Effective Control of Instrumentation and Control (I&C) Modernization, Methods and Tools

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INTRODUCTION

SALIENT FEATURES

- Karachi Nuclear Power Plant (KANUPP), located near Arabian Sea coast, about 11 miles (17.7 km) west of Karachi.
- Heavy water moderated and cooled, natural uranium fuelled CANDU type Reactor.
- Horizontal pressure tubes.
- Once-through, on-power bi-directional fuelling.
- Reactor shutdown by moderator dump.
- Reactor building designed for total containment of any pressure or activity resulting from a credible accident.
- Gross plant output 137 MW(e) net output 125 MW(e).
I&C at KANUPP

Primary purpose of the I&C systems is to exercise proper control & provide automatic protection against unsafe and improper reactor operation during steady-state and transient power operations & to provide initiating signals to mitigate the consequences of faulted conditions. Digital techniques are used for plant control, computation, and monitoring of parameters, annunciation & logging purposes & for fueling machine control.

Two digital computers are used for reactor power regulation & for individual channel monitoring, while two separate computers used for fuelling machines.

The remaining I&C can be sub-divided into:

- Measurement Loops
- Control Loops
- Reactor Protection Loops
- Engineered Safeguard Loops
Need for I&C Modernization at KANUPP

- The I&C used for KANUPP was based on the technology of early sixties. During last four decades the advancement in technology has revolutionized the field. Vendor support to the old pneumatic and / or discrete electronic instrumentation had been discontinued and due to lack of availability of spares it was not possible to maintain the equipment / system.

- Due to technological advancements various features have been added in the new plants like SPDS, CPDS and Operator Information Systems, that enables the operator to take prompt action. The regulatory authority imposed such requirements on KANUPP also which could not be met through old instrumentation.
I&C Modernization Project at KANUPP

- PAEC had foresighted the need to perform I&C modernization based on the above mentioned reasons and other rehabilitations projects for KANUPP to operate the plant safely and efficiently.

- PAEC initiated the study for I&C modernization. After completion of the study, the bids were invited from International suppliers. Overcoming the difficulties in procurement of equipment at last the contract was signed with the consortium of CEGELEC (France) and CEGELEC-ACEC (Belgium). Under that contract the consortium only provided the equipment, while PAEC took the sole responsibility of engineering and implementation.
Project Objectives

The Obsolescence / lack of vendor support was the major problem while technological up-gradation was the benefit target with following prime objectives:

- New equipment should improve the maintainability, reliability, & availability of the systems resulting in improvement the Plant performance.
- New equipment be based on modern day technology so that plant may be kept operational without any problem for the remaining / extended life.
- The replaced systems shall comply strictly to safety criteria specified in KANUPP Final Safety Analysis Report (KFSAR).
- Enhance the quality of information for the operator by addition of Process Information System & improvement in Man-Machine Interface.
Project Targets

1. Replacement of:

   a) Regulation Systems Computers,
   b) Annunciation System,
   c) Channel Temperature Monitoring System,
   d) Bearing Temperature Monitoring System,
   e) Data Logging System
   f) 72 measurement loops,
   g) 42 control loops,
   h) 49 reactor protection loops,
   i) 15 engineered safeguard loops.
Project Targets

2. Provision of a Process Information system to provide the operator information regarding plant status and functioning of various equipment.


4. Replacement of Nuclear Instrumentation.

5. Addition of Safety Parameter Display System (SPDS) and Critical Parameter Display System (CPDS).
Effective Control of I&C Modernization

The project objectives and targets are achievable within the planned budget and scheduled time only if the project is effectively controlled. The effective control is required to achieve following objectives:

1. I&C modernization evaluation performed timely and cover all necessary areas of modernization.

2. Proper planning for I&C modernization be carried out to ensure that the system, for which the work is being undertaken, remains available before and after modernization and the system unavailability time (if any) be as low as possible.
FIG 2: MAJOR-ACTIVITIES PLAN FOR KC11 PROJECT
Effective Control of I&C Modernization

3. System functionality meets or exceeds the one presently provided by the old system.

4. I&C modernization does not jeopardize the safety, reliability or availability of plant.

5. I&C modernization be completed within planned budget and scheduled time.

6. After modernization is carried out, the plant personnel be trained to effectively use / maintain the new system / equipment and that sufficient support is available to keep the plant operational for its life (extended by 15 years beyond designed life).
Tools and Methods used for Effective Control of I&C Modernization

The methods and tools used for managing the modernization of Instrumentation and Control at Karachi Nuclear Power Plant (KANUPP), resulting in successful achievement of the goals set by the organization are:

