2013	ConvEx-1a
2.	June, 2013	ConvEx-1c
3.	June, 2013	ConvEx-2b
4.	September, 2013	ConvEx-1b
5.	October, 2013	ConvEx-2a
6.	November, 2013	ConvEx-3
7.	April, 2014	ConvEx-2a
8.	May, 2014	ConvEx-1b
9.	September, 2014	ConvEx-2b
10.	September, 2014	ConvEx-1c
11.	October, 2014	ConvEx-1a
12.	March, 2015	ConvEx-2a
13.	April, 2015	ConvEx-1c
14.	July, 2015	ConvEx-1a
15.	August, 2015	ConvEx-2b
16.	November, 2015	ConvEx-1b
17.	December, 2015	ConvEx-2c
18.	February, 2016	ConvEx-2a
19.	March, 2016	ConvEx-1a
20.	April, 2016	ConvEx-1c
21.	June, 2016	ConvEx-2b

4. Exercise Conducted by NRECC Communication Test Exercise (COMTEX)

Sr. No.	Date of Exercise	Type of Exercise
1.	January, 2013	COMTEX
2.	May, 2013	MRML
3.	June, 2013	COMTEX
4.	October, 2013	MRML
5.	October, 2013	COMTEX
6.	February, 2014	COMTEX
7.	June, 2014	MRML
8.	June, 2014	COMTEX
9.	October, 2014	COMTEX
10.	November, 2014	MRML
11.	February, 2015	COMTEX
12.	May, 2015	MRML
13.	June, 2015	COMTEX
14.	November, 2015	COMTEX
15.	November, 2015	MRML
16.	February, 2016	COMTEX
17.	June, 2016	COMTEX

Annexure–XII: Progress on Implementation of IAEA Nuclear Safety Action Plan

Pakistan actively participated in the development of the IAEA Nuclear Safety Action Plan and endorsed the finalized Action Plan during the IAEA Board of Governors Meeting and subsequently during the IAEA General Conference in September, 2011. A brief overview of the progress made by Pakistan in fulfillment of the IAEA Nuclear Safety Action Plan is presented below:

Safety assessments in the light of the accident at TEPCO's Fukushima Daiichi Nuclear Power Station

PNRA issued a directive to NPPs in August 2011 to conduct Self Assessments in the following areas:

i. Re-assessment of natural hazards
ii. Availability of infrastructure necessary for plant safety such as AC power supply sources, heat sinks, etc.
iii. Consideration of the station black-out condition (loss of all AC power) for longer duration
iv. Re-evaluation of the design features provided at nuclear power plants for controlling and removing hydrogen such as hydrogen recombining system, hydrogen mixing system
v. Re-evaluation of the Emergency Operating Procedures (EOPs) and Severe Accident Management Guidelines (SAMGs)
vi. Re-evaluation of the off-site Emergency Preparedness Plan (EPP) including Emergency Plan Implementing Procedures (EPIPs)
vii. Re-evaluation of the training program in the light of the Fukushima Daiichi Accident with particular emphasis on the limitations of simulator.

A comprehensive plan " Fukushima Response Action Plan" (FRAP) was chalked out at PAEC for re-visiting design of nuclear power plants to re-assess safety margins in line with IAEA Nuclear Safety Action guidelines. PAEC Corporate office, reporting to Chairman PAEC , has been made responsible for periodical monitoring of the progress on measures being taken with regard to Fukushima Response Action Plans (FRAP) submitted by all three operating NPPs.

The implementation of FRAP is currently in progress. Progress on FRAP is being reviewed on a half yearly basis. Details of activities performed in response to Fukushima Daiichi Accident are presented in Section 2.2.

International Peer Reviews

Pakistan is committed to uphold the peer review process so that meaningful enhancement of nuclear safety at NPPs is achieved.

Self Assessment is a regular feature at PNRA and PAEC. PNRA hosted an IRRS Mission in April-May, 2014. Prior to the IRRS Mission, Self Assessment was conducted in preparation of using the IAEA updated SAT tool.

Independent reviews and assessments are also performed by international expert organizations at NPPs periodically.

Following is a list of WANO led Missions during 2013-2016.

