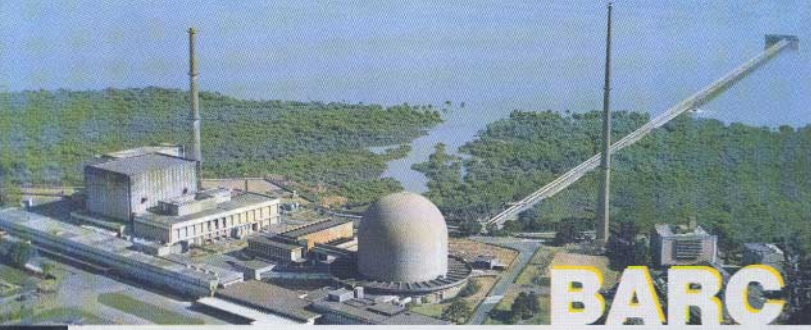

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# DILUTE CHEMICAL DECONTAMINATION OF CLEAN-UP SYSTEM OF UNIT - 2, TAPS : CHEMISTRY ASPECTS AND SALIENT FEATURES

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*Work on the dilute chemical decontamination of Clean-up System of Unit-2, TAPS, was taken up during August 1-17, 2000 using a AP-CEA formulation developed at the Applied Chemistry Division, BARC. A team from BARC (Applied Chemistry, Reactor Engineering Divisions and Water & Steam Chemistry Laboratory) and personnel from TAPS executed this task. This article deals with the chemistry aspects of this campaign and briefly highlights the results obtained.*

## Preamble

Thermodynamically, the structural materials employed in Water Cooled Nuclear Reactors are not immune to corrosion. A very good chemistry control of the various cooling water circuits is ensured to minimize the corrosion process. Since the steady state corrosion product release rate is less than its generation rate, over a period of time, the corrosion product film builds up as oxide on the surfaces of structural materials. This is especially true with respect to the materials in the high temperature (543 K) water circuits as they corrode at a higher rate at the operating temperatures of the primary coolant (543 K). The uniform corrosion rate itself is well taken in the design allowance from system integrity point of view. But the point of concern is that the corrosion products, released to the coolant in the primary system in minor amounts, get transported through the core where they undergo neutron activation,

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which is a phenomenon unique to the nuclear industry. This leads to the generation of Activated Corrosion Products (ACPs) containing nuclides such as $^{60}Co$, $^{54}Mn$, $^{51}Cr$, etc which have long half lives. When a re-deposition of these ACPs occurs on the out-of-core surfaces, it leads to a build-up of radiation field around the reactor primary circuit causing radiation exposure problems to the occupational personnel during the maintenance activities. In the case of the Tarapur BWRs, it is observed that $^{60}Co$ is the controlling radio-nuclide for this radiation exposure problem. Fission products (FPs) escaping from leaky fuel bundles (those with clad defect), if any, can also get sorbed onto the oxide film and thus can add to the radiation field buildup problem caused by ACPs.

In order to minimize the radiation exposure to occupational personnel in the nuclear power plant and achieve the objective of ALARA (as low as reasonably achievable), it is very essential to reduce the radiation field on the system surfaces. The removal of radioactivity from the reactor system is known as "decontamination" and various chemical, electrochemical and mechanical methods have been proposed for this purpose. Dilute Chemical Decontamination (DCD) is the most suited method for decontaminating the internals of piping, tube/shell type heat exchangers, pumps, valves, etc. of a reactor in service, since it ensures good base material compatibility while simultaneously yielding acceptable decontamination factors (DF) (DF = Initial radioactivity or radiation field before decontamination / Final radioactivity or radiation field after decontamination ).[1]

The choice of a particular decontamination formulation depends on the type of oxide encountered on a particular structural surface. Thus, the requirement for a formulation in the case of reactors such as the TAPS boiling water reactors (BWRs) employing stainless steel as the major structural material and oxidizing water chemistry [dissolved oxygen (DO) in primary coolant ≈ 150-200 ppb] in their primary system is different from the one suited for pressurized heavy water reactors (PHWRs) which employ carbon steel, monel-400 / incoloy-800 as major structural materials and practise a reducing water chemistry regime [DO ≤10 ppb]. BWRs employing AISI-304/304L and 316 LN as major materials of construction in their primary system develop, under the operating temperature (543 K) and chemistry conditions of the primary coolant, an oxide layer which is really a mixture of oxides of the cubic type such as $FeCr_2O_4$, $Fe_{3-x-y}Cr_xNi_yO_4$ (0.1 <x or y < 1.0), $Fe_3O_4$ and the hexagonal type such as $Cr_2O_3$ and $Fe_2O_3$.[2] The Cr rich layers, viz., $Cr_2O_3$ and the iron chromite, form the thin inner layer and the Fe rich layer forms the thicker outer layer.