- Project Organization (organization chart)
- Identification of Problematic Areas
- Requirement specification for I&C Modernization at KANUPP
- Methodology to ensure plant safety / operability during installation /commissioning
- Testing of new I&C system
- Quality Assurance
- Resource Planning
- Documentation control
- Cost Control
- Change Management
- Schedule Control
- Implementation Plan
- Progress Evaluation
- Feedback collection and corrective Action Implementation
- Questioning Attitude
- Consultation with relevant working group
FIG : 1  PROJECT ORGANISATION
Tools and Methods used for Effective Control of I&C Modernization

• **Project Organization**
  Guiding and supervising the project personnel is an important and crucial aspect of project management function and the Project organization specifies how to integrate the functions of personal involved in a project and their responsibilities and level of authority.

Project Organization for KANUPP for I&C Modernization:

**Project Manager (PM)**
Responsible for overall implementation of project and interface with Top PAEC management/ Regulatory Authority / Vendors.

**Project In-charge (PI)**
Responsible for planning, integration and technical coordination with design / installation / commissioning teams.
Tools and Methods used for Effective Control of I&C Modernization

Senior Design Engineer (SDE) Responsible for design activities for their concerned areas. The areas were:

- Process control & Instrumentation
- Computerized control and monitoring
- Annunciation system
- Data Acquisition system
- Infra-structure
- Support facility
- Process Information

Senior Installation Engineer (SIE) Responsible for all installation related activities like Infrastructure, Wiring, Electronic room, control room modification & equipment placement etc.
Tools and Methods used for Effective Control of I&C Modernization

Senior Commissioning Engineers (SCE) Responsible for commissioning related activities are up to quality assurance principles and the functionality of the system as per design requirement and plant safety is not effected.

Senior Quality Engineers (SQE) Responsible for Quality Assurance of project from design phase to the commissioning.

Project Management Engineers (Project office) Responsible for managing project activities such as documentation, material management, resource planning under guidance of project In charge.
Tools and Methods used for Effective Control of I&C Modernization

Identification of Problematic Areas:

Following criteria was established after consultation and discussion with all relevant working groups:

- Replacement of Regulating Computer.
- Safety Loops.
- Measurements and Control loops that are critical / not maintainable and problematic from operational point of view.

Requirement Specification for I&C Modernization

The Requirement Specification were prepared after detailed Engineering study i.e.

- Primary sensor and final control element would not be replaced.
- Modern state of the Art electronic equipment would be used to replace pneumatic equipment as for as possible.
Tools and Methods used for Effective Control of I&C Modernization

Requirement Specification for I&C Modernization (Cont.)

- For Analog signal transmission 4-20mA DC signal be used as a standard between field, electronic and control room equipment.
- For Binary signal 24 V DC signal transmission would be used.
- All electronic equipment would be supplied with redundant 24VDC UPS
- Configuring PCs would be supplied by 220 VAC UPS.

Quality Assurance

Project QA manual was developed defining the requirement to ensure the quality & control at different phases. A QA plan was also established.
Methodology to ensure Plant Safety at diff. project phases

To ensure Plant safety during installation and commissioning following strategies were adopted:

• Installation of infrastructure material in accessible areas of plant to be done during plant operation while in non accessible areas to be done during extended shutdown without interacting with any plant systems.
• No change over to be made during plant operation.
• Changeover and installation of equipments would be only in extended shutdown and the system should be out of service prior to its I&C is changed.
• Pre-commissioning team would ensure availability of individual devices and their Integrated performance using actual process signal injection from transmitter after changeover is complete.
Tools and Methods used for Effective Control of I&C Modernization

- Commissioning of the new I&C system would be done according to the process requirements such as shutdown, during the plant startup process etc.

- For the commissioning of I&C systems for which plant was required in fully operational, availability of all safety parameters/actuations were ensured before starting of commissioning of such I&C systems.

- Operation Division would perform independent verification for all I&C loops/systems to verify that the performance of replaced loops are as per acceptance criteria and any shortcomings would be brought to the knowledge of Project In-charge to rectify it accordingly.

- Safety loops would be commissioned first and their dynamic testing would be done before plant startup and witnessed by regulatory representative.
Tools and Methods used for Effective Control
Modernization of I&C at KANUPP

Testing of New I&C Systems

Testing of new I&C system was carried at following stages

- Performance Evaluation Tests
- Factory Acceptance Tests
- Site Acceptance Test
- Off-Plant Testing
- Pre-commissioning Tests.
- Commissioning Tests.
Tools and Methods used for Effective Control
Modernization of I&C at KANUPP

Resource Planning

Project goals achieved through the utilization of resources, e.g. to provide required equipment, tools, spares, test equipments and necessary installation material at right time. This tool is used to prevent non productive effect, to assure cost effectiveness of the project. Resource scheduling, availability and optimization are considered KEY to successful project management.

