Implementing an Integrated Management System for Effectively Managing Ageing SSCs of GHARR-1

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Outline of presentation

- Introduction and Overview of Ghana Research Reactor-1 (GHARR-1)
- The GHARR-1 Facility Management System
- The GHARR-1 Facility Management Responsibilities
- GHARR-1 Ageing Management Framework
- Periodic Maintenance Activities
- Conclusion
- End of presentation

Overview of GHARR-1 (Ghana Research Reactor-1) 1/3

The Ghana Research Reactor-1 (GHARR-1) is a Miniature Neutron Source Reactor (MNSR) designed as a tank in a pool reactor.

Its main utilization involves neutron activation analysis and human resource development in nuclear sciences and engineering.

The reactor previously (1994-2017) used HEU core, 90.2% enriched fuel for the core assembly with a nominal power of 30 kW, corresponding to neutron flux of 1.0×10^{12} $ncm^{-2}s^{-1}$.

After a successful feasibility study had been carried out under the auspices of US DoE and IAEA as well as other stakeholders like CIAE of China, SOSNY of Russia, UJV and SKODA of Czech Republic and all MNSR operating Countries,

GHARR-1 was converted to a Low Enriched Uranium (LEU) core (13.0 % U-235) in July 2017. The nominal power of the LEU is 34 kW, corresponding to a neutron flux of 1.0×10^{12} $ncm^{-2}s^{-1}$

The Main Features Of GHARR-1 MNSR HEU and LEU Core are compared

Overview of GHARR-1 2/3

Comparison of HEU and LEU Cores of GHARR-1 (MNSR)

Parameter/Feature	HEU Core	LEU Core
Fuel Meat	U-Al	UO_2
U-235 Total Core Load	~998 g	~1358 g
U-235 Enrichment	90.2%	13.0%
Density of Meat	3.456 g/cm³	10.6 g/cm³
Cladding Material	Al-303-1	Zirc-4
Number of Fuel Rods	344	335
Power	30 kW	34 kW
Grid Plate Material	LT-21	Zirc-4
Control Rod Material	Cd, SS	Cd, SS, Al
Core Shape	Cylindrical	Cylindrical
Core Height	23 cm	23 cm
Core Diameter	23 cm	23 cm
Re-fuel Period	More than 10 years	More than 10 years
Burn-up	~1%	~1%
Temperature Coefficient	~0.10 mk/°C	~0.10 mk/°C
Number of Irradiation Sites	10	10
Control Rod	1	1
Max Thermal Neutron Flux	1×10^{12} n·cm^{-2}·s^{-1}	1×10^{12} n·cm^{-2}·s^{-1}

Overview of GHARR-1 (Ghana Research Reactor-1) 3/3

The GHARR-1 received a new core but still operates in the old existing structures and auxiliary systems.

The control systems circuit boards for the instrumentation and sample transfer system tubes were refurbished.