Sr. No.	Title	Date
1.	Review of planned modified chemistry approach at KANUPP for the second PLEX period.	March 10 – 14, 2014
2.	WANO Mission to review implementation status of recommendations of WANO Significant Operating Experience Reports (SOERs) at KANUPP	May 5-13, 2014
3.	WANO Mission on Peer Review Standard Training at KANUPP	October 20-24, 2014
4.	WANO Mission on improvement in WANO Performance Indicators SP1, SP2 and SP5 at KANUPP.	January 26-30, 2015
5.	WANO Mission on Benchmarking visit for KANUPP Spent Fuel Dry Storage.	October 20-22, 2015
6.	WANO Peer Review of KANUPP	Jan 14-28, 2016
7.	WANO Mission on improvement in Human Factor in wake of Fukushima Disaster at KANUPP.	February 15-19, 2016
8.	WANO Mission on Contamination Control and Dose Reduction at KANUPP.	February 22-27, 2016
9.	WANO Technical Support Mission on "Management of Installation Verification Activities" at C-3/C-4	February 23-27 , 2015
10.	WANO Technical Support Mission on "Root Cause Analysis (RCA)" at C-1/C-2	March 15-17, 2016

A WANO Peer Review of PAEC Corporate office was conducted in May 2015 with follow-up in Nov, 2015.

A full scope WANO Peer Review Mission is planned in 2016 at KANUPP. IAEA safe guard inspectors were routinely invited in every quarter of the calendar year during 2013-2016.

One WANO Follow-up Peer Review (May 2015) and one OSART Mission (23rd Nov to 10th Dec, 2015) have been received at C-1 during the reporting period (Please see section 2.1.8 for details). The action plan for improvements after OSART Mission is under preparation.

For establishment of Integrated Improvement Plan, the software (database) of integrated improvement plan has been developed. Implementation is in progress.

C-2 requested and hosted a WANO Pre-Start-up Peer Review during its commissioning phase in July, 2010.

A WANO Peer review mission was conducted at C-2 from April 30, 2015 to May 14, 2015.

A WANO Technical Support Mission on "Root Cause Analysis (RCA)" was conducted on request of C-1/C-2 from 15th to 17th March, 2016 at CNPGS.

C-3 has hosted a WANO Pre Start-Up Peer Review (PSUR) in January, 2016 while its follow-up is planned for July 2016. A PSUR for C-4 is planned for January, 2017. WANO Technical Support Mission on "Management of Installation Verification Activities" was conducted on request of C-3/C-4 in February, 2015.

Improvements at NPPs as a result of the above-mentioned missions are reported in Section 2.1.8 of this report.

Emergency Preparedness and Response

PNRA directed the licensee to re-evaluate and strengthen emergency preparedness and response arrangements in the light of the Fukushima Daiichi Accident considering unavailability of necessary infrastructure (bridges, roads, communication means, etc.) due to severe natural disasters and demonstrate implementation of emergency plans specially the evacuation aspects by involving public. PNRA also required licensee to re-evaluate Emergency Planning Zones (EPZs). The licensee has submitted action plans for the re-assessment of emergency preparedness and response arrangements. The process for finalization of National Radiological Emergency Plan (NREP) has also been expedited after the Fukushima Daiichi Accident.

The “Fukushima Response Action Plan” (FRAP) developed by the NPPs has identified several areas for improvement in emergency preparedness and response. EPZ has been revised at KANUPP and is under revision at C-1 and C-2. Provision of additional access routes to the site has been assessed at C-1 and C-2. Personnel de-contamination facility in local hospital has been upgraded at Chashma.

At KANUPP, several improvements in emergency preparedness and response have been made. Alternate Emergency Control Center (AECC) has been upgraded for use as command point in severe accident conditions. Availability of on-line Critical Parameter Display System (CPDS) in AECC has been ensured. Alternate communication means will be made available at plant and AECC. Quantity of Potassium Iodide (KI) tablets is being increased for population up to 16 Km of the plant.

National Regulatory Body

The monitoring of the regulatory performance of the PNRA is based on twelve (12) strategic performance indicators. (Please refer to Annexure–VI for a list of performance indicators). As part of its self assessment program, PNRA conducts an internal audit of activities of all its directorates on annual basis to identify areas for improvement in order to enhance regulatory effectiveness. All directorates also perform self-assessment on a periodic basis. Regulatory Affairs directorate assesses the progress made on the self assessment action plans during the Internal Audits. PNRA presents its progress to the Government through a comprehensive Annual Report. PNRA also received an IRRS Mission in 2014.