We have done resource planning for:

- Equipment and Spares (were procured from vendor)
- Infrastructure material (arranged locally)
- Tools and Test Equipments (arranged locally or from sub-suppliers)
- Test facilities were developed inside plant premises to ensure timely testing of equipments before installation at site
- Manpower acquired mostly from KANUPP and was trained for project.
Tools and Methods used for Effective Control Modernization of I&C at KANUPP

Documentation Control
Project office was responsible for controlling multiple revision of the documents and retaining all previous versions for reference.

A data base “Project documentation Filing system” named as Master Index was developed and used for proper filling and numbering of various documents which were generated during various phases of Project implementation.

Cost Control
Cost control was managed by Project Manager and Project In-charge. During their special meetings any cost over run was discussed in the presence of Project Team and strategies were formulated to control the cost within the budget provision.
Tools and Methods used for Effective Control
Modernization of I&C

Implementation Plan

Implementation plan is very important. The realistic scheduling, ensure proper implementation of the project, we made this plan with incremental change philosophy.

It was divided into following phases:

- Infra Structure Phase
- Evaluation Phase
- Implementation Phases (First Phase, Second Phase, Third Phase)

Schedule Control

Schedule control has been used to plan the work and for evaluation of progress. The schedule consists of removal of old Equipments, Installation of equipments area wise and other activities related to pr-commissioning and commissioning. All efforts were made to keep the schedule updated and remained effective throughout the Project.
Tools and Methods used for Effective Control Modernization of I&C

Progress Evaluation

It has been done with different manners, i.e.

All SDE, SIE, SQE are responsible for preparation of their respective areas weekly progress report.

Preparation of Weekly and Monthly report: Responsibility of PE, reported to PI and PM

Monthly Progress Evaluation Meeting: Called by PI and attended by all SDEs, SIE and SQE and Minutes of the meeting recorded by PE.

Follow up action: Taken by respective SDE, SIE, SQE and SCE and copies of report forward to PM(TUP)

Quarterly Progress report: PI reported to PM and top management of PAEC.
Development of Support Facilities to support I&C Modernization

Support Facilities

With the project in mind it was felt that support facilities for the C&I modernization project was very essential. The facilities that were envisaged were:

- Offline Test and Calibration facility (Static Calibration)
- Dynamic Test Facility (I&C Test Rigs)

The Dynamic Test facility was also used for training of personnel for the new technology and man-machine interface.
Support Facilities

TEST RIGS
Process C&I
Devices (New or repaired) can be tested on these Rigs for observing their performance in dynamic conditions before installation on plants/processes. Equipment i.e. heat exchanger, pump, relief valve, etc. can also be tested.
Lesson Learned and Experiences

- **Importance of human resource**
  - Had we not the competent manpower we could not have implemented such a huge retrofitting project on our own saving a lot of foreign exchange.

- **Testing / Training**
  - Establishment of Pressure, Temperature, Level & Flow Test Rigs proved its worth by providing:
    - Dynamic testing of new C&I devices.
    - Support of new Control and Instrumentation system.
    - Operators training on new panel equipment

- **Procurement Problems**
  - At the time of procurement the size of panel instruments were larger but later supplies were of different sizes. Hence it is advisable to procure ample spares.

- **Panel Modification**
  - In our case steel panels modification was quite difficult hence it is better to have mosaic panels.
Overview of Change

KANUPP CONTROL ROOM

PANEL ENGINEERING

GIVE AN EASE TO OPERATORS

OLD PANEL WITH PNEUMATIC CONTROLLERS

NEW PANEL WITH PLC CONTROLLERS

IAEA-CN-155/073
Overview of Change

NEW REACTOR POWER REGULATION CONSOLE & PROCESS INFORMATION SYSTEM

OLD
CONSOLE
WITHOUT
VDU

34.94
99.80
34.99
Overview of Change

OLD LINE PRINTERS

MAN-MACHINE INTERFACE OF NEW I&C SYSTEMS
Conclusion

Effective Control of I&C modernization was achieved using appropriate methods and tools that provided the support to implement the project successfully and meeting the desired objectives. As I&C modernization was of a big nature including all safety loops, most of the control loops and significant numbers of measurement loops therefore, the project was a complex one and if the proper managing tools were not used in spite the availability of all the resources the project could not have been successfully accomplished. Thus proper project management is necessary to execute a project of this nature and complexity and if appropriate tools are used the success is achievable.
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THANK YOU