For three decades of continuous operation, the facility is undoubtedly ageing

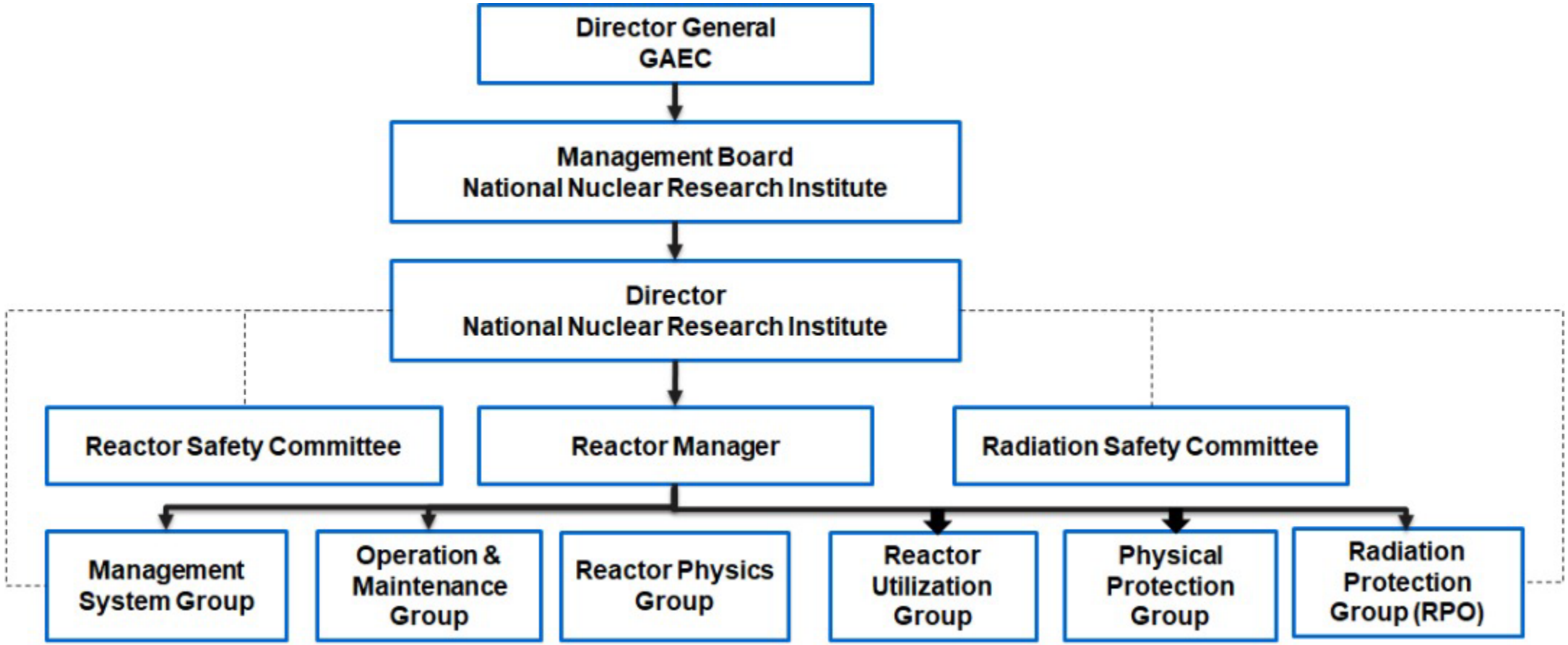
GAEC's management kept task in the provision of the needed resources for ageing management at GHARR-1. The reactor manager is actively involved in carrying out these activities.

An integrated management system at GHARR-1 has helped manage ageing SSCs. Despite switching from HEU in 1994 to LEU in 2017, the reactor still operates efficiently with its original SSCs

The success is due to an integrated system that combines quality, safety, and regular maintenance, following regulations. It has improved efficiency, performance, and streamlined operations.

This presentation covers the main elements of GHARR-1's ageing management system: management responsibility, resource management, process implementation, evaluation, and improvement.

The GHARR-1 Facility Management System 1/2



The GHARR-1 Facility Management System 2/2

- Based on the organogram above, the management/administration of the reactor facility consists of the Director of NNRI/GAEC and the Manager of NRRC/NNRI.

- The various units that work with management to operate and utilize the reactor facility—ensuring nuclear safety, security, environmental protection, and the achievement of economic goals—include:
- Reactor Operation and Maintenance Group
  - Reactor Utilization Group
  - Radiation Protection Group
  - Physical Protection Group
  - Reactor Physics Group
  - Management System Group

GHARR-1 Facility Management System Responsibilities

The management system ensures effective coordination of various units of Management to support the safe operation and utilization of the reactor.

- Key functions include:

1.Development of the **management system policy/manual** and related Quality Assurance and Quality Control (QA/QC) documents

2.Implementation of **standard procedures and specifications** for operation, maintenance, Ageing Management of SSCs and utilization

3.Record keeping of all management, QA/QC documents

4. Sustaining **nuclear knowledge management** for continuous human resource development

➢ Key responsibilities: Providing financial and material resources

GHARR-1 Ageing Management Framework

The Ageing management program of GHARR-1 facility's SSCs is inherent in maintenance approach.