Various formulations such as CITROX (Citric acid + Oxalic acid), $V^{2+}$ based LOMI (low-oxidation metal ion), CORD ($HMnO_4$ + Oxalic acid), etc., have been used for stainless steel surfaces both under reducing and oxidizing water chemistry regimes with and without an oxidative pre-treatment step.[1] A two stage formulation based on oxide pre-treatment with alkaline potassium permanganate (AP) followed by a reductive dissolution step involving Citric acid (C) - Ethylene diamine tetra acetic acid (E) - Ascorbic acid (A) (CEA) was earlier developed in Applied Chemistry Division, BARC, after a detailed experimentation with representative coupons and pipe surfaces prepared from the piping component removed during the regenerative heat exchanger replacement work (after 21 years of its service) carried out in the Clean-up System of Unit-1 of TAPS.[3,4] The base metal compatibility of this formulation was investigated in detail and the CEA formulation was qualified.[5] The achievability of dissolved oxygen (< 100 ppb) and temperature of about 363 K required for decontamination in the C/U System was separately established during Phase-1 of this project.[6]

Using the AP-CEA formulation in three cycles, the actual decontamination of the Clean-up System of Unit-2 was successfully carried out during the Unit's 16th refuelling outage in August 2000. This article

describes the results of this campaign in addition to the chemistry of the decontamination process. To the best of our knowledge, the CEA process is being tried out for the first time to decontaminate the SS surfaces of a BWR.

## Chemistry of the Decontamination Process

Chemical decontamination of the primary system of nuclear power plants essentially involves the chemical dissolution of iron oxides such as $Fe_3O_4$, Ni,Cr substituted $Fe_3O_4$, $Fe_2O_3$, etc. When the bulk oxide (inactive) is solubilized, the ACPs, which are present in small amounts in the bulk oxide matrix also, go into solution. This is true of FPs which can also be present in the oxide in extremely small chemical amounts. The literature information reveals that in BWR around 85% of radioactivity is present in the outer layer and as such the dissolution of ferrite type outer layers can contribute to a significant level of decontamination.[2] The chemistry of dissolution of iron oxides such as hematite has been investigated in detail in ApCD.[7-9] Supplementing the results of these investigations with the already reported dissolution data on spinel / inverse spinel oxides, it is observed that, to achieve a fast kinetics of dissolution, it is important to provide enough acidity (pH), adequate complexing capability, low dissolved oxygen, a reducing agent in the initial stages of dissolution and a temperature ≥ 363 K. If any one of the above chemical parameters is not adequately met, then the rate of oxide dissolution or the net amount of dissolution in a certain time period sharply goes down. The dissolution in the case of haematite and magnetite lattices can be represented by the following equations 1 (1a+1b) and 2 (2a+2b) respectively:

$$Fe_3O_4 + RH_2 + 4H^+ \rightarrow 2Fe^{2+} + 3H_2O + R \quad .....(1a)$$

$$2Fe^{2+} + 2[H_2Y]^{2-} \rightarrow 2[Fe^{2+}Y]^{2-} + 4H^+ \quad ..... (1b)$$

$$Fe_3O_4 + RH_2 + 2[H_2Y]^{2-} \rightarrow 2[Fe^{2+}Y]^{2-} + 3H_2O + R \quad .....1 \text{ (i.e.,1a + 1b)}$$

where $H_2Y^{2-}$ represents the complexing anion of EDTA, $RH_2$ denotes the externally added reducing agent in the protonated form such as ascorbic acid, and $H^+$ denotes the acidity from the added citric acid.

$$Fe_3O_4 + RH_2 + 6H^+ \rightarrow 3Fe^{2+} + 4H_2O + R \quad .....(2a)$$

$$3Fe^{2+} + 3[H_2Y]^{2-} \rightarrow 3[Fe^{2+}Y]^{2-} + 6H^+ \quad .....(2b)$$

$$Fe_3O_4 + RH_2 + 3[H_2Y]^{2-} \rightarrow 3[Fe^{2+}Y]^{2-} + 4H_2O + R \quad ..... 2 \text{ (i.e., 2a + 2b)}$$

When the $[Fe^{2+}Y]^{2-}$ acts as an internally generated reducing agent as shown below (chemical eqn.1c), then the externally added reducing agent $RH_2$ remains unutilized:

$$Fe_3O_4 + 3[H_2Y]^{2-} + 2H^+ \rightarrow 2[Fe^{3+}Y] + [Fe^{2+}Y]^{2-} + 4H_2O \quad ..... (3)$$

Thus at the end of dissolution of $Fe_3O_4$, we have $[Fe^{3+}Y]^-$ and $[Fe^{2+}Y]^{2-}$ in solution nearly in 2:1 mole ratio which is the ratio in which $Fe^{3+}$ and $Fe^{2+}$ are present in the original magnetite lattice. In the case of dissolution of $Fe_2O_3$, nearly all the dissolved iron is present in solution as $[Fe^{3+}Y]$. The above reactions constitute the mechanism of reductive dissolution using a reductive-complexing formulation. The aim of the experiments carried out with the representative surfaces removed from the system was to ascertain the kinetics of these reactions though thermodynamically they are known to be favourable.

Once the oxide dissolution has proceeded to a significant extent, the formulation can attack the base metal (eqn.4) through the pores in the oxide:

$$Fe \rightarrow Fe^{2+} + 2e^- \quad ....(4)$$

This reaction cannot occur at a considerable rate especially when the reducing agent employed in the formulation is able to suppress the corrosion potential of the material or the base metal intrinsically has a very low uniform corrosion rate (like in the case of stainless steel). Though the CEA formulation does not lower the corrosion potential of austenitic stainless steel as compared to that

observed in a simple acidic solution without the reducing agent, yet in dilute concentrations of the formulation, it yielded a low corrosion rate of the order of $10^{-3}$ μm / h [10]. Further, the CEA formulation did not lead to any localised attack such as the intergrannular attack[5].

