Bournemouth Meeting on Water Chemistry of Nuclear Reactor Systems #6

Bournemouth, England
October 12-15, 1992

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Building 703M
Upton, NY 11973

As with previous conferences in this series, this was an excellent and highly technical conference in which most recent experiences on reactor water chemistry and related research studies throughout the world were summarized. About half of the papers presented were available in a bound volume (Volume 1), which will be included in the proceedings of the meeting. Most of the other papers were available as individual reprints so the writer has a nearly complete set of the proceedings. It is impossible to summarize the wealth of information that was presented at this meeting in a brief trip report, so the writer will merely highlight some of the notes taken at the meeting in the following. The number given refers to the paper number corresponding to the agenda. The same number is used to identify the papers in the proceedings. This number is followed by the title of the paper, then by the last name of the first author, who was also the person who usually presented the paper at the meeting. Missing numbers imply notes were not taken.

1. **Status Report on Radiation Exposure Reduction at U.S. Nuclear Power Plants** - *Wood* (EPRI): Steam generator capacity factor losses were down from about 6% in the 1980's to about 2% recently. BWR peak losses occurred in 1984 and were due to corrosion problems. There has still been no test of iron-based alloys in U.S. plants; the Germans are way ahead. Zinc injection is okay, but there are problems of increased radiation fields if hydrogen water chemistry is also used. 130,000 cSv were saved by the use of the LOMI decontamination process during the past six years. (Dr. C.J. Wood, Sr. Program Manager, Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, CA 94304)

2. **Effects of pH of Primary Coolant on PWR Contamination** - *Anthoni* (CEA): In their experience, pH 7 was better than 7.2. Changing pH didn't significantly change the Co^{58} evolution in steam generator tubes. 7.2 to 7.4 seems optimum in other studies. EDF may use 7.2 with primary system conditioning. (Dr. S. Anthoni, Centre de Cadarache, 13108 Saint Paul lez Durance Cedex, France)

3. **Evaluation of Factors Affecting Radiation Field Trends in Westinghouse-designed Plants** *Bergman* (U.S.): Low cobalt in steam generator tubing and less corrosion of 690 inconel leads to about 65% reduction in dose rate. Use of coordinated chemistry and fuel management practices (use of low cobalt in nickel plating of fuel grids, or use of zirconium grids) after 1979 each affected dose rates by 20-25%. (Mr. C.A. Bergmann, Principal Engineer, Westinghouse Electric Corporation, P.O. Box 355, Pittsburgh, PA 15230)

4. **Behavior of PWRs in Spain Following Changes to Modified Chemistry and to Fuel Specifications** - *Lillo* (Spain): In one of their PWR plants the optimum pH seemed to

be 7.3 to 7.4. Above 7.3 Co^{58} and Co^{60} seem to increase relative to iron. High dose rates in cycles 1 through 3 of a zinc plant were due to a valve lapping operation before cycle 1. (Mr. M. Boronat (co-author), Chemistry Assistant Manager, ASCO Nuclear Power Plant, Central Nuclear ASCO, 43791 - ASCO, Tarragona, Spain)

5. **An Overview of the Impact of Stellite Removal on Radiation Fields in KWU PWRs** *Garbett* (U.K.): Antimony in the bearings of KWU PWRs is now being replaced. Dose rates in the channel heads of German convoy plants are only 0.5 to 1 R/hr. The big changes result from reduction of cobalt in the reactor vessel but not control-rod drive mechanisms. Cobalt in steam generators and stainless steels has not been reduced. One station changed from inconel to zirconium for fuel grids and its dose rates changed markedly. Stellite is especially important in the vessel. Cobalt in construction materials is less important. High pH is thought to have a factor of two effect. Dose rates in the convoy plants are 5 to 10 times lower than the EPRI goal for 1995. The lower dose rates are thought to be the main factor contributing to low collective doses for these plants. (Dr. K. Garbett, Research Officer, Nuclear Electric plc, Berkeley Technology Centre, Berkeley, Gloucestershire GL13 9PB, United Kingdom)

Question and answer period on above papers:

