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Presentation on:

Dose Reduction and Management during Overhauling of Reactor Coolant Pump at CHASHMA NPP-1

Delivered by:
Makshoof A Mubbasher
Manager HPD C-1

Contents

1. Mission Statement

To generate electricity in a demonstrably safe, reliable and cost effective manner over the long term for the benefit of our society and stake holders as well as to consolidate the basis for development of the nuclear power industry in Pakistan.

2. Plant Specific Information

- Owner Pakistan Atomic Energy Commission (PAEC)
- Regulatory Regime of Pakistan Nuclear Regulatory Authority (PNRA)
- Supplier CZEC/China
- Designer SNERDI/China
- Rated Th. Power 998.6 MWth
- Gross Elec. Output 325 MWe
- 2 loop PWR light water reactor
- Fuel Assemblies -121, Enriched Uranium 3.4%.
- Construction started in 1992
- Project Completion in 2000.
- RCA is divided into 5 Radiation Zones based on dose rate.
- 1st Criticality (3rd May 2000)
- Commercial Operation since 15th Sep. 2000.
- Cumulative Availability Factor is 76.7%, and in Cycle-9, it is 96.13%
- Cumulative Capacity Factor is 73.51%, and in Cycle-9, it is 93.1%
- 08 Refueling Outages till date
- 239 days continuous operation in cycle-8

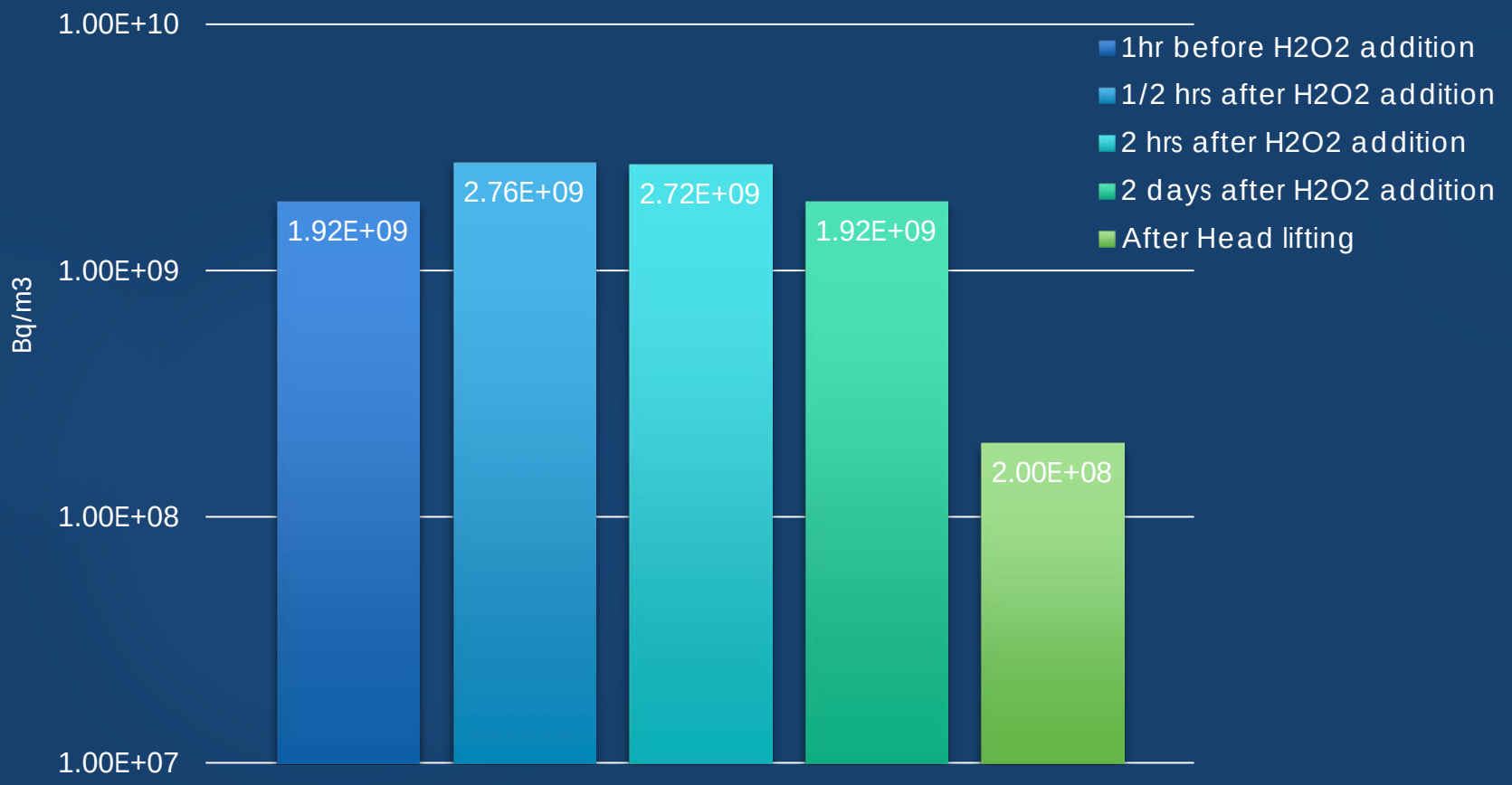
3. Dose Monitoring and Control in Plant Processes