Our studies on hematite powder dissolution in the presence of various alloys in CEA medium have shown that in a stainless steel system, when the base metal corrosion is low, base metal assisted dissolution (i.e., base metal taking the role of a reducing agent through the reaction (4) and providing the electrons necessary for the reduction of $Fe^{3+}$ in lattice positions to $Fe^{2+}$ or the $Fe^{3+}$-EDTA in solution to $Fe^{2+}$-EDTA) could be negligible [11]. Hence, at the end of dissolution most of the dissolved iron from hematite existed as $Fe^{3+}$-EDTA. Since $Fe^{3+}$-EDTA does not dissociate on the cation exchanger, regeneration of EDTA by providing a cation exchange column in circuit is not possible. Hence, a multicycle process with dilute concentration of chemical was adopted.

In a stainless steel system such as the primary system of TAPS BWR, the corrosion product oxide is expected to contain low amounts of Cr. However, our experiments with representative surfaces from the system had shown a high amount of Cr in the oxide. Directly treating the oxide bearing surface with a reductive complexing formulation, without employing an oxidative pre-treatment step to selectively solubilize and remove this high amount Cr, did not result any significant oxide dissolution. When the specimens were given a oxidative pre-treatment using an alkaline permanganate (AP) solution, appreciable amounts of Cr could be detected in the spent AP solution due to the following reaction:

$$Cr_2O_3 + 2KMnO_4 + 2KOH \rightarrow 2K_2CrO_4 + 2MnO_2 + H_2O \quad \ldots\ldots (5)$$

Subsequent application of the reductive-complexing formulation resulted in significant oxide dissolution and high decontamination factors could be achieved.[3,4] Our studies also showed that while 75% of the radioactivity removal occurred if the temperature of the formulation was kept at 343 K, the radioactivity removal could be 95% when the temperature was increased to 363 K.[3] Based on these observations, a three cycle AP-CEA process was decided to be implemented in the C/U System of Unit-2 of TAPS.

## Chemical Process Executed at TAPS

1) Oxidative pre-treatment of the oxide surface using 0.3% $KMnO_4$ solution in NaOH medium (0.5% - 1.5%) in the temperature range of 343 – 360 K.
2) Draining the system through extensive fill and flush method until residual Mn level in wash solution was < 15 ppm.
3) A wash step using 0.4 - 0.5% citric acid solution at 333 - 338 K to remove any $MnO_2$ deposited on the oxide surface during the pre-treatment step and to bring the pH to about 3.2-3.3.
4) At the end of the wash step as determined by unchanging Mn levels and pH in wash solution, the citric acid solution circulating in the wash step was deoxygenated by adding a 1%(w / v) hydrazine ($N_2H_4$) in the required amounts.
5) Once dissolved oxygen level was brought to < 100 ppb in the citric acid wash solution, EDTA as its disodium salt (to a system concentration of ≈ 0.17%) and ascorbic acid (to a system concentration of ≈0.08% ) were injected into the wash solution to constitute the final dissolution formulation. With the system constraints, treatment with the CEA formulation could be carried out only in the temperature range 347–358K though the desired temperature was ≥ 363 K.
6) Three cycles of the above-enumerated steps 1-5 were employed.

In Fig.1, the C/U System is indicated between the dashed horizontal lines. The main C/U pumps, the surge tank and the C/U demineralizer were by-