In discussions of differences due to pH, one needs to specify temperature and solubility factor. Differences between 7.2 and 7.4 can result from use of different solubility factors in theoretical prediction. Most people are now using the Marshall and Frank dissociation constant for water at 300°C. The French used to use something else that gave 6.9 and now everyone is using the Marshall and Frank system that gives 7.0. The French are not planning to use steam generator channel-head electropolishing due to the cost-benefit evaluation they did. Chris Wood indicated that the current chemical guides were not based on cost-benefit evaluations. Their next project will address that question. It was indicated that electropolishing was cost-effective in the Millstone 2 project where manual polishing techniques were employed and a $20,000 per rem saved value was placed on dose reduction. The cost-benefit is critically dependent on the number of inspection entries that are planned. The effects of changing to a high pH are somewhat variable, and it was suggested that U.S. plants may not respond as quickly to chemistry changes due to their age. Spanish plants, which showed more improvement than the French plants were apparently younger plants.

6. **VVER Primary Coolant Chemistry Experience and Perspectives -** *Kysela* (Chech and Slovak Fed. Rep.): Collective dose in eastern VVER 440 are 100 to 400 rem per year in eastern countries, and 30 to 150 rem per year in western countries. The 1,000 megawatt VVER plants are in two groups with the newer showing much lower collective doses than the older. Dose rates at the steam generator correlates with occupational exposure. The standard chemistry in these plants uses ammonia to provide hydrogen. Recent changes to hydrazine chemistry provides higher hydrogen concentrations than the standard chemistry and reduces the Co^{60} to iron ratio by about a factor of 2. Changing from the ammonia to the hydrazine regime is intended to provide pH about 7.2. (Dr. J. Kysela, Head of Dept. of Irradiation Exper., Nuclear Research Institute, 250 68 Rez, Near Prague, Czech/Slavok FR)

7. **Elemental and Radiochemical Measurements Carried Out on the Primary Coolant at the WWER-440 PWRs PAKS 1 & 2 in Hungary during Steady Full Power Operation at the End-of-Cycle Shutdown** - *Schunk* (Hungary): Activity concentration dropped by more than a factor of 10 in 2,000 to 4,000 hours after introducing hydrazine chemistry. Significant reductions in dose rates and particulate concentrations were also seen. (Dr. J. Schunk, Head of Special Chemistry Group, Paks Nuclear Power Plant Ltd., H-7031 Paks, P.O. Box 71, Hungary)

8. **Standard and Hydrazine Water Chemistry in Primary Circuit of VVER 440 Units** - *Burclova* (Czech and Slovak Federal Republic): In their VVER plants, for the last part of the cycle, doses mainly from Co^{58} are most important. They found no relationship between dose rate and surface activity for Co^{60}, but there was a correlation for Co^{58} at the steam generator channel-head. (Dr. J. Burclova, Nuclear Power Plants Research Institute, Okruzna 5, 918 64 Irnava, Czechoslovakia)

9. **Activity Transport and Corrosion Processes in PWRs** - *Lister* (Canada): It has still not been resolved if the soluble or the particulate activity is the most important in-core. For out-of-core processes, corrosion of steam generator tubes and stellites are most important. Regarding cobalt sources, stellite erosion provides a constant input, whereas, corrosion of inconel plating goes down in time. (Dr. D.H. Lister, Professor of Nuclear Engineering, University of New Brunswick, P.O. Box 4400, Frederickton, New Brunswick E3B 5A3, Canada)

10. **A Review of the Effect of Lithium on PWR Fuel Cladding Corrosion** - *Polley* (U.K.): Less than 100 μm clad corrosion is an important limit on fuel burn up. Lithium is bad for corrosion. Greater than 100 ppm of boron gives low corrosion. 1200 ppm boron gives protection even at temperature with nucleate boiling at the surface. There seems to be a threshold void fraction to give enhanced corrosion, about 3% for French experience, and about 10% based on recalculation. There are some differences in how one calculates void fraction. Elevated lithium gives about 15% enhanced corrosion over the lifetime of the plant, so the effect is small. Tin and carbon content and heat treatment can give comparable effects. In Ringhal's elevated lithium for 15 cycles gave no significant increase in the oxide thickness. Comparisons between plants are not clear due to other differences. (Dr. M.V. Polley, Nuclear Electric, Berkeley Nuclear Laboratories, Berkeley, Gloucester GL 13 9PB, United Kingdom)

