

# **SAFETY AND SECURITY INTERFACES DURING LIFETIME OF A NUCLEAR POWER PLANT- NATIONAL EXPERIENCE**

S. R. Ali  
Pakistan Atomic Energy Commission  
Islamabad, Pakistan  
Email: srafatali@gmail.com

N. Sabir  
Pakistan Atomic Energy Commission  
Islamabad, Pakistan

## **Abstract**

Nuclear technology has been used worldwide for peaceful purposes including nuclear power plant. Apart from being an inexhaustible supply of clean energy, nuclear power plants are often a more consistent source of power than wind, solar, or hydroelectric sources that depend on weather conditions. The production of nuclear energy is inexpensive, reliable and doesn't create greenhouse gases. Despite these benefits, there are challenges involved in the application of nuclear technology including safety, security and safeguards. Measures are taken to enhance awareness of the intersection between nuclear safety and security among operators of nuclear power plants in Pakistan. The workshops and trainings are conducted to brief the safety related people about security and vice versa. Nuclear security awareness programme is being carried out at nuclear facilities. Pakistan Atomic Energy Commission (PAEC) provide forums at different levels to cultivate the safety and security culture. The paper is intended to highlight the National experiences towards nuclear safety, nuclear security, and their interfaces during lifetime of a Nuclear Power Plant.

**Keywords:** Nuclear safety, Nuclear Security, Nuclear Power Plant, National Experiences, Safety and Security Interface

## 1. INTRODUCTION

In Pakistan five (5) nuclear power plants viz; C-1, C-2, C-3, C-4, and K-1 are operational under the umbrella of Pakistan Atomic Energy Commission and under the regulatory control of Pakistan Nuclear Regulatory Authority (PNRA). Two more nuclear power plants viz; K-2 and K-3 are currently in construction phase. The existing and upcoming nuclear power plants are closing the energy gap of the state responsibly by ensuring the safe and secure operation of these nuclear power plants. Safety and security is of utmost importance during all stages of a nuclear power plant lifecycle.

## 2. NUCLEAR SAFETY AND SECURITY

Nuclear Safety is defined as “the achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards”[1] while Nuclear Security is defined as “the prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities”[2].

## 3. SAFETY AND SECURITY REGIMES

The nuclear safety and nuclear security regimes are based on a number of international legal instruments (conventions, resolutions and codes of conduct). Pakistan is the party of Convention on Nuclear Safety. Comprehensive Safety Assessment is carried out at all stages of Nuclear Power Plant in Pakistan. PNRA Regulations PAK/910 establish requirements for site evaluation and determination of site characteristics to be used as design parameters. PNRA Regulations PAK/911 address assessment and verification of safety during Design. PNRA Regulations PAK/913 specify requirements for assessment and verification during commissioning and operation. PNRA Regulations PAK/914 require that licensee shall develop, test, and put in place an infrastructure

according to the hazard category. The requirements for safe management of radioactive waste in the country have been specified in Regulation PAK/915. Nuclear Power Plant Licensee is responsible to ensure the effectiveness of the quality assurance program as established in PAK/912. Requirements of PNRA Regulations PAK/916 are completed for safe transport of radioactive material.

Guidelines of National and international instruments related to nuclear security are adopted at Nuclear Power Plants in Pakistan. Pakistan is party to the Convention on Physical Protection of Nuclear Material (CPPNM). Pakistan has ratified the amendment of CPPNM in March, 2016. Requirements related to Physical Protection of Nuclear Material and Nuclear Facilities are addressed in PNRA Regulations PAK/925. The requirements for Security of Radioactive Sources have been specified in PAK/926. Pakistan is subscribed to United Nations Security Council Resolution 1373 and 1540.

Implementation of International instruments relevant to both nuclear safety and nuclear security ensures the Safety and Security Interface Issues. 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. Pakistan implements the IAEA Code of Conduct on Safety & Security of Radioactive Sources. Guidance on Import and Export of Radioactive Sources and Guidance on Management of Disused Radioactive Sources are supplement documents to the Code of Conduct on Safety and Security that provides further guidance for implementation.

#### 4. NATIONAL EXPERIENCE TOWARDS SAFETY OF NUCLEAR INSTALLATIONS

##### 4.1. Nuclear Safety Policy

Pakistan Atomic Energy Commission (PAEC) is the operator of nuclear power plants in Pakistan. PAEC has formally established and implemented a Nuclear Safety Policy from which specific safety rules, procedures and other requirements are derived.