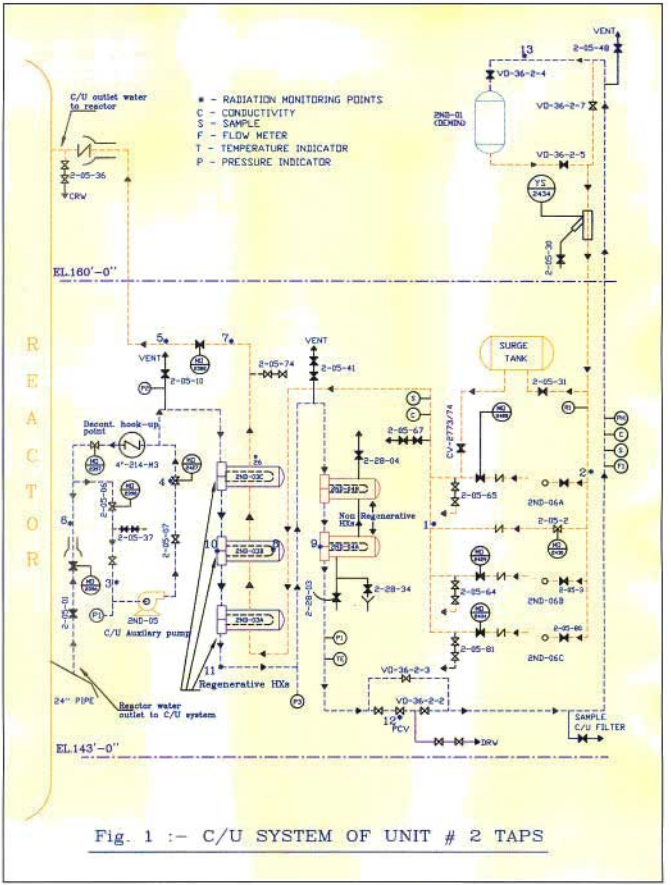


Fig. 1 :– C/U SYSTEM OF UNIT # 2 TAPS

*Fig.1 C/U System of Unit-2, TAPS*

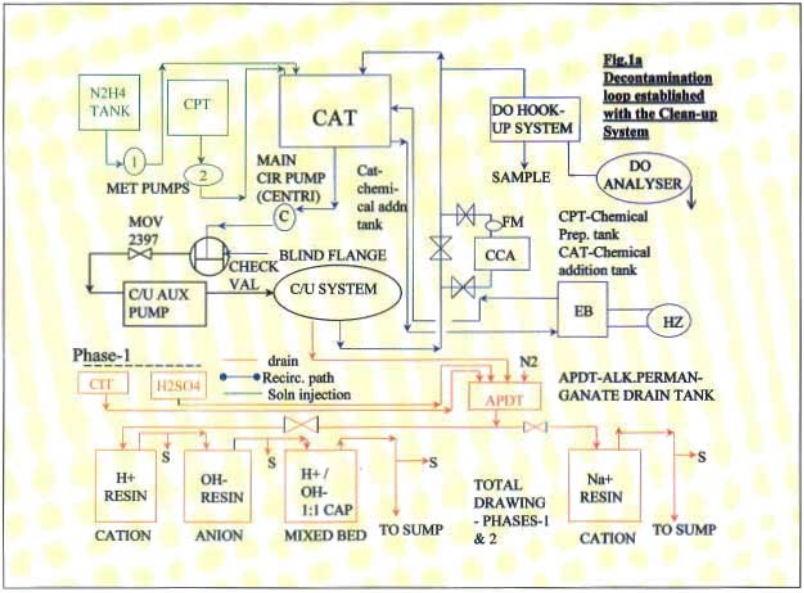


*Fig 1a Decontamination loop established with the Clean-up system*

passed and the remaining part of the system was taken up for the chemical decontamination. Connecting the Chemical Addition Tank (CAT), Corrosion Coupon Autoclave (CCA), External Circulation Pump (500 lpm) and Sampling Station for on-line dissolved oxygen (DO) measurements to the C/U System established the decontamination loop (Fig.1a). An Electrode Boiler (EB) delivering 200 kg/h steam at a maximum pressure of 10 kg/cm$^2$ to the semicircular metal coil wound on the outside surface of the CAT and the pump heat from the circulation pump served the purpose of ultimate heat source for decontamination. A Chemical Preparation Tank (CPT) and a Hydrazine Tank were connected to the CAT through separating metering pumps for feeding the chemical solutions to CAT. Figs.2&3 show a view of the CAT with the EB and CPT respectively. Fig.4 shows a view of the on-line DO measurement facility and the sampling station.

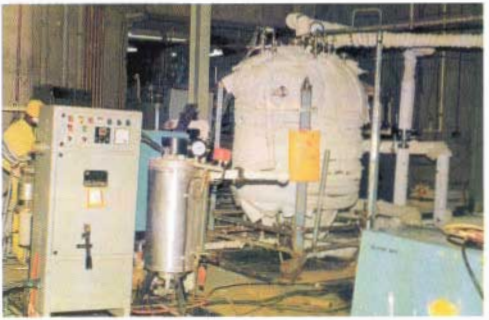

*Fig.2 Chemical Addition Tank (CAT) with Electrode Boiler (EB) in front*

*Fig.3 Chemical Preparation Tank (CPT) with the metering pump in front*

*Fig.4 Sampling Station and On-line Dissolved Oxygen measurement facility*

The spent AP solution from each cycle was drained from the system by the fill and flush method into a 10 $m^3$ AP Drain Tank (APDT), was neutralized in the tank by careful addition of appropriate volumes of concentrated $H_2SO_4$, then the permanganate was reduced with citric acid and the resulting $Mn^{2+}$ was sorbed in the $Na^+$ form of cation exchange column.

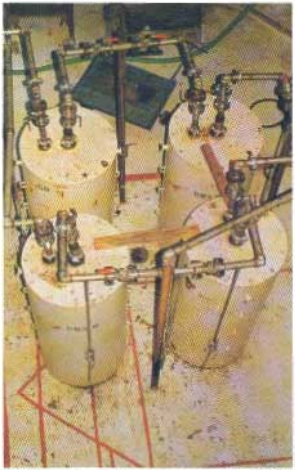

*Fig.5 Ion-exchange columns inside lead casks for treatment of spent decontamination solution*

The spent CEA formulation which nearly completely solubilized the corrosion products was drained through APDT into a battery of cation, anion and mixed bed columns. Fig.5 shows a view of the lead casked ion-exchange columns meant for the treatment of the spent decontamination solution while Fig.6a&b show respectively the lowering of one of these lead shielded spent columns and loading it onto the trailer for transportation to the waste burial site for lowering in the tile hole. The following section gives the important results of this campaign. A separate detailed report is being prepared giving many details of various chemistry parameters and radiochemical analysis results apart from the results mentioned in the next section.