11. **Light Water Reactor Materials and Water Chemistry Studies at Halden** - *Karlsen* (Norway): 4 to 4.5 ppm lithium did not enhance corrosion. PWR cracking in 304 stainless steel growth slowed significantly with hydrogen water chemistry. (Mr. T.M. Karlsen, Research Scientist, Halden Reactor Project, P.O. Box 173, Halden, Norway)

12. **Shutdown Chemistry in Spanish Plants** - *Llovat* (Spain): The ratio of Co^{58} to Co^{60} increased rapidly with oxygen concentration increase at shutdown— (due to ex-core versus in-core activities?). Co^{58} in crud followed the same pattern in ex-core. (Mr. R. Llovet, Ms-Chemistry, Westinghouse (WSEE), Agustin PE Foxa 29 Madrid, 28036, Spain)

13. **PWR In-Pile Loop Studies in Support of Coolant Chemistry Optimization** - *Kohse* (USA): Clear benefit was found for pH increases to 7.2 for both Co^{58} and Co^{60} and the benefit continues to 7.6 for Co^{60}. (Dr. G.E. Kohse, Principal Engineer, Massachusetts Institute of Technology, 138 Albany Street, NW13-260, Cambridge, MA 02139)

15. **The Effect of Dissolved Oxygen in Activity Transport in Lithiated Coolant** - *Allsop* (Canada): Bruce A has been boiling with three times as much activity in the outlet as the inlet. (Dr. H.A. Allsop, Research Scientist/Engineer, AECL Research, Chalk River Laboratories, Station 61 AECL Research, Chalk River, Ontario KOJ 1JO, Canada)

16. **Effect of Surface Treatment on Radioactivity Deposition on Stainless Steel and Inconel Coupons Exposed in Doel 2** - *Pick* (U.K.): Studied four types of metals, each given 6 different treatments by placing coupons in Doel 2. (Mr. R. Roofthooft (co-author), Head of Dept. Chem in Power Plants, Laborelec, Rodestraat 125, 1630 Linkebeek, Belgium)

18. **Modelling Activity Transport in PWRs/The Diffusion of Cobalt into Oxide Films - A Theoretical and Experimental Study** - *Harper* (U.K.): The Conrad model was used for loop studies and showed that out-of-core sources are only 10% of in-core contributions for Co^{60} in PWRs. (Dr. A. Harper, AEA Technology, Building 10.5, Harwell, Didcot, Oxfordshire OX11 ORA)

19. **Moving from Ultra-pure BWR Water to Plant-tailored Water Chemistry** - *Fejes* (Sweden): Cobalt is not permitted in the reactor primary system of ASEA BWRs. Chlorine ion specifications were used from the beginning. Powdered resin condensate clean-up systems are employed. Bead-type ion exchange columns are used in the reactor clean-up system. Operational experience has shown that copper presents problems due to pressure drop in the core and due to fuel damage. Copper is now restricted to 0.1 ppm in the condenser tubes. Hydrogen has been added to the feedwater to reduce oxygen, but this led to high electrochemical potentials in the high temperature reactor portion of the system with possible corrosion in the core. Increasing the iron-to-nickel ratio gave lower cobalt concentrations in the feedwater. Occupational exposures are going down even though contamination level was increasing with reduced zinc and copper input. Sodium hydroxide has been added to reduce cobalt activity. Reductions in sulfuric acid concentration are important to reduce crack rates in 304 stainless steel. Crack rate growth increased from 10^{-8} mm/s to 10^{-6} mm/s for increases of sulfuric acid from 0.025 ppm to 0.1 ppm, versus a clean system. These plants use a 1-page computer printout display of the sequence of filter changes for six different systems covering a period of four months. (Mr. P. Fejes, Company Senior Scientist, ABB Atom AB/R, S-721, Vasteras, Sweden)

20. **Chemistry Parameters Influencing the Dose Rate Build-up in BWR Plants** - *Marchl* (Germany): One wants the nickel to iron ratio to be less than 0.2 to avoid cobalt concentrations. However, the additional iron injected may lead to increased crud release under sudden shutdown conditions because of a thicker oxide crud layer on the fuel. Cobalt concentrations follow the oxygen concentration in the oxygen range from 130 to 430 ppm. A pH of about 7.8 gave a minimum of Co^{60} and CO^{58} in the primary coolant, about 2 times less than at pH 7.0. The optimum chemistry, however, is plant specific.