PNRA has reviewed its organizational capabilities and regulatory oversight processes in the light of Fukushima Daiichi Accident. Review and Revision of the PNRA Management system revealed some areas for improvement and need for some additional documents. Competence Needs Assessment using IAEA SARCON methodology will also be performed from 2016-17 for PNRA directorates.

PNRA revisited regulatory requirements for the safety of nuclear power plants to incorporate lessons learnt from Fukushima Daiichi Accident. Furthermore, the requirements of the Vienna Declaration were also scrutinized for incorporation in the PNRA Regulations. As a result, a number of recommendations have been made which are under review process for revision of the regulations. The regulations are currently under revision.

Operating organization

The safety of the plant is continuously assessed and verified during all phases of the plant life. This includes self assessments, reviews of plant safety performance by plant safety committee, quality assurance division, engineering department, health physics division and relevant operation and maintenance departments. Independent reviews and assessments by the PAEC corporate safety body and international reviews such as WANO Peer Review, OSART Mission, etc. are conducted for reassurance of safety.

Although, Internal Peer Review (IPR) of the Operational Safety of NPPs at the corporate level was initiated in 2009, the scope was expanded after Fukushima Daiichi Accident to include Design Safety and Emergency Preparedness & Response (EPR). A team of the specialists from diverse disciplines conducted Internal Peer Reviews of all three operating NPPs and recommended various actions and measures to assure nuclear safety. The Review Team also utilized ‘IAEA Safety Action Plan’ and ‘ENSREG Stress Test specifications’ as guidelines for the review of Fukushima Response Action Plan.

Internal Peer Review (IPR) of KANUPP was first conducted in October, 2011 by experienced nuclear professionals. There has been satisfactory progress on the actions identified. Combined progress review of C-1 and C-2 on Fukushima Response Plan was conducted initially in January, 2012. Internal Peer Review (IPR) of C-2 was repeated in August, 2013.

An internal peer review of KANUPP was again conducted from Feb - March, 2016 as per WANO Performance Objectives and Criteria 2013. Several improvements were identified by the reviewers in different performance areas. Actions plan has been submitted to PAEC HQ to improve the weak performance areas. Corporate safety review of C-1 was conducted by Directorate of Nuclear Safety in May, 2016 whereas the Corporate Safety Review for C-3 was conducted in Feb, 2016.

Review meetings are being conducted on regular basis by Corporate office to assess the progress on FRAP-K1 and FRAP-C12.

IAEA Safety Standards

The PNRA regulatory framework is mainly based on the IAEA Safety Standards.

PNRA participates in the proceedings of various IAEA committees for the development of safety standards, such as the Nuclear Safety Standards Committee (NUSSC), Transport Safety Standards Committee (TRANSSC), Waste Safety Standards Committee (WASSC), Radiation Safety Standards Committee (RASSC), Emergency Preparedness & Response Standards Committee (EPReSC), and the Commission on Safety Standards (CSS).

International Legal Framework

Pakistan is party to the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, Convention on Physical Protection of Nuclear Material (CPPNM) along with the Convention on Nuclear Safety. Pakistan has ratified the amendment of CPPNM in March, 2016.

Pakistan is a permanent member of United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR) and PNRA represents the country in UNSCEAR by contributing to the activities of this UN committee through sharing necessary information and expertise. During the reported period, PNRA participated in 62nd session of the UNSCEAR.

Pakistan has registered its National Assistance Capabilities (NACs) in IAEA Response and Assistance Network (RANET). Being the NCA designated under Early Notification and Assistance Conventions, PNRA, with the consent of GoP, offered assistance to Japan through IAEA in areas of radiation monitoring, source search and recovery, environmental measurements and assessment and advice on emergency response.

PNRA has bilateral agreements between the National Nuclear Safety Administration (NNSA)of China and its technical support organizations regarding technical support in nuclear safety and capability development of regulatory staff.

Capacity Building

PNRA has reviewed its organizational capabilities and regulatory oversight processes in the light of Fukushima Daiichi Accident. PNRA further enhanced its capability for review and assessment of licensee submissions and regulatory inspections by strengthening its TSOs (Center for Nuclear Safety and Safety Analysis Center) and training institute (NISAS).

PAEC is continually enhancing the capacity and quality of its key training institutes, such as Pakistan Institute of Engineering and Applied Sciences (PIEAS), Karachi Institute of Nuclear Power Engineering (KINPOE), and CHASNUPP Center for Nuclear Training (CHASCENT) as a matter of course. To meet the objective of expansion of the country's Nuclear Power Generation Program, additional demand of trained/skilled human resource is being met from these institutes.