*Fig.6a*

*Fig.6b*

*Fig.6a&b Spent ion-exchange column being lowered and loaded onto a trailer to be taken for lowering in the tile hole in the Waste Disposal Facility*

Table-1

**The amount of radioactivity and metals removed from oxide dissolution during decontamination of C/U System of Unit-2 of TAPS**

| Description of Chemical Step / Reaction conditions | Total Radioactivity removed in each step(Ci) / (% contribution from the main isotopes) | Metals removed (g) |
|---|---|---|
| **FIRST CYCLE** | | |
| AP Step (70 – 75 °C), 4 h | 3.103 (98% $^{51}$Cr) | 1237 (Cr), 3.4 (Fe), 0.2 (Ni), 2 (Zn) |
| Citric Acid Wash Step (75 - 81°C), 2 h | 1.808 (96% $^{60}$Co, 4% $^{58}$Co) | 500 (Fe) |
| CEA Step (74 – 82°C), 4 h | 1.47 (92% $^{60}$Co, 8% from $^{58}$Co, $^{137}$Cs etc.) | 1255 (Fe), 24 (Ni), 9.05 (Cr), 5 (Zn) |
| **SECOND CYCLE** | | |
| AP Step (74 – 84 °C), 6 h | 0.527 (96 % $^{51}$Cr) | 1590 (Cr), 5 (Zn) |
| Citric Acid Wash Step (70 – 80°C) 2 h | 3.358 (96% $^{60}$Co, 4% from $^{137}$Cs, $^{58}$Co etc.) | 530 (Fe) |
| CEA Step (83 – 85°C), 4.6 h | 0.587 (96% $^{60}$Co, 4% from $^{137}$Cs, $^{58}$ Co etc.) | 825 (Fe), 35 (Ni), 66.6 (Cr), 10(Zn) |
| **THIRD CYCLE** | | |
| AP Step (82 - 87°C), 5 h | 0.024 ( 64% $^{51}$Cr i.e., 0.015 Ci and the rest 0.009 Ci mainly due to $^{60}$Co, $^{137}$Cs) | 371 (Cr), 1.3 (Zn) |
| Citric Acid Wash Step (79 - 83°C), 1 h | 1.37 (96% $^{60}$Co, 4% from $^{137}$Cs, $^{58}$ Co etc.) | 1025 (Fe), 17.6 (Ni), 4 (Cr), 5 (Zn) |
| CEA Step (80-82°C), 5 h | Nil | 1892 (Fe), 18.6 (Ni), 23 (Cr), 1.3 (Zn) |
| **Total** | **3.65 Ci (3.56 Ci from $^{51}$Cr) (in 3 AP steps), 8.59 Ci ( 8.19 Ci from $^{60}$Co) in 3 CA+CEA steps) Total Curies removed - 12.25** | **3198 g Cr, 3.4 g (Fe), 0.2 g (Ni), 8.3 g (Zn) (in 3 AP steps), and 5997 g Fe + 95.2 g Ni + 102.6 g Cr, + 21.3 g Zn in 3 CA + CEA steps Total metal removed – 9426 g** |

## Results

Table-1 shows the amount of radioactivity removed and also the amounts of metals removed during the different stages of three cycles of decontamination. As shown in these data, a removal of a total 12.25 Ci comprising of 3.65 Ci (3.56 Ci from $^{51}$Cr) removed by the three AP steps and 8.59 Ci (8.19 from $^{60}$Co) removed by the three CA wash + CEA steps could be achieved in the decontamination campaign. The AP oxidative pre-treatment step, as envisaged in the feasibility report, has proved to be very effective in removing Cr from the oxide layers. The third AP step has resulted in much less Cr removal than the first two steps showing a possibility that the inner layer contained very little Cr

than the outer layers. Similarly, $^{51}Cr$ observed in AP solution after the first AP step was 6 times more than that observed in the second AP step which in turn was > 10 times the $^{51}Cr$ removed in the third AP step. This showed that, like the chemical Cr, the radioactive $^{51}Cr$ could be concentrated in the outer oxide layers and negligible amount of $^{51}Cr$ could be present in the inner layer. Hence, the source of chemical Cr is surmised to be from the coolant water side and not from the base metal (stainless steel) side. The presence of high amounts of $^{51}Cr$ was not envisaged in the feasibility report. However, this chromium radioactivity problem was tackled in the plant radwaste facility, under suggestions and experimental verifications by ApCD and station chemical laboratory, by reducing the $CrO_4^{2-}$ to $Cr^{3+}$ by ferrous sulphate addition and increasing the pH to about 10 - 11 to co-precipitate Cr as Chromium hydroxide along with Iron hydroxide.

The third CEA cycle did not bring out any $^{60}Co$ radioactivity in spite of a significant amount of iron solubilized by the formulation. This suggested that the innermost layers did not possibly have any $^{60}Co$. Almost the entire $^{60}Co$ removed during this decontamination is removed in the first two AP-CEA cycles itself. These observations are in line with what is reported in literature that 90% of the activity in BWR oxides is concentrated in the outer and outermost layers. [2]

Fig.7 shows the data on radiation field measurements (DF) taken at thirteen selected locations (indicated in Fig.1) in the C/U System before and after decontamination. While teletector contact readings were taken at the marked points in all the locations, seven locations had fixed on-line radiation monitors facing these locations at a close proximity. However, these radiation detectors had no special lead shielded collimators and as such these measurements were done at the points selected in a general radiation background area. Among the thirteen locations chosen, five locations were deliberately chosen in the flow starved regions to observe the extent to which the formulation could