Hence the AMP is guided by the IAEA Specific Safety Guides and manufacturers' manuals on equipment.

Notably, the following IAEA Safety Guides provide key direction:

- *Ageing Management for Research Reactors, Specific Safety Guide, No. SSG-10 (Oct. 2010)*
- *Safety of Research Reactors, Specific Safety Requirements No. SSR -3 (Sept. 2016)*
- *IAEA-TECDOC-792, Management of research reactor ageing.*
- *IAEA, Code on the Safety of Nuclear Research Reactors: Design, Safety Series No. 35-S1, IAEA, Vienna (1992)*
- *IAEA, Code on the Safety of Nuclear Research Reactors: Operation, Safety Series No. 35-S2, IAEA, Vienna (1992)*

Objectives of GHARR-1 AMP

The program aims to apply periodic maintenance activities
to ensure that Structures, Systems, and Components (SSCs) are:

- *Inspected*
- *Tested*
- *Maintained*
- *Repaired or Replaced*
- *Monitored and*
- *Calibrated*

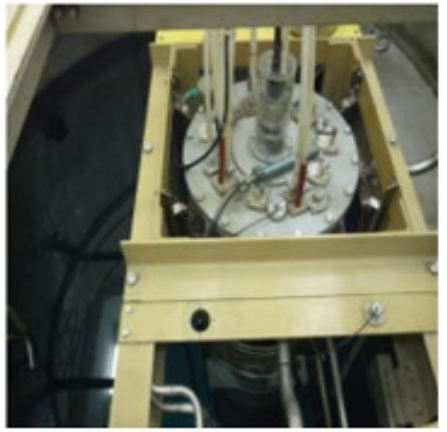
To ensure continued functionality and integrity of SSCs under all conditions defined in their design basis.

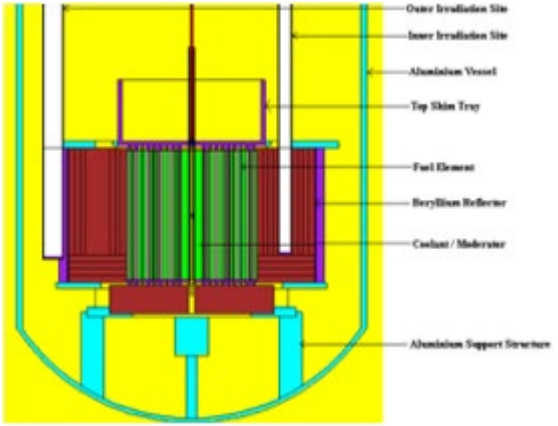
Periodic Maintenance Activities of the Reactor Core and Structures

1.Weekly purification of the reactor vessel and pool water to meet the accepted water quality: (0.5 – 1.0 µS) and (1.0 -2.0 µS) respectively.

2.Annual inspection of the reactor vessel and the pool lining structure for defect detection using Under water camera.

4.Weekly reactivity check for core worth SAR OLC (3.5-4.9mk)