At present, two training programs namely PGTP (Post Graduate training Program) and PDTP(Post diploma training program) are offered at CHASCENT as well as KINPOE. By strengthening training facilities and enhanced capacity, CHASCENT and KINPOE have almost doubled the recruitment for PGTP and PDTP batches. All the labs at CHASCENT and KINPOE are upgraded with state of the art equipment for imparting training to plant personnel.

To impart maintenance and technical training to plant personnel, a full fledge Maintenance Training Building is being constructed with all major facilities. It is planned to purchase mock ups of plant's equipment to provide better understanding to workers for improving their working skills.

Lessons learnt from Fukushima Daiichi Accident are compiled and made part of the training program for personnel at the training organizations of both PNRA and PAEC.

Protection of People and the Environment from Ionizing Radiation

After the Fukushima Daiichi Accident, Pakistan started air sampling at various stations throughout the country. Results of the sampling analysis showed no anthropogenic radio

nuclides and no change in background radiation level. An air analysis study was also performed under NEMP after the Fukushima Daiichi Accident and the report was submitted to UNSCEAR.

To further ensure public protection, PNRA in coordination with Pakistan Customs restricted import of edible goods from Japan without radiation free certificate issued either by PNRA or Japan.

At NPPs, a number of improvements related to on-site and off-site emergency preparedness have been made as part of the FRAP implementation plan, e.g. Potassium Iodide (KI) tablets were increased for population up to 16 Km of the plant at KANUPP. Personnel de-contamination facility in local hospital has also been upgraded at Chashma.

Three state of the art Environmental Monitoring Laboratories have been established at Islamabad, Chashma and Karachi under NEMP. At this time, two laboratories at Karachi and Chashma have been fully established and operational. The construction work of Islamabad lab has been completed.

NEMP conducts measurement of radioactivity in sand/soil, air, water, flora/fauna in the whole country. Under this program, various samples have been analyzed around NPPs and environmental data provided by the licensees has been verified. This program also assesses the radiation survey and analysis of NORM related activities at national level.

Communication and Information Dissemination

PNRA is continuously working on improving the communication interface with the public. In this regard, limited scope public awareness program has been started with the involvement of educational institutes and universities throughout the country. Spokes-persons are routinely designated for satisfying the questions from the media and public.

At PAEC, the Scientific Information and Public Relations Directorate is assigned the task of Public Communication. However, special sessions are held as and when needed. PAEC conducted various sessions to provide answers to the public when media raised questions on the Site registration of the K-2 and K-3 project during 2014-15. PAEC officials also participated in media shows for this purpose. The K-2 and K-3 Environmental Impact Assessment Report has also been placed at the PAEC public website for this purpose.

PAEC has also identified certain actions for improving the communication interface with the public around nuclear installations during possible emergencies as part of the FRAP implementation plan.

Research and Development

PNRA routinely conducts research and development activities in view of enhancing regulatory capability with the involvement of national universities and also under IAEA Technical Cooperation Program and Coordinated Research Projects. PNRA officers routinely supervise the PNRA fellows at PIEAS and KINPOE in their research projects for their master's degree thesis.

Accident Analyses of C-1 and C-2 were revisited after Fukushima Daiichi disaster based on insights from the Fukushima Daiichi Accident and international operating experience and assessed the consequences of the limiting cases.

Research and development activities are being conducted by PAEC personnel at international repute academic and research institutions like PINSTECH and PIEAS in the nuclear and radiation safety related fields. After Fukushima Daiichi Accident research and development activities are more focused to various disciplines for enhancing safety at nuclear installations with special emphasis on equipment qualification, severe accident analysis, and combustible gas control and filtered venting of containment. Probabilistic Seismic Hazard Analysis (PSHA) for nuclear installations is currently being performed.