##### 4.2. Safety in Nuclear Power Plants Operation

In compliance with the Safety Policy of PAEC, safety is given the highest priority at nuclear power plants. The Vision, Mission, Goals and Objectives of power plants 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 is encouraged and any plant worker can report events and near misses through a user friendly reporting system. Safety and quality takes precedence 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. In order to enhance safety and reliability, Technical Support Organizations (TSO) are established which provide the technical support required for operations and maintenance activities of the plants.

Safety is being taken as a continuous journey in nuclear installations of Pakistan. Safety upgrades as suggested in Regulatory Review, Corporate Review and International Missions are always given highest priority. Several WANO technical missions including a Peer Review Mission were conducted at KANUPP-1. Peer review mission and 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. A WANO Peer Review mission was conducted at C-2 in April -May, 2015. A WANO Pre-Startup Review mission for C-3 was conducted in Jan, 2016.

##### 4.3. Safety in Design and Construction of Nuclear Power Plants

Upon satisfactory completion of licensing process, Construction licenses have been awarded to K-2 and K-3 in 2015 and currently both plants are in construction phase. 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. At design stage, probabilistic safety assessment was performed in addition to the deterministic safety analysis. A 'Management System 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 is applicable to all the safety related structures, systems and components as well as important non-nuclear safety structures, systems and components.

#### **4.4. PAEC Corporate Safety Oversight Program**

PAEC has established a corporate safety office, Directorate General of safety, reporting to Chairman PAEC, and is aimed to oversee the implementation of safety standards at nuclear power plants. Directorate of Nuclear Safety (DNS) is created under Directorate General of Safety 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.

Directorate of Physical Protection and Emergency Management (PP&EM) is created under Directorate General of Safety to oversee the radiological emergency preparedness and response plans and coordination with all relevant entities in any such event. Emergency exercises/drills are conducted in nuclear power plants periodically and officials from corporate safety office participate as observers and suggest Areas for Improvements (AFIs). Follow up of AFIs is conducted as per agreed timeline with the operators.

A Coordination Center, PAEC Emergency Response Coordination Center (PERCC), is established at corporate level to coordinate between the stakeholders and activate the required sources from within the commission as well as from sister organizations in case of an emergency event. PERCC is manned on 24/7 basis.

#### **4.5. Safety Evaluation by PNRA**

PNRA regulates various aspects of safety of nuclear power plants such as licensing, design, operation and quality assurance. Monitoring and Evaluation of nuclear power plants is conducted by PNRA through its regional nuclear safety directorates established at Nuclear Power Plant Sites. The monitoring of the regulatory performance of the PNRA is based on strategic performance indicators (SPIs). In addition, Safety committees advise the management on safety and quality related issues.

### **5. NATIONAL EXPERIENCE TOWARDS SECURITY OF NUCLEAR INSTALLATIONS**

#### **5.1. Security in the design and construction of Nuclear Power Plants**

Upon satisfactory completion of licensing process, Construction licenses have been awarded to K-2 and K-3 in 2015 and currently both plants are in construction phase. The physical protection is included in the safety analysis reports of these upcoming power plants. Nuclear Security/Physical Protection is considered in the initial phases including the siting, layout and design. The PP arrangements are based on graded approach and principle of defence in depth as per fundamental principles of Physical Protection referred in amendment to CPPNM, 2005. Design of Physical Protection System for nuclear power plants are based on graded approach consistent with Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225).

#### **5.2. Security in Operation of Nuclear Power Plants**

An integrated Physical Protection System is designed, implemented and maintained at C-Series nuclear power plants. The Physical Protection System is based on Design Basis Threat (DBT) and counter measures are ensured with the change in threat. The Design and Evaluation Process (DEPO)[3] is adopted in designing the Physical Protection System; facility characterization, target identification and threat definition are the key inputs for the design of Physical Protection System. Graded approach and principle of defence in depth are adopted in the design. The PP programme of all nuclear power plants are approved by PNRA and are periodically updated to address the current evaluation of threat.

A robust Central Alarm Station (CAS) is established for monitoring and assessment of alarms and communication to response force. A Backup Alarm Station (BAS) is also established to ensure its functionality in case of unavailability of CAS i.e. under attack. Trained manpower is manning the CAS round the clock. Redundant and divers means of communication are available for timely communication to response force, facility management and corporate safety and security office of PAEC.

Physical Protection Programs are prepared and submitted to PNRA. Audits, exercises and drills are conducted for evaluating the effectiveness of the Physical Protection System.