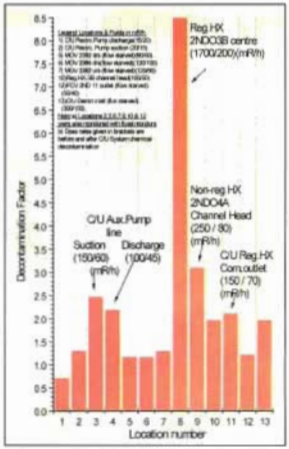


*Fig.7 Radiation fields obtained at selected locations before and after C/U system chemical decontamination in Unit-2, TAPS.*

work in these locations. Decontamination factors (DFs) ranging from 1.2 to 8.50 were obtained in twelve out of the thirteen locations. The central zone of the regenerative heat exchanger (2NDO 3B), where the highest dose of 1700 mR/h (17 mSv/h) was observed initially, has shown a DF of 8.5 after decontamination. Additionally, telemonitor readings were taken after the decontamination in the central zones of the remaining two regenerative heat exchangers and the two non-regenerative heat exchangers and compared with the dose rate values recorded in these locations sometime before decontamination. This was done to ensure whether the high DF of 8.5 obtained in the central zone of regenerative heat exchanger 2NDO 3B was representing the real reduction of dose rate on the heat exchangers. Fig.8 shows the DFs obtained in the central zones of the remaining two regenerative heat exchangers (2NDO 3A and 2NDO 3C marked

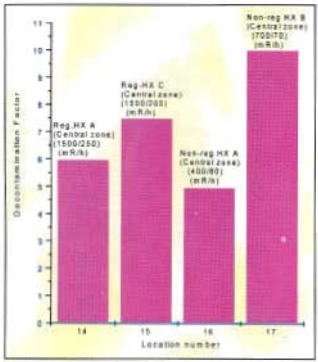


*Fig. 8 Additional locations monitored for radiation fields before and after C/U system chemical decontamination in Unit-2, TAPS*

as points 14 & 15 in Fig.1) and in the central zones of the two non-regenerative heat exchangers (2NDO 4A and 2NDO 4B marked as points 16 & 17 in Fig.1). A DF of 5-10 has been observed in these locations. The heat exchangers contribute significantly to the total surface area of the C/U System and the initial (before decontamination) high dose rate at its centre is also a cause for the general background radiation level observed in the heat exchanger room. A radioactivity removal to the extent of > 85% from this location signifies the effectiveness of the formulation employed. There was a significant (> a factor of 2) reduction in the area background in the HX room. The five flow starved locations (5, 6, 7, 12 and 13) have shown lower DFs in the range 1.2 – 2.0. These dead end locations could not have seen proper concentrations of the chemicals and the flows and as expected have also shown lower DFs. The dose at two locations (locations 1 & 2), where the initial fields were already low (< 20 mR / h), have practically not shown any change due to decontamination. The system was given an extensive flushing at high flows (900 lpm) after disconnecting it from the decontamination loop and connecting to the main system. Water Chemistry was made normal before the system was valved-in with the reactor. This high flow flushing operation has resulted in the removal of residual oxide (crud) loosened by the chemicals but still remained undissolved and accounted in real term for an additional 10% activity removal over what was achieved with the chemicals. Elsewhere after a chemical decontamination, system pipes are subjected to an ultrasonic wave treatment to suspend any loosened undissolved deposit still sticking to the pipes and this process is known to improve the DFs. In the present case, extensive flushing at high flows has helped in a similar manner.

The radioactive waste volumes generated in the process were along the expected lines envisaged in the feasibility report. The $^{51}Cr$ activity which did not contribute much to dose but contributed significantly to processed radwaste discharges was managed by the co-precipitation route devised during the course of decontamination. The minor leakages in certain parts of the system and mechanical seal of the recirculation pump resulted in some $^{60}Co$ finding way into the sump but this was ultimately handled through the ion-exchange columns designed for spent decontamination solution processing, followed by plant radwaste treatment facility.

Sensitized stainless steel coupon specimens exposed in the Corrosion Coupon Autoclave to the three cycle AP-CEA formulation did not show any susceptibility to intergranular attack while uniform corrosion was found to be negligible. Visual observation of the internals of a flow-control valve carried out after the chemical decontamination revealed a shining surface without any deposit or colouration.

## Conclusions

1) The AP-CEA process developed for the decontamination of stainless steel surfaces of TAPS system has proven to be successful.

2) DFs ranging from 1.2 to 10 depending on location have been obtained. Both the regenerative and non-regenerative heat exchangers have shown high DFs.

3) A total of 3.65 Ci from the three AP steps (of which 3.56 Ci is $^{51}Cr$) and 8.59 Ci from the three CA wash + CEA steps ( of which 8.19 Ci is $^{60}Co$) has been removed.

4) The AP step effectively removed chromium along the expected lines. This also included $^{51}Cr$ radioactivity in significant amounts.

5) A methodology to handle such $^{51}Cr$ radioactivity has been established.

6) The data of third cycle of the AP-CEA process suggest that there is a quantitative removal of $^{60}Co$ from the system. This is also true for both chemical Cr and $^{51}Cr$.

7) The good compatibility of the formulation to the base metal (SS) observed in laboratory experients was experienced in the actual decontamination.

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## BRNS - IANCAS NATIONAL WORKSHOP

The Indian Association of Nuclear Chemists and Allied Scientists, popularly known as IANCAS, has been conducting three or four National Workshops every year on "Radiochemistry and Application of Radioisotopes" at different Universities and National Institutes in India, mainly for the benefit of the university teachers.