(Ms. T.F.J. Marchl, Siemens AG KWU, Hammerbacherstr 12+14, D-8520 Erlangen, Germany)

21. **Operating Experience with Japanese Improvements and Standardization of BWRs and the Behaviour of Radioactivity** - *Aizawa* (Japan): Cobalt increases in some of their newer plants is not understood and is not controlled by the nickel-to-iron ratio. (Mr. M. Aizawa, Lead Engineer, Hitachi Engineering Co. Ltd., 3-2-1 Saiwai-cho, Hitachi-shi, Ibaraki-ken 317, Japan)

22. **Overview of Activities for the Reduction of Dose Rates in Swiss BWRs** - *Alder* (Switzerland): Average dose rates increase by about 33% at KKM, but doses went down about a factor of 2. At another plant, KKL, dose rates were down by a factor of 2, but dose was approximately constant, and this was a zinc plant. Without zinc, iron strongly decreases the Co^{60} concentration, whereas with zinc, iron strongly increases the Co^{60} concentration. So, one should not add iron if using zinc additions. On the other hand, it was stated that KKL results should not be generalized. Results were for reactor water not for deposited activity on surfaces. In loop studies, the lowest deposition occurred at 1.5 ppm zinc, but not at higher concentrations. Note that data is for very low flow rates. The results in their laboratory studies confirm to some extent the Swiss plant experiences. Hydrogen additions always increase nitrogen 16 and operational dose, but if maintenance is low during operations, the dose is acceptable. This needs specific analysis for each plant. (Dr. H-P Alder, R&D Division Head, Paul-Scherrer-Institute (PSI), Ch-5232 Villigen-PSI, Switzerland)

Discussion Period:

It was stated that concentration of hydrogen required to protect the recirculation system, including the main steam line, increased dose rates by about 1.75 and this is all that is usually needed. However, to protect reactor components, hydrogen concentrations are required which increase dose rates by a factor of 5 to 8. The nitrogen 16 problem is plant and operations specific. Each plant needs to do an optimization study.

23. **A Utility Approach to Radiation Field Reduction by Coolant Chemistry Control** - *Hudson* (U.S.): Northeast utilities began a broad ALARA program in 1986 and began employing $20,000 per rem as a value of dose saved, even though only about $5,000 to $8,000 per rem is technically justified. Zinc injections of 10 to 15 ppb were reduced to 3 to 5 ppb with reductions of cobalt down a factor of two and recontamination also down about a factor of 2 at the lower concentration. As a result of zinc incorporation into oysters, they had to change the concentration of zinc permitted in liquid effluents. Four BWRs are to use depleted zinc in an EPRI-sponsored project. It is planned to also study if zinc is only needed near the end of the cycle. Different reactors are to test at different times in 1993. Zinc 65 contributes 90% to the pipe dose in zinc plants. Tests of elevated pH at Millstone 3 gave good results, however, pH was reduced from 7.4 to 7.2 to reduce the time at high lithium concentration due to cladding corrosion above the Westinghouse guidelines. Ringhals uses high lithium for only about 1 month. Millstone 3 is now using it for approximately for 5 months. They are now gradually changing to zirconium fuel grids at Millstone 3. Some Millstone control rods had spalling at 50

gwd/MT. (Mr. M.J.B. Hudson, Senior Scientist, Northeast Utilities, P.O. Box 270, Hartford, Connecticut 06141, USA)

24. **Distribution of Metal Oxides in the Water Steam Circuit of BWR** - *Ruehle* (Germany): Detailed studies of the corrosion products in the primary circuit of a BWR has confirmed our hypothesis that the activated components of the reactor materials and/or the activated crud on the reactor internals and not the stellites from valves and pumps from the secondary side of the water steam circuit are the main contributors to activity buildup. (Dr. W. Ruehle, Chemistry Manager, Kernkraftwerk Philippsburg GmbH, Rheinschanzinsel, D 7522 Philippsburg, P.O. Box 1140, Germany.