Under water camera in use for vessel inspection

Periodic Maintenance Activities of the Reactor Control Systems 1/8

1. Annual Maintenance of reactor Control Systems

2. Control Rod drive Mechanism and its auxiliary systems.

3. Periodic testing of neutron flux and temperature Circuits and verification of their performance parameters.

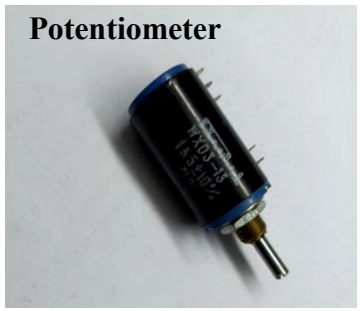
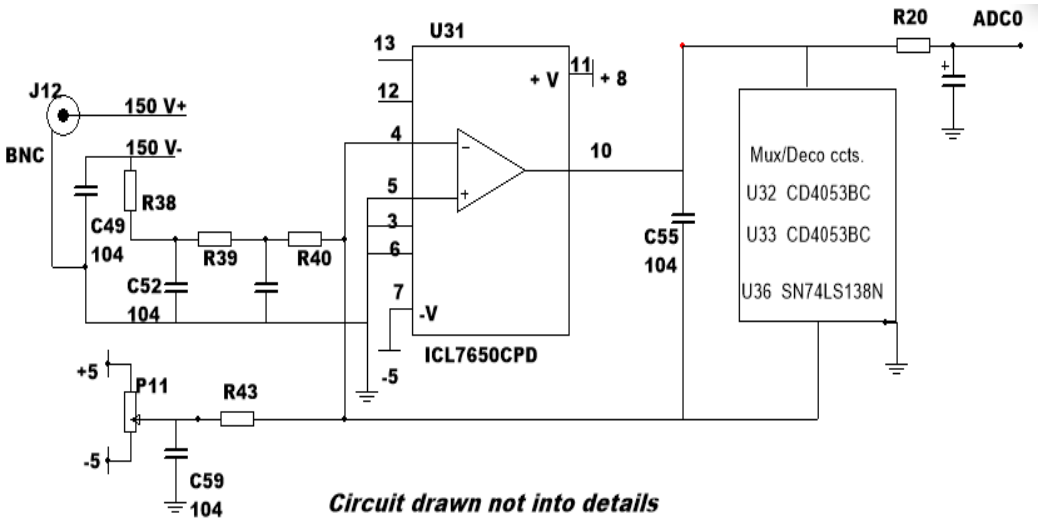


Table 4.0 Resistance Measurements of Key Components of the CEDM

	Yearly Resistance Measurement(Ω)		
Components for Inspection	2021	2022	2023
1.Motor coil	78.40	78.40	78.40
2.EMC	180.20	180.20	180.20
3.Potentiometer	353.0	353.0	353.0
4. Capacitor	infinity	infinity	Infinity
	Voltage measurement of CRDM (VDC)		
Voltage of EMC Terminal	2021	2021	2021
	24.20	24.20	24.20

Periodic Maintenance Activities :
Testing of Neutron Fux Circuit their parameters to the base values 2/8



Circuit drawn not into details

Circuit Test Current, I (µA)	Expected Out voltage at Pin 10 (IC, U31)	Expected Neutron Flux (Ø) [n/cm2.S]	Theoretical Thermal Power (P)
0.14	1.32	5.00 x 109	170.0 W
8.16	0.83	2.93 x 1011	10.0 kW
14	1.42	5.04 x 1011	17.0kW
27	2.74	9.72 x 1011	34.0 kW
35	3.55	1.26 x 1012	40.8 kW

$$\emptyset = \frac{I \times k}{10^{-12}} \quad (1) \qquad P = 3.4x\,10^{-8}\emptyset \quad (2)$$

Baseline Data for Neutron Flux Circuit Performance Test

Keithley Calibrator source. Instrument

- ***The use of Keithley Calibrator Source Instrument for the test is carried out annually,***
- ***While weekly test is done using a voltmeter to measure the output voltages at pin 10***
- ***for the respective neutron flux settings through raising of the control rod.***