It conducted a ten-day Workshop at St.Joseph's College for Post-Graduate Studies, Tiruchirapalli, Tamil Nadu, during March 29 – April 7, 2001.


*Inauguration of the 44th BRNS-INCAS National Workshop on "Radiochemistry and Application of Radioisotopes" at St. Joseph's College, Tiruchirappalli, by Dr S.B. Manohar, President, IANCAS and Head, Radiochemistry Divison, BARC, on March 29, 2001. (Seated on the dais from left to right are Rev. Dr Joseph Srinivasan, Secretary of the College, Fr. A. Joseph, College Rector, Rev. Dr S. John Britto, College Principal, Dr S.B. Manohar, President, IANCAS, Dr V. Venugopal, Vice-President, IANCAS, Dr G.K. Gubbi and Dr G.R. Rethan, BRNS*

The Workshop was inaugurated by Dr.S.B.Manohar, President, IANCAS. He highlighted the role of Atomic Energy in India and applications of radioisotopes in industry, agriculture and healthcare. Dr.A.J.Tamhankar of Nuclear Agriculture & Biotechnology Division (NA&BTD), BARC, gave a special lecture on "Applications of Radioisotopes in Agriculture." Following the coverage of the Workshop in the local newspapers, the Trichy unit of the Confederation of Indian Industries (CII) requested IANCAS for a special lecture on "Food Irradiation." Hence, a lecture on "Food Irradiation" by Dr.D.R.Bongirwar, Head, Food Technology Division, BARC, was arranged at the CII meet for a group of 40 industrialists. Dr.V.Venugopal, Head, Fuel Chemistry Division, BARC, gave a lecture on "Nuclear Reactors" and Dr.P.R.Vasudeva Rao, Associate Director, Chemistry Group, IGCAR, delivered a lecture on "Actinides." Dr.G.K.Gubbi of Radiochemistry Division, BARC, was the coordinator on behalf of the IANCAS.

*During experimental work at the Workshop, Mr. S. Venkateswaran, RCD, BARC and resource person of IANCAS, interacting with the participants of the Workshop*

Seven simple experiments were conducted using low level radiotracers. An experiment on the natural environmental activity was demonstrated by sampling the atmospheric air and counting the activity.

IANCAS also conducted National Workshops at M.S.University, Baroda, Birla Institute of Technology & Science (BITS), Pilani, Kishinchand Chellaram College, Mumbai and Ramnarain Ruia College, Mumbai, during 2000.

## BARC OBSERVES FIRE SERVICE WEEK

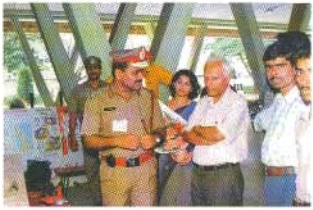
On the fourteenth day of April 1944, an explosion ripped through a ship docked at Mumbai Port Trust resulting in a huge fire. Fire service personnel displayed exceptional courage and exemplary devotion to duty as they fought the leaping flames.

Many firemen succumbed to burn injuries. From 1952, April 14 is observed every year as the National Fire Service Day as a mark of respect to those brave men.

*Mr A.K. Tandle, Chief Fire Officer, BARC, receiving contribution from Mr B. Bhattacharjee, Director, BARC, after he inaugurated the fund raising campaign*

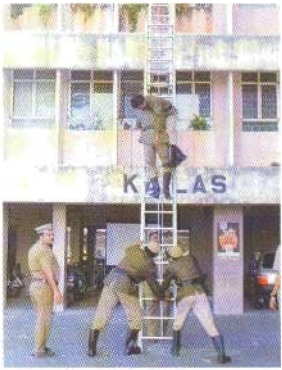
The Fire Service Week in BARC began this year on April 14, with Mr A.K. Tandle, Chief Fire Officer, placing wreaths on behalf of BARC at the memorials erected on the grounds of Mumbai Port Trust and Mumbai Fire Brigade Headquarters. In continued efforts to increase awareness on fire safety, the Fire Services Section, BARC, organized, with the active participataion of Mumbai Fire Bridgade, a Demo-cum-Exhibition near Kailash building, Anushakti-nagar. About 800 residents watched with amazement as the firemen demonstrated their skills in rescue and fire fighting operations with advance fire fighting units including the Jumbo Tanker, Simon Snorked Jumbo and Mini Rescue Ladder.

The Annual Fire Service Pin Flag fund-raising campaign was inaugurated with pin flags being offered to Mr B. Bhattacharjee, Director, BARC, and other invitees. In his message, Mr B. Bhattacharjee lauded the commendable job that Fire Services Section, BARC, had done so far, but, in a loud and clear message, cautioned them not to be complacent and instead continue to aim for higher fire safety goals adopting latest technology developments. He wished them all success in their endeavours.



*Mr A.K. Tandle, Chief Fire Officer, BARC, explaining the exhibits on Fire Safety to Mr D.S.C. Purushotham, Director, Nuclear Fuels Group, BARC and Chairman, CFSRC*

Posters and banners were displayed at a number of locations in the campus of BARC. An exhibition in Modular Laboratories, BARC, was arranged and Mr D.S.C. Purushotham, Director, Nuclear Fuels Group and Chairman, CFSRC, paid a visit to it.