- Design Provisions
  - Radiological status of the plant is monitored through Process, Area and Effluent Radiation Monitors , 30 APR, 63 AAR and 27 AER.
  - On-line monitoring of reactor coolant dose rate (APR-021& 421)
  - Purification system in downstream of Let-down HX

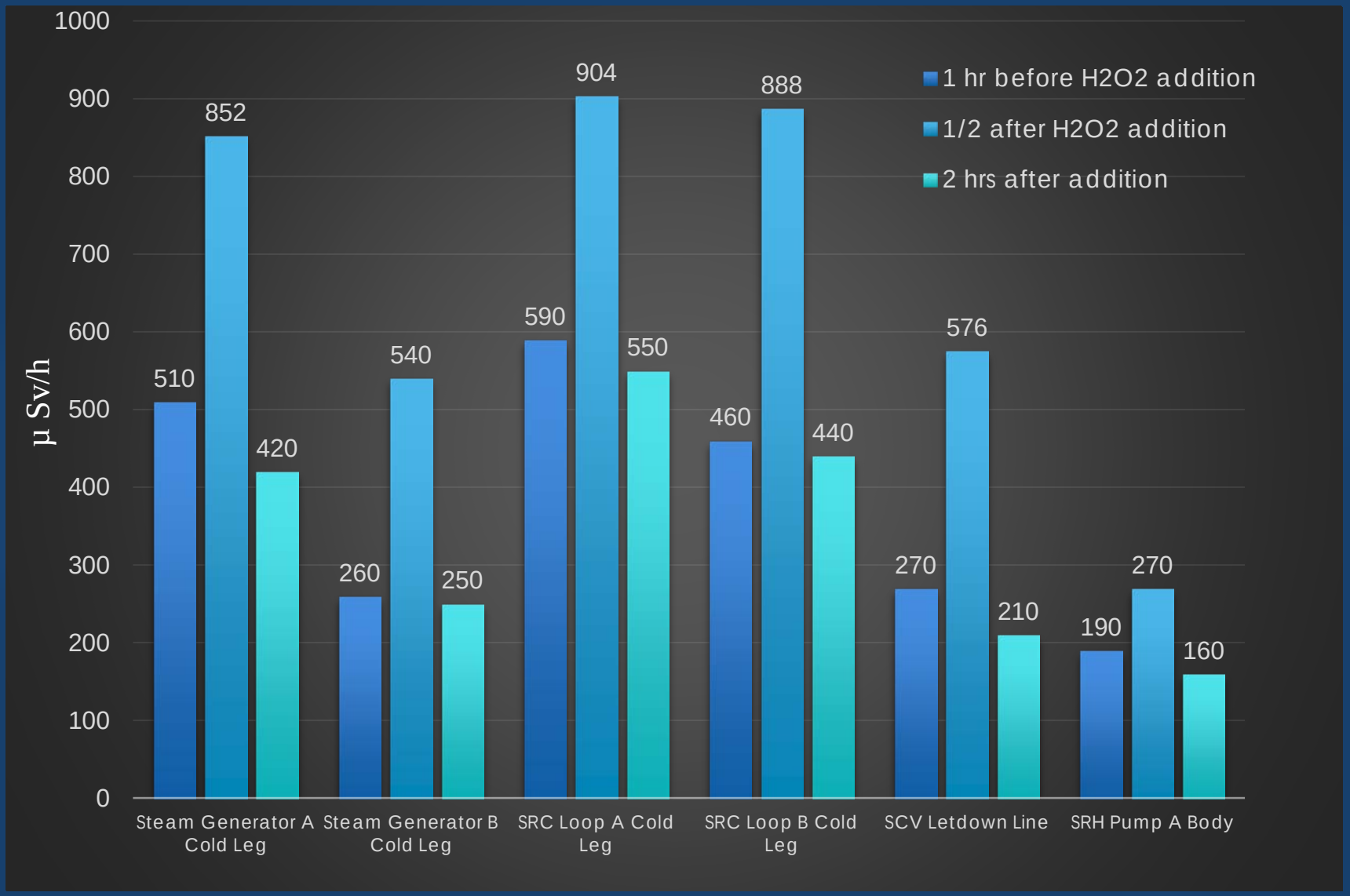
    Cat-ion/An-ion/Mixed-bed resin column
  - Filter in SCV at up/down stream of mixed bed.
- Routine Operation
  - Routine monitoring of reactor coolant activity
  - Compliance with Tech Spec on coolant activity
    - a) ≤ 1 µCi/g [Dose Equivalent I-131], and
    - b) ≤ 100/E µCi/g [Gross radioactivity].

- Gas stripping function
  - Radioactive Noble gases are removed during normal operation
  - Pressurizer & VCT
  - SGW for treatment
- Outage Preparation
- Oxidation Process
  - The process is considered as dose reduction technique.
  - The process involves removal of the magnetite layer (mostly Nix $Fe_3 O_4$) of corrosion products formed during power operation.
  - Hydrogen peroxide (H_2O_2) is injected in the primary system. The corrosion products get detached from the system.
  - The contaminants are removed through ion exchange column (mixed bed) and filter in SCV.
  - RPV Head is opened when radionuclide concentration in SRC meets a certain criteria:
    - Total γ <4E9 Bq/m3 and/or
    - Co-58 < 2E8 Bq/m3, Co-60 < 2E8 Bq/m3, I-131< 5E7 Bq/m3, Xe-133 < 1E8 Bq/m3