Presently Physical Protection Upgrades are being implemented at KANUPP-1 under IAEA-Pakistan Nuclear Security Cooperation Program. Plant Site is divided into different zones i.e. Offsite, Limited Access Area, Protected Area and Core Area. The design of Physical Protection System includes measures for Access control, Personnel and vehicle search, contraband detection, intrusion detection, assessment and Surveillance at each protection layer. Isolation zone is established at the perimeter of protected area with arrangements of detection and assessment. Marker Piles are installed on the sea-side for demarcation of protected area. CAS and BAS are designed for continuous alarm monitoring.

### **5.3. PAEC Corporate Security Oversight Program**

Directorate of Physical Protection and Emergency Management (PP&EM) is created under the corporate security office of PAEC i.e. Directorate General of Safety to oversee the physical protection program of NPPs, its implementation and radiological emergency preparedness and response plans and coordination with all relevant entities in any such event. Physical Protection plans are reviewed under national regulations [4],[5]. Physical Protection/Security exercises/drills are conducted in nuclear power plants periodically and officials from corporate security office participate as observers and suggest Areas for Improvements (AFIs). Follow up of AFIs is conducted as per agreed timeline with the operators. As per national regulation [6], Physical protection plan must be in place and rehearsed before introduction of Nuclear Material in to the facility.

## **6. SAFETY-SECURITY SYNERGY AT NUCLEAR INSTALLATIONS IN PAKISTAN**

### **6.1. Safety-Security Synergy**

Nuclear safety and nuclear security have same fundamental goal i.e. to protect the public, the property and the environment from harmful effects of radiations [7]. Nuclear safety is meant for protection of incidents/accidents resulting in radiological releases due to human error, component failure, natural disasters etc. while nuclear security aims to protect malevolent human actions/attacks resulting in radiological releases. Although safety and security have common goals but both have different approaches and culture. A synergic approach for safety and security, throughout the lifetime of a nuclear facility will augment the effectiveness of the common goal associated with nuclear safety and nuclear security.

National experiences towards safety and security interfaces during the lifetime of a nuclear power plant includes the following major areas:

- (a) Establishment, implementation and maintenance of nuclear safety regime;
- (b) Establishment, implementation and maintenance of nuclear security regime;
- (c) Identification of areas where nuclear safety and security share similarities;
- (d) Identification of areas where nuclear safety and security differ;
- (e) Identification of safety concepts, criteria, and operational practices which enhances protection;
- (f) Integration of safety and security measures such that implementation of one does not compromise the other;
- (g) Awareness of safety and security synergy.

### **6.2. Areas where nuclear safety and security share similarities**

Nuclear safety and security share similarities in various areas including design, construction, operation and other associated activities. For example; the placement of reactors inside containment structures intended to keep radiation from reaching the environment, even if reactors leak radioactive materials in the event of an accident, while simultaneously providing a robust structure that protects the reactor from a terrorist attack.

Another example of achieving synergy in safety and security practiced in Pakistan is controlled access to containment of Nuclear Power Plants. Electronic Pocket Dosimeter (EPD) are used by personnel accessing the containment building to comply with safety requirements i.e. to ensure radiation protection and maintaining the dose record for personnel to comply with permissible dose level of radiation workers. The security requires access of authorized personnel only, which is usually achieved through electronic reader machines operated by respective tokens. The synergy is achieved by interlocking the turnstile gate with EPD reader. The potential free contact of EPD reader is interfaced with turnstile gate for access control of containment building and hence requirements for safety and security are met simultaneously.

In addition, doors or barriers in vital areas are made robust which serve both safety and security purpose. Doors or barriers have a safety function by serving as a radiation barrier while security purpose is also fulfilled because it will provide more delay to the unauthorized access.

### **6.3. Areas where nuclear safety and security differ**

The areas where nuclear safety and security differs includes information sharing. As an example, safety requires information sharing on free and for all basis while security emphasizes on need to know principle. Safety establishes wide outreach for communication channels while security emphasizes on secure network. Another interface is access control. Safety norms for access control is knowledge based movement while security believes in need based movement. Efforts are being made for achieving synergy in information sharing in nuclear power plants of Pakistan by implementing movement on need basis supplemented with necessary knowledge. Safety and Security is at par with international standards at Nuclear Power Plants in Pakistan.