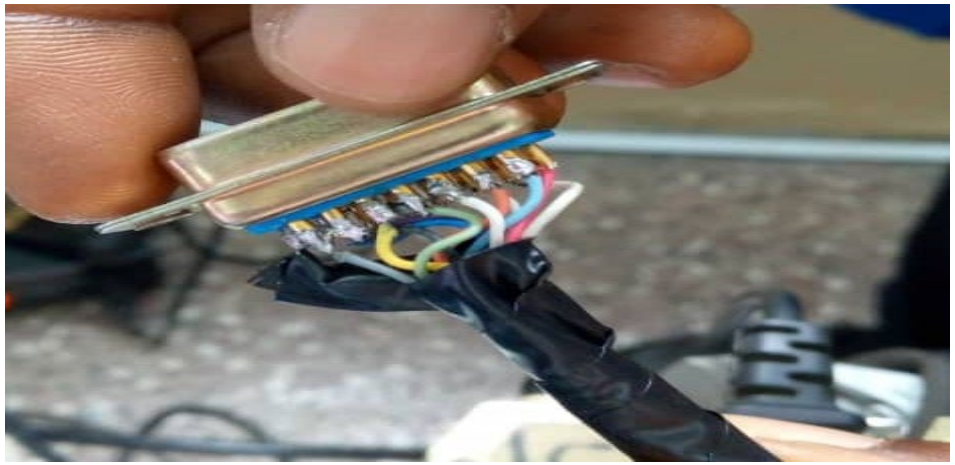
Periodic Maintenance Activities 3/8

Pumps terminal inspection and re-tightening

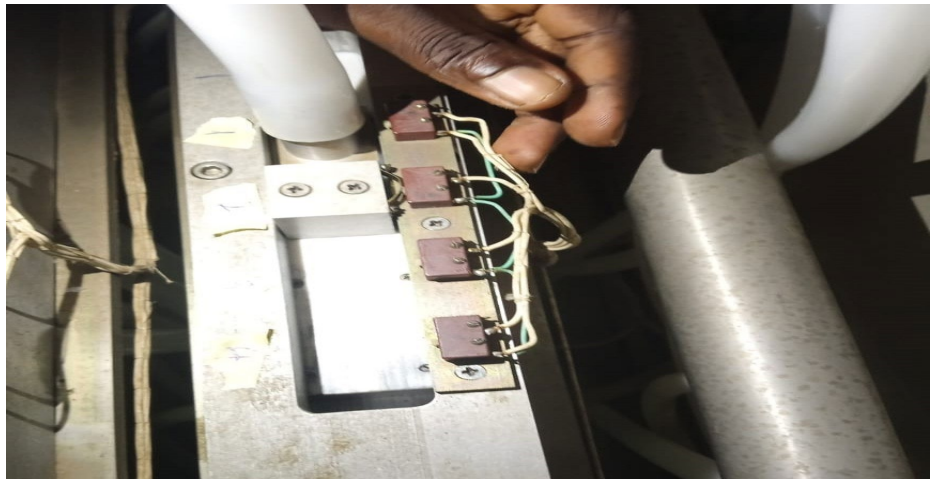
Replacement of sample transfer system tubes

Periodic Maintenance Activities :Inspection 4/8

An examination of SSCs for ageing degradation, to determine whether they are acceptable for continued safe operation or whether remedial measures should be taken (SSG-10)



Cable Inspection (MCCLS)



Cable Inspection in (PTS)

Periodic Maintenance Activities : Use of Check List 5/8

Checklist for Routine Maintenance

GHARR-1 MAINTENANCE CHECKLIST

The Periodic Maintenance Activities of GHARR-1 involve the following activities as checklist:

Activities	Abbreviation	Activities	Abbreviation
1. Lubrication	Lub.	10. Revision	Rvi
2. Oiling	Oil	11. Criticality	Crt.
3. Cleaning	Cln	12. Visual Inspection	V.insp
4. Test Run	Trn	13. Functional Test	Fnt
5. Calibration	Cal	14. A walk through	Wkt
6. Voltage Measurement	Vmt	15.Systerm Update	Sup
7. Resistance Measurement	Rmt	16.Elemental Analysis	EtA
8. Purification	Puf	17.Continuity Test	Cnt
9. Tightening	Tgt	18. Parameter Inspection	P.Insp.