Behavior of Coolant Activity during oxidation Process



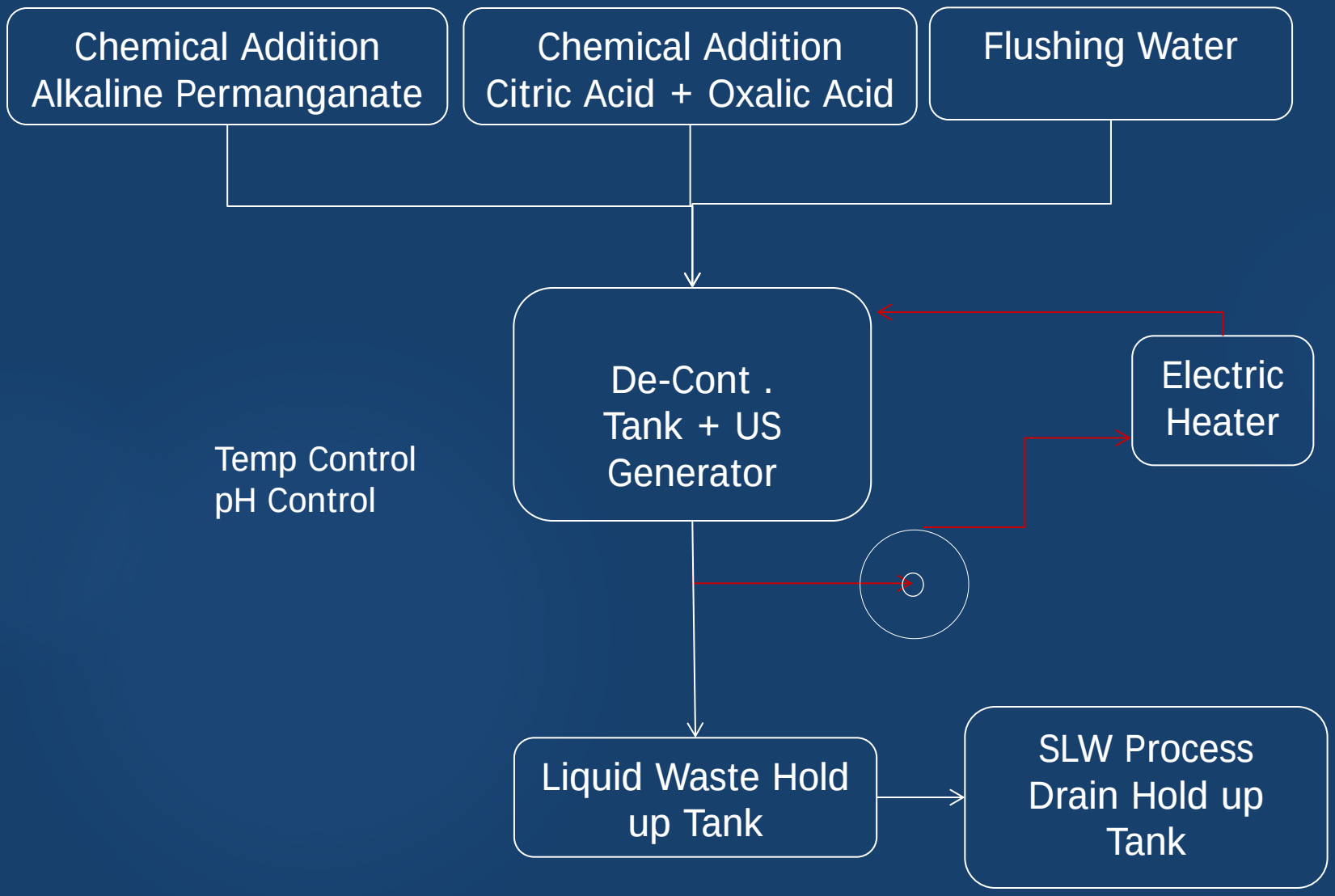
Dose Rate at Selected Points of Primary Loop



4. Dose Reduction during Overhauling of RCPs

- Chemical De-Contamination Facility
  - RCP decontamination
  - Sleeve / Impeller /studs De-Cont.
  - Long tools decontamination
  - The facility is equipped with followings:
    - Main tank equipped with ultrasonic generator device
    - Recirculation pump
    - Electrical heaters
    - Sampling system
    - Reagent preparation as subsystem
    - Liquid waste storage tanks
- It also provides space for overhaul of Pump & Motor

De-Cont. Scheme



De-Contamination Process [AP-CITROX]

AP-CITROX , a proven De-Cont. method was applied. Following were salient features of the process.