### **6.4. Safety concepts and operational practices which enhances protection**

Nuclear installations are designed by applying the defence in depth principle for both safety and security. Certain design criteria imposed for safety purposes may serve to reinforce security. As an example, the single failure criterion applied to safety systems requires the nuclear installation to be designed with a sufficient level of redundancy and/or diversification to ensure that safety functions are maintained. Single failure criterion demands that safety be maintained even if one set of equipment in the system fails. This design feature is helpful for security purposes as well. The redundancy in safety design also serves as security layers against adversaries' actions i.e. by application of this criterion, adversaries' must compromise several safety layers in order to cause a radiological release.

Similarly the Physical Protection System installed in nuclear power plants of Pakistan are based on defence in depth i.e. establishment of protection layers in a sequence. As per defence in depth principle, adversary must avoid or defeat a number of protection layers in a sequence to achieve his goal. The several layers of protection reinforce safety as the adversary needs to by-pass these layers for accessing the safety systems/controls. Similarly in security events, the redundancy in safety systems reinforce security.

### **6.5. Integration of safety and security measures without compromising either**

During the lifetime of a nuclear power plant in Pakistan, both the safety and security measures are implemented in an integrated manner. For example, the emergency exit doors installed in vital/inner areas are designed such that they provide unhindered egress in case of emergency but do not compromise security. The emergency exit doors are made operational from secure/inner side only. Moreover the emergency exit doors are alarmed and the door alarm is reported in Central Alarm Station (CAS) along with appropriate means of surveillance and assessment. The design and installation of emergency exit doors is such that it enhances the intruder penetration time and the security measures are in place to ensure the early detection of any attempt of intrusion.

### **6.6. Areas to improve synergy**

Measures are taken to enhance awareness of the intersection between nuclear safety and security among operators of nuclear power plants in Pakistan. Safety people are made aware of the security arrangements at the

power plant and the security personnel are also provided with the basic knowledge of the safety. Moreover, the safety people are made on board in the design of physical protection system of nuclear power plants in Pakistan, resulting in enhanced synergy. Refresher courses for plant personnel are arranged on periodic basis. The refresher courses includes both safety and security features/requirements of the plant and provide a forum to cultivate the safety and security culture among plant personnel. Moreover, to improve synergy following actions are implemented:

- Plant Operations Review Committee is functional;
- Work planning and control Committee is functional;
- Design control and configuration management;
- Quality assurance and audit.

The above listed committees and groups will determine, that whether a planned change will affect safety or security before implementation.

### **6.7. Corporate Office for Safety and Security**

PAEC has established a corporate safety and security office with the aim to oversee the implementation of safety standards, meet security requirements and achieve synergy in safety and security approaches.

The corporate safety office played a vital role in establishment of common working forum for the safety and security personnel of nuclear power plants. Safety people are taken on board in development of physical protection programme and related procedures. Similarly the security personnel are educated on basic safety principles and practices.

The corporate office provides the platforms that encourage the people with a sufficient knowledge of safety to interact and share their knowledge with other safety and security people and vice-versa. The workshops and trainings are conducted to brief the safety related people about security. Nuclear security awareness programme is being carried out at nuclear facilities.

The corporate office took initiative of involving security personnel in radiological emergency drills. In certain scenarios the communication system of security personnel was utilized.

### **6.8. Safety and Security Culture**

A culture of safety and security that governs the attitudes and behavior of individuals is integrated in the management system. Safety culture and security culture are based on similar principles. Safety culture is defined as the assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance. Meanwhile, nuclear security culture is defined by the IAEA as “the assembly of characteristics, attitudes, and behaviors of individuals, organizations and institutions which serves as a means to support and enhance nuclear security.”

These cultures often involve individuals of diverse backgrounds and experiences. Importance of cooperation and balance between safety and security culture is achieved by giving due consideration to each area. The refresher courses are conducted for both safety and security people of the plant to cultivate the safety and security culture among plant personnel. Consequently, safety and security co-exist with each other and mutually enhance each other.

## **7. CONCLUSION**

Safety and security have common goals but both have different approaches and culture. A synergic approach for safety and security, throughout the lifetime of a nuclear facility will augment the effectiveness of the common goal associated with nuclear safety and nuclear security.

Safety security synergy is very important because ineffective management of a safety/security interface could potentially result in:

- Delays of scheduled activities;
- Unintended security vulnerabilities ;
- Unintended impacts to safety systems;
- Unintended impacts to emergency response activities.

It has also been experienced that many commonalities between safety and security are frequently obscured by the use of different terminology. Thus, to achieve a shared understanding of the key concepts within each field, there is a need to establish a common terminology and to develop a glossary of terminology.

It has also been experienced that interface platforms such as workshops and table talks are vital in uncovering the commonalities between safety and security and also the differences could be sort out using such forums.

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