25. **First Experience of Hydrogen Water chemistry Verification at a Japanese BWR/Radioactive Nitrogen Behaviour in Japanese BWRs** - *Takagi* (Japan): He reported on Japanese experience with hydrogen water chemistry. They found they needed 16 to 20 standard cubic feet per minute to mitigate IGSCC in the reactor water clean-up units. Hydrogen injections at 40 standard cubic feet per minute caused pH to increase to about 7, electrochemical potentials to drop to about 600 mV, the steam dose rate to increase by a factor of 5, dose rate in the pump room to decrease by 40%, and dose rate in the tunnel room to increase by a factor 4.7. (Mr. K. Ichikawa (co-author), Assistant Manager, EBARA Corporation, CO: 1-13 1 Chome, Shimbashi, Minato-ku, Tokyo, Japan)

26. **Feedwater Iron Crud Reduction for Chin Shan Nuclear Power Station** *Wen* (Taiwan): Tai Power found the insoluble iron content in the feedwater of the Chin Shan Nuclear Power Station had increased apparently after condenser retubing in which copper alloy was changed to titanium tubing in March 1986. Improved iron crud reduction in the feedwater is considered necessary during plant shutdown and start-up. In addition, they are proposing the adoption of a dual purification system and ion exchange resin with reduced granular size. (Mr. T-J Wen, Associate Scientist, INER AEC, P.O. Box 3-6, Lung-Tan 32500, Taiwan)

27. **Generation and Accumulation of Activated Corrosion Products in BWR** - *Takiguchi* (Japan): He reported that Takai 2 had exceptional deposition of Co^{60} on fuel due to an earlier valve problem. (Mr. H. Takiguchi, Plant Chem/Radioactive Waste Group, The Japan Atomic Power Company, 6-1, 1-Chome, Ohtemachi, Chiyoda-ku, Tokyo 100, Japan)

30. **Evaluation of Crud Behaviour in BWR Primary Cooling Systems Using Multi-region Model** - *Nagase* (Japan): Based on model calculations it was concluded that, in addition to mechanical decontamination, the reduction of iron input is effective in reducing crud recontamination on structural material surfaces. (Mr. M. Nagase, Researcher, Hitachi Ltd., Energy Research Laboratory, 1168 Moriyama-Cho, Hitachi-shi, Ibaraki-Ken 316, Japan)

32. **Flow Field Dependence of Reactor Water Chemistry in BWR** - *Hemstrom* (Finland): Since reliable in-situ monitoring of the corrosion potential in the lower part of Forsmark 1 and 2 reactor pressure vessels is difficult, it was decided to perform a detailed computer simulation of the recombination in the downcomer. Results indicate that part

of the reactor water passes the downcomer with essentially zero admixture of hydrogen rich feedwater, implying that good recombination is difficult to achieve. Therefore, hydrogen addition to the feedwater has been discontinued in Forsmark 1 and 2. (Dr. Hemstrom, Vattenfall Utveckling, S-B1070 Alvkarleby, Sweden).

38. **Decomposition of Hydrogen Peroxide in BWR Cooling Circuit** - *Lin* (U.S.): He indicated that hydrogen peroxide is probably more important than oxygen in BWR corrosion chemistry. (Dr. C.C. Lin, Principal Engineer-Program Manager, GE Nuclear energy, Vallecitos Nuclear Center, P.O. Box 460, Pleasanton, CA 94566, USA)

39. **Full Primary System Chemical Decontamination Qualification Program** - *Miller* (U.S.): This was an excellent paper on the full primary system chemical decontamination qualification program in the U.S. and the speaker volunteered to present a similar talk at our international workshop, which is planned for April or May 1994. Evaluations of long-term benefits of full system decontamination and passivation yielded estimates of the radiological benefits ranging from a low of 500 to a high of 3500 manrem for a once only decontamination. An estimated 16,000 manrem could be avoided if 60 contaminations were performed over the remaining plant licensed operating period. Decontamination was assumed to occur at the 10th refueling outage with 30 operating cycles remaining during the plant licensed operating period. Using a conservative dollar figure of $5,000/manrem saved for the purposes of illustration, the dose savings could thus vary from about $4.5 to $80 million. For some plants, these savings would more than compensate for the cost of decontamination and waste disposal. However, for others there may not be a net benefit, therefore, a complete cost-benefit evaluation must be made on each plant. He pointed out that expected savings at the Indian Point Plant over the next five cycles will be 3,500 rem. Fifty three of the control rod drive lines containing 410 stainless steel will be removed because of stress corrosion cracking problems. Decontamination incurred a 15-day extension of the critical path on this PWR. Con Edison's Indian Point 2 plant will be the national demonstration site for decontamination in 1995. (Mr. P.E. Miller, Manager Plant Application, Westinghouse Nuclear, Advanced Technical Division, P.O. Box 355, ECE 511A, Pittsburgh, PA 15230, USA)