- work piece is kept at 90-95 °C in AP Solution [alkaline + $KMnO_4$] for a certain time, followed by rinsing with Demineralized Water (DMW).
- work piece is kept at 90-95 °C in CITROX Solution [Citric Acid + Oxalic Acid] + Corrosion inhibitor + EDTA for certain time, followed by rinsing with DMW.
- work piece is made passive by use of H_2O_2 at 60 °C in an acidic medium for certain time, followed by rinsing with DMW.

- Total Activity Leached out from RCP;
  - Total 158 GBq (~4 Ci) removed.
  - Nuclide leached out were mainly Mn-54, Cr-51, Co-58, Co-60, Zr-95, Nb-95, Sb-124, Mo-99, Fe-59 & Sn-113.
  - The isotopes having maximum activity were Co-60, Co-58 & Cr-51.
  - Dose rates at the surface of RCP for different selected points were < 1mSv/h (except hot spot).
- Liquid Waste Produced
    - Maximum liquid waste generated in De-Cont. process of RCP was 60 m^3.

5. Radiological Condition of RCPs

- Pre De-Cont. Survey data

Outage	RFO-6	RFO-7
RCPs	RCP-B	RCP-A
Survey Points	mSv/h	mSv/h
Pt.1	113	50
Pt.2	50	145
Pt.3	92	66
Pt.4	48	40
Pt.5	50	35
Pt.6	28	28

Post De-Cont. Survey data and Dose Reduction Factor (DRF)

Outage	RFO-6		RFO-7	
RCPs	RCP-B	DRF	RCP-A	DRF
Survey Points	mSv/h		mSv/h	
Pt.1	11	10.27	20	2.5
Pt.2	2.5	20	2.5	58
Pt.3	3	30.7	2	33
Pt.4	2	24	5	8
Pt.5	1	50	1	35
Pt.6	1	28	4	7
DRF Range		11~50		2.5~58
Ave. DRF		27		24

6. Dose Management during Overhauling

- ALARA procedure developed for overhauling;
  - Procedure developed jointly by Maintenance and RP, considering all important steps of overhauling, number of personnel involved and estimated time of each overhauling step.
- Maintenance, ISI and RP Teams Formation
  - 03 Maintenance teams each composed of 07 personnel were formed to perform overhauling tasks. 02 personnel supervised the job. Besides this, 01 ISI team composed of 05 personnel conducted inspection of various components of RCP.
  - 02 RP teams were formed each composed of 03 personnel to perform the survey, look after dosimetery requirement and personnel protection during the overhauling.

- On Hand Training
  - Organized by Maintenance Division and RP
  - Practice on various steps of overhauling
  - Use of protective
  - Use of shielding
  - Time management and control
- Use of removable shielding to reduce exposure
  - Portable lead plates (6mm)
  - Portable lead blanket (5mm)
  - Lead Gloves (3mm)
  - Lead Apron (3mm)
- Establishing collective dose(CD) targets

  Considering the job scope, personnel involved and expected time, collective dose were estimated. Following is the comparison of estimated & actual CD along with maximum personal dose.

OUTAGE	CD Target (man-mSv)	CD Actual (man-mSv)	Maxi. Individual Dose (mSv)
RFO-6	50	51	3.5
RFO-7	45	39.7	3.25

RCP Overhauling Steps

(work on shroud)

RCP Overhauling Steps

(work on Impeller)

7. Conclusion

- Dose Reduction Factor (DRF)

  AP-CITROX was successfully applied. Following were achieved:

  - Radioactivity removed =158 GBq (~4 Ci)
  - Average DRF achieved = 24
  - Maxi DRF =58

- Dose Management

  Target CD were carefully estimated. In case of RCP-B overhauling, the actual CD was in close agreement with the target CD while for RCP-A it was well below the target CD.

Thus principle of optimization of protection was successfully implemented. However, further improvement in reducing the worker doses can be made with application of technologically advance maintenance tools and improving the De-Cont. processes.

Questions

thanks & appreciations for patience and attention