Annexure–XIII: List of Abbreviations

6NR	Sixth National Report
7NR	Seventh National Report
ABCC	Automatic Boiler Crash Cool
ACA	Apparent Cause Analysis
AdSec	Advisory Committee on Nuclear Security
AECC	Alternate Emergency Control Centre
AISC	American Institute of Steel Construction
ALARA	As Low as Reasonably Achievable
AMI	Accident Monitoring Instrumentation
ARP	Alarm Response Procedures
ASME	American Society of Mechanical Engineers
BDB EQ	Beyond Design Basis Equipment Qualification
BDBA	Beyond Design Basis Accidents
BFW	Boiler Feed Water
BPTC	Basic Professional Training Course
C&I	Control and Instrumentation
C-1	Chashma Nuclear Power Plant Unit-1
C-2	Chashma Nuclear Power Plant Unit-2
C-3	Chashma Nuclear Power Plants Unit-3
C-4	Chashma Nuclear Power Plant Unit-4
CAA	Civil Aviation Authority
CANDU	Canada Deuterium Uranium
CAP	Corrective Action Program
CBI	Safety system by-pass and inoperable status indication system
CERO	CHASNUPP Emergency Response Organization
CHASCENT	CHASNUPP Center of Nuclear Training
CHASNUPP	Chashma Nuclear Power Plant
CMMS	Computerized Maintenance Management System
CNPGS	Chashma Nuclear Power Generating Station
CNPO	China Nuclear Power Operation Technology Corporation
CNS	Convention on Nuclear Safety
COER	CHASNUPP Operating Experience Report

COG	CANDU Owners Group
COMTEX	Communication Test Exercise
ConvEx	Convention Exercise
CPC	Plant Computer System
CPDS	Critical Parameter Display System
CPDS	Critical Parameters Display System
CPPNM	Convention on Physical Protection of Nuclear Materials
CRDM	Control Rod Drive Mechanism
CSA	Canadian Standards Association
CSRC	Corporate Safety Review Committees
CSS	Commission on Safety Standards
CTIR	Commissioning Test inspection reports
DBA	Design Basis Accidents
DBE	Design Basis Earthquake
DCO	District Coordination Officer
DDMA	District Disaster Management Authority
DGs	Diesel Generator or Director General
DFO	Diesel Fuel Oil
DFR	Deficiency Reports
DFS	Detailed Functional Specification
DID	Defence-in-Depth
DMW	De-mineralized Water
DNS	Directorate of Nuclear Safety
DOS	Directorate General of Safety, (PAEC)
DQA	Directorate of Quality Assurance
DSW	Dousing Spray Water system
DTS	Directorate of Technical Support
ECC	Emergency Control Center
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EFW Room	Emergency Feed Water Room
EIICA	Events & Issues Identifications and Corrective Action Program (generally called CAP)
EMG	Emergency Management Group
ENR	Event Notification and Reporting

ENS	Event Notification Sheet
ENSREG	European Nuclear Safety Regulators Group
EOP	Emergency Operating Procedures
EPA	Environmental Protection Agency
EPIPs	Emergency Plan Implementing Procedures
EPP	Emergency Preparedness Plans
EPReSC	Emergency Preparedness and Response Standards Committee
EPREV	Emergency Preparedness Review
EPZ	Emergency Planning Zones
ERC	Emergency Relief Cell
ERT	Emergency Response Team
ETRES	Education and Training Review Services
EWI	Emergency Water Injection
EX	Electrical Island
FCIA	Fuel Chanel Integrity Assessment
FCVS	Filtered Containment Venting System
FFS	Fitness For Service
FIJW	Forced Emergency Injection Water System
FRAP	Fukushima Response Action Plan
FSA	Focused Self Assessment
FSAR	Final Safety Analysis Report
FSTS	Full Scope Training Simulator
FW	Fire Water
GIS	Gas Insulated Switchgear
GNSSN	Global Nuclear Safety and Security Network
HDTR	High Density Tray Racking
HFE	Human Factors Engineering
HMC-3	Heavy Mechanical Complex -3
HMI	Human Machine Interface
HPME	High Pressure Melt Ejection
HRA	Human Reliability Analysis
HRD	Directorate of Human Resource Development
HSI	Human System Interface
IAEA	International Atomic Energy Agency