Structure Systems &Components SSCs	Activities	Date	Periods								
			Wk1	Wk2	Wk3	Wk4	Wk5	Qtly	Mthly	Yrly	Remarks
1 Reactor Vessel	Vin									☑	
2 Control Rod	Vin									☑	
3 Drive Mechanism	Vin, Oil, Cln									☑	
4 Control Rod wire	Vin									☑	
5 Rod Guide Tube	Vin									☑	

Periodic Maintenance: Use of Check List 6/8

Structure Systems &Components SSCs	Activities	Date	Periods								
			Wk1	Wk2	Wk3	Wk4	Wk5	Qtly	Mthly	Yrly	Remarks
6 Radiation Tubes/ Channel	Vin									☑	
7 Vessel & Pool lining	Vin									☑	
8 Fuel Element	EtA NORM		☑								
9 Pool lining	Vin		☑							☑	
10 Coolant (Vessel)	Vin		☑								
11 Radiation Detectors	Vnt, Rmt, Cln									☑	
12 I & C System	Vnt, Rmt,Cln									☑	
13 Control Console	Vnt, Rmt, Cln									☑	
14 Computer System	Fnt		☑							☑	

Reactive Maintenance Activities: Work order Request form 7/8

GHANA REACTOER RESEARCH CENTRE
GHANA RESEARCH REACTOR -1
NATIONAL NUCLEAR RESEARCH INSTITUTE
GHANA ATOMIC ENERGY COMMISSION

GHARR-1 /WRF/……./20……..

WORK REQUEST FORM **PRIOR APPROVAL REQUIRED BEFORE ANY WORK IS INITIATED ON MNSR FACILITY**
A. WORK REQUEST (Initiator)
Requested by : *Date:*
Purpose of Request :
Names of Equipment parts to be worked on:
Job description:
B. WORK ALLOCATION (Facility Engineer)
Job assigned to:
Special instruction (if any):

Reactive Maintenance Activities : Work order Request form 8/8

C. RADIATION MONITORING(Radiation & Safety Officer, RSO)	
Radiation protection measures (if any):	
Date:	*signature:*
D. WORK APPROVAL (Reactor Manager)	
Additional instructions:	
Date:	*signature:*
E. WORK COMPLETION	
Description of work done and components replaced: *Time spent on the job:* *Remarks:*	*signature:*
F. WORK COMPLETION CERTIFICATION	
Facility Engineer : *date:*	*signature:*
Reactor Manager: *date:*	*signature:*

Some key Maintenance activities undertaken at GHARR-1 over the years

No.	Activity	Date
1	Snapped of the control rod wire (First major problem)	29th March, 1996
2	Breaking down of High Voltage Power Supply System of the gamma monitor located on the control console. New one was designed to replace the old one	10th May, 1997
3	Repair of control rod drive mechanism	11th February, 2001
4	Addition of Be shim plates (3mm thickness added)	26th February, 2002
5	Reactivity adjustment (Removal of one reactivity regulator)	27th July, 2005
6	Maintenance and repair of control rod drive mechanism	15th November, 2007
7	Addition of Be shim plates (3mm thickness added)	28th April, 2009
8	Installation of a new control rod drive mechanism	4th August, 2009
9	Installation of new HPGe detector (model: 6MX40P4)	5th July, 2010
10	Installation of large sample irradiation tube	3rd November, 2010
11	Installation of WINSPAN (NAA)	17th January, 2011
12	Addition of Be shim plate (3 mm thickness added)	26th January, 2011
13	Removal of large sample irradiation tube and shim tray for HEU with three 3 mm Be shim plates	28th August, 2016
14	HEU core removal	28th August, 2016
15	LEU core loading	12th July, 2017

Conclusion

- Implementing an Integrated Management System for the GHARR-1 Ageing Management Programme (AMP) has helped coordinate the activities of top management and maintenance personnel, ensuring the safe and reliable operation of the facility.
- The GHARR-1 maintenance, periodic testing, and inspection program is aimed at making the facility safely available for utilization.
- Through the successful implementation of the program, the Ageing Management objectives have been met so far.
- The maintenance, periodic testing, and inspection program is based on IAEA safety standards and guides

THANK YOU FOR YOUR ATTENTION