*Rescue demonstration conducted by the staff members of Fire Services Section, BARC, at Kailas building, Anushaktinagar*

The week culminated with a ceremonial parade at Cross Maidan in which an impressive contingent of BARC's Fire Services Section personnel and equipment participated.

# MEETING ON INTERNAL RADIATION DOSE MANAGEMENT

An International Satellite Meeting on Internal Radiation Dose Management was held at Jaipur University during February 26-27, 2001 and was organised jointly by Dr H.S. Dang of BARC and Dr Ashok Kumar, Head, Department of Zoology, University of Rajasthan. This meeting was jointly sponsored by University of Rajasthan, Jaipur, and Indian Association for Radiation Protection (IARP, Mumbai) and was held in conjunction with the International Conference on Radiation Protection held at Mumbai during February 20-23, 2001.

It was the first conscientious effort ever made to bring under one roof the international community and national experts dealing with whole chain of events and their control with regards to internal exposure such as : 1) the measurement of low levels of important radionuclides in biological samples, 2) biokinetic modes of actinides and important radionuclides, 3) decorporation of radionuclides deposited in the body, using various chelating agents, and 4) the use of various radioprotectors to alleviate harmful effects of nuclear radiation. All these aspects would go a long way to assess, limit and effectively control any harmful effect of nuclear radiation.

The Satellite Meeting, inspite of being subject specific, received overwhelming response from the international and national radiation protection community. It was attended by eleven foreign delegates (9 gave invited talks and 2 others were observers) from various countries such as Germany, Canada, Belgium, Japan, Slovenia, etc. About 50 scientific papers were presented as invited talks (12), oral (9) and poster presentations (30) in the two days programme.

The Meeting was inaugurated by Dr V. Venkat Raj, Director, Health, Safety and Environment Group of

*Dr V. Venkat Raj, Director, Health, Safety and Environment Group, BARC, delivering the inaugural address during the International Meeting on Internal Radiation Dose Management held at Jaipur during February 26-27, 2001. Others on the dais are (left to right) Prof. Ashok Kumar, Univ. of Rajasthan, Prof Kamal, Vice Chancellor, University of Rajasthan, Dr P.N. Srivastava, ex-Member, Planning Commission, and Dr H.S. Dang of BARC.*

BARC and was presided over by Dr P.N. Srivastava (ex-Member, Planning Commission). The brief opening remarks regarding the aim and objectives of the Meeting were delivered by Dr H.S. Dang of BARC. The Satellite Meeting received a very enthusiastic and large coverage in the Media. The Press lauded the efforts of the Indian scientists for using methodologies and practices of international standard for the purpose of radiation protection.

The foreign delegates were quite appreciative of the scientific contents of the papers presented in the Meeting. They complimented the BARC scientists on the quality R&D work being carried out on radiation protection by them. Four scientific papers, two each from the oral session and the poster session were adjudged as the best four papers presented in the Meeting. Two of these papers, one by Sharda Bhati and R.C. Sharma, and the other by H.S. Dang, D.D. Jaiswal and R.C. Sharma were contributed from BARC. The Meeting ended on a successful note.

## VISIT OF SENIOR CITIZENS TO BARC

*Dr A.P. Jayaraman, Head, Media Relations Section, Library and Information Services Division, BARC, briefing the senior citizens about BARC's research activities.*

About 40 senior citizens from Indian Association of Retired Persons, Gohil House, Mahim, Mumbai, along with their president Mr R.G. Mohadikar, visited BARC on April 24, 2001.

Dr A.P. Jayaraman, Head, Media Relations Section of Library and Information Services Division, BARC, briefed the visitors about the activities of DAE in general and BARC in particular. Later on, they visited the Dhruva reactor, and the facilities at Food Technology Division and Nuclear Agriculture & Biotechnology Division.

Dr S.E. Pawar of NA&BTD and Dr K.P. Karanth of RSFT Division accompanied them during their visit. The visitors expressed their admiration for the work done at BARC. Mr Mohadikar thanked the Public Relations Officer, BARC, for making the visit possible and said that it was a very unique and unforgettable experience for the senior citizens.

## BARC SCIENTISTS HONOURED

- The "Ron Halmshaw Award" of the British Institute of NDT will be given to Mr P.R. Vaidya of the Atomic Fuels Division, BARC. The award is given every year for the best research paper published in their journal *Insight : Non-destructive Tests and Condition Monitoring* on any aspect of industrial radiography or radiology. It carries a certificate and a cash award of £300. The paper by Mr Vaidya titled, "Use of modulation transfer function in the determination of focal spot dimension" *(Insight, 42, 5, 323-328)* proposes a new method of measuring the size of the X-ray focal spot in microfocus X-ray units, which is presently considered a difficult task. This work forms part of Mr Vaidya's Ph.D dissertation.

The award will be conferred on him during the annual conference of the Institute at Coventry, England, in September 2001.

- Mr D. Mandal of Chemical Engineering Division, BARC, had stood first in the Industrial Civil Defence Management Course, conducted by National Civil Defence College (NCDC) at Nagpur in April 2000. For this, Mr Mandal has been awarded a Gold Medal by the Ministry of Home Affairs, Government of India, and it was handed over to him on April 29, 2001, by the Director General, Civil Defence (DGCD) at NCDC, Nagpur.

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