ICCC	Instrumentation Control & Computer Complex
ICD	Directorate of International Cooperation
IEC	International Electro-technical Commission
I&E	Inspection and Enforcement
IEE	Integrated Emergency Exercise
IEEE	Institute of Electrical and Electronic Engineers
IG	Imperial Gallon
IGALL	International Generic Ageing Lessons Learned
INDC	Intended Nationally Determined Contribution
INES	International Nuclear and Radiological Event Scale
INES	International Event Scale
IOEP	Internal Operating Experience Program
IPR	Internal Peer Review
IPSART	International PSA Review Team
IPTC	In-Plant Training Center
IRRS	Integrated Regulatory Review Services
IRS	International Reporting System
IRS	Incident Reporting System
ISD	Directorate of Information Services
ISI	In-Service Inspection
ISO	International Organization for Standardization
ITDB	Incident and Trafficking Database
KANUPP	Karachi Nuclear Power Plant
KERO	KANUPP Emergency Response Organization
KFSAR	KANUPP Final Safety Analysis Report
KINPOE	Karachi Institute of Power Engineering
KOFREP	KANUPP Offsite Radiological Emergency Plan
KONREP	KANUPP Onsite Radiological Emergency Plan
KRERC	Karachi Radiological Emergency Response Committee
KSC	KANUPP Safety Committee
KSFDS	KANUPP Spent Fuel Dry Storage
LAN	Local Area Network
LER	Licensee Event Report
LLW	Low Level Waste

LOCA	Loss of Coolant Accident
LTOK	Long Term Operation of KANUPP
LTSK	Long Term Safety of KANUPP
LUMS	Lahore University of Management Sciences
MAWT	Minimum Acceptable Wall Thickness
MCR	Main Control Room
MELCOR	Computer code to model the progression of accidents in nuclear reactors(Estimation of Leakage and Consequences Of Releases)
MET	Meteorological
MENA	Middle East & North Africa
MOU	Memorandum of Understanding
MOV	Motor Operated Valve
MRML	Mobile Radiological Monitoring Labs
MSL	Mean Sea Level
NAC	National Assistance Capabilities
NCA	National Command Authority
NCMC	National Crisis Management Cell
NCN	Non-conformances Notices
NCNDT	National Center for Non-Destructive Testing
NCRO	Northern China Regional Office
NDCL	National Dosimetry and Protection Level Calibration Laboratory
NDE	Non Destructive Examination
NDMA	National Disaster Management Authority
NDMC	National Disaster Management Commission
NDMO	National Disaster Management Ordinance 2007
NDRP	National Disaster Response Plan
NDT	Non Destructive Testing
NEMP	National Environmental Monitoring Programme
NEMS	Nuclear Emergency Management System
NEPRA	National Electric Power Regulatory Authority
NERSP	National Environmental Radioactivity Surveillance Programme
NEW-1	Nuclear Equipment Workshop-1
NEWS	Nuclear Events Web Based System
NGA	Next Generation Attenuation
NGOs	Non Governmental Organizations

NIAB	Nuclear Institute of Agriculture and Biology
NISAS	National Institute of Safety and Security
NNSA	National Nuclear Safety Administration
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear Power Plant
NRECC	National Radiological Emergency Coordination Centre
NREP	National Radiological Emergency Plan
NRO	Northern Regional Office
NS	Non-Seismic
NSAP	Nuclear Security Action Plan
NSC	Nuclear Safety Centre
NSD	Directorate of Nuclear Safety
NSGC	Nuclear Security Guidance Committee
NSLD	Nuclear Safety and Licensing Division
NSTC	Nuclear Security Training Centre
NUML	National University of Modern Languages
NUSSC	Nuclear Safety Standards Committee
NX	Nuclear Island
OBE	Operating Basis Earthquake
OEF	Operating Experience Feedback
OGRA	Oil and Gas Regulatory Authority
OIR	Operation Inspection Reports
OPEX	Operating Experience
OPP	Operating Policies and Principles
OQAP	Overall Quality Assurance Program
ORIGEN	Name of a Computer Code
OSART Mission	Operational Safety Review Team
OSRC	Operational Safety Review Committee
OTD	Operation Training Division
PAEC	Pakistan Atomic Energy Commission
PAM	Post Accident Monitoring System
PARs	Passive Autocatalytic Recombiners
PARR-I	Pakistan Research Reactor – I
PARR-II	Pakistan Research Reactor – II

PCR	Plant Conditions Reports
PDMA	Provincial Disaster Management Authority
PDTP	Post Diploma Training Program
PEE	Partial Emergency Exercise
PEPA	Pakistan Environmental Protection Agency
PEWG	Programme Element Working Group
PGA	Peak Ground Acceleration
PGTP	Post Graduate Training Program
PIEAS	Pakistan Institute of Engineering and Applied Sciences
PIE	Postulated Initiating Events
PIM	Pakistan Institute of Management
PINSTECH	Pakistan Institute of Nuclear Science and Technology
PLC	Programmable Logic Control
PLEX	Plant Life Extension
PMD	Pakistan Met Dept
PMI	Pakistan Manpower Institute
PNRA	Pakistan Nuclear Regulatory Authority
PPD	Directorate of Policies and Procedures
PPRA	Public Procurement Regulatory Authority
PPSD	Directorate of Physical Protection and Security
PRC	PNRA Residential Colony
PRISMA	Practical Illustration and Use of the Safety Case Concept in the Management of Near Surface Disposal Project
PSA	Probabilistic Safety Analysis
PSAR	Preliminary Safety Analysis Report
PSDP	Public Sector Development Programme
PSHA	Probabilistic Seismic Hazard Analysis
PSI	Pre-Service Inspection
PSP	Physical Security Plan
PSQCA	Pakistan Standard and Quality Control Authority
PSR	Periodic Safety Review
PSUR	Pre Start-Up Peer Review
PTA	Pakistan Telecommunications Authority
PWI	Pakistan Welding Institute
PWR	Pressurized Water Reactor

QAD	Quality Assurance Divisions
QAM	Quality Assurance Manual
QAP	Quality Assurance Program
QNPC	Qinshan Nuclear Power Company
R&D	Research and Development
RAD	Directorate of Regulatory Affairs
RAG	Radiological Assistance Group
RANET	Response Assistance Network
RAS	Asia region termed as IAEA Regional Asia
RASIM	Radiation Safety Management System
RASSC	Radiation Safety Standards Committee
RAWSA	Radioactive Waste Storage Facility
RCA	Radiation Controlled Area
RCC-M	Design and Construction Rules for Mechanical Components of PWR Nuclear Island (French Code)
RCO	Radiation Control Officer
RCP	Reactor Coolant Pump
REP	Radiological Emergency Procedures
RFO	Refueling Outages
RFW	Reserve Feed Water System
RHR	Residual Heat Removal System
RLO	Relicensing Outage
RNSD	Regional Nuclear Safety Directorate
RNSI	Regional Nuclear Safety Inspectorate
RPD	Radiation Protection Detector
RPV	Pressure Vessel
RSD	Directorate of Radiation Safety
RSIL	Research Society of International Law
RSR	Result Summary Reports
RWP	Radiation Work Permits
SAC	Safety Analysis Centre
SAF	Auxiliary Feed Water System
SAMG	Severe Accident Management Guidelines
SAP	Self Assessment Program
SARCON	Systematic Assessment of Regulatory Competence Needs

SAR	Safety Analysis Reports
SAT	Systematic Approach to Training
SBO	Station Blackout
SCF	Reactor Cavity Flooding System
SCG	Severe Challenge Guide
SCM	Steering Committee Meeting
SCW	Component Cooling Water System
SDV	Screening Distance Value
SED	Site Emergency Director
SEOP	Symptom Based EOPs
SEPA	Sindh Environmental Protection Agency
SER	Site Evaluation Report
SFP	Spent Fuel Pool
SG	Steam Generator
SGL	Safety Grade Level
SIS	Safety Injection System
SNERDI	Shanghai Nuclear Engineering Research and Design Institute
SNRS	School for Nuclear and Radiation Safety
SOER	Significant Operating Experience Report
SOP	Systems Operating Procedure
SPD	Strategic Plans Division
SPDS	Safety Parameters Display System
SPI	Safety Performance Indicators
SRC	Reactor Coolant System
SRS	Sealed Radioactive Sources
SSC	Structures Systems and Component
SSE	Safe shutdown earthquake
STI	Secretariat Training Institute
TC	Technical Cooperation
TEPCO	Tokyo Electric Power Company
TEWS	Tsunami Early Warning System
TLD	Thermo Luminescent Dosimeter
TRANSSC	Transport Safety Standards Committee
TSC	Technical Support Committee

TSO	Technical Support Organization
UHS (CJLC)	Ultimate Heat Sink (Chashma Jhelum Link Canal)
UNCFCC	United Nations Convention Framework on Climate Change
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiations
UPS	Un-interrupted Power Supply
USNRC	US Nuclear Regulatory Commission
VCW	Vault Cooling Water
VDNS	Vienna Declaration on Nuclear Safety
VHF	Very High Frequency
VSS	Vehicle Service Station
VUJE	Nuclear Power Plant Research Institute, Slovak Republic
WANO	World Association of Nuclear Operators
WAPDA	Water and Power Development Authority
WASSC	Waste Safety Standards Committee
WSD	Directorate of Transport and Waste Safety
WUH	Ultimate Heat Sink System