40. **Full System Chemical Decontamination and Countermeasures Against Recontamination of the Fugen Nuclear Power Station** - *Naoi* (Japan): Full system chemical decontaminations of the Fugen Nuclear Power Station were discussed. It was concluded that average decontamination factors of 3.4 and 5.1 were obtained in the decontamination. Occupational radiation doses of 6.6 and 7.8 man-Sievert were saved by the decontaminations. Materials integrity during and after the decontaminations was confirmed. After one year of operation, activity has built up again to approximately 70% of pre-decontamination levels. To reduce the recontamination, crud on the reloaded fuels was removed by ultrasonic vibration. This slightly reduced recontamination. (Mr. Y.N. Naoi, Assistant Sr. Chemistry, Power Reactor & Nuclear Fuel Dev. Co., 3 Myojin-cho, Tsuaruga-Shi, Fujui-ken, 914, Japan)

41. **Concept and Experience of System Decontamination with CORD** - *Wille* (Germany): The Siemens concept for the decontamination of systems with the CORD process was outlined. One of the major aims during this application was to minimize the amount of

waste generated as well as the reduction of dose rate. Decontamination of complete primary loops of BWR and PWR systems were performed. Decontamination of a PWR with three CORD cycles in a nine-day operation resulted in only 1.3 m^3 of spent ion exchange resins. A decontamination factor greater than 10 led to a personnel dose saving of 4 to 8 man Sieverts. The full system decontamination of the BWR (16 MWe) was performed in June 1992. However, neither the traveler's notes nor the published paper from the meeting indicate the results of this decontamination. (Dr. H.C. Wille, Manager, Siemens AG KWU, Hammerbacherstr 12+14, D-8520 Erlangen, Germany)

42. **Decontamination Waste Volume Reduction by the ELOMIX Process** - *Bradbury* (U.K.): The ELOMIX process was described. It is an electrochemical ion exchange technique for continuously removing radioactive elements from chemical decontamination solutions used in nuclear power plants. In the process the ion exchange resin is used as an intermediate waste form and is continuously regenerated by the passage of an electric current. The radioactivity from the reactor circuit is obtained in the form of a particulate metallic deposit which can be transported hydraulically to a vessel for solidification and final disposal. Two separate on-site pilot-scale trials have been performed and in both the process performed well. It has been possible through this two tests to demonstrate the feasibility of all aspects of the process. (Dr. D. Bradbury, Managing Director, Bradtec Ltd., Bristol Polytechnic, Coldharbour Lane, Bristol BS16 1QY, United Kingdom)

43. **The Study of Application of Chemical Decontamination** - *Takiguchi* (Japan): Experience with the CORD process which a dilute chemical decontamination process with use of dicarboxylic acid was described. The advantage of this system is that the chemical can be easily decomposed by heating or use of oxidizing agents. It was concluded that decontamination performance was better than the reference processes yet corrosion attack was negligibly small. The acid and its chelate were decomposed to carbon dioxide and water below 100°C by small amount of permanganic acid which is the same agent as the per oxidation agent of CORD. Ion exchange and evaporation treatment methods through decompose the decontamination agent and its chelate compounds by permanganic acid, have been developed and established. These methods can reduce waste volume to less than approximately 1/4 compared with conventional decontamination processes. (Mr. H. Takiguchi, Plant Chem/Radioactive Waste Group, The Japan Atomic Power Company, 6-1, 1-Chome, Ohtemachi, Chiyoda-ku, Tokyp 100, Japan)

47. **Reducing Radioactivity Build-up and Corrosion by Hydrothermal Chromate Treatment** - *Jindrich* (Czechoslovakia): Preconditioning of stainless steel surfaces by incorporation of chromium into the corrosion layer was tested in the laboratory and an experimental water loops. Treatment of stainless steel surfaces resulted in thinner corrosion layers (a factor of 20 times), the corrosion rate of stainless steel was decreased at least by a factor of 10, and the amount of radioisotopes deposited in the corrosion layer was at least 3 times lower than for the usually treated surface with the exception of Co^{60} where the depletion factor for the radioisotope was a factor of 5 lower. (Dr. Jinrich, Dept. of Irradiation Exper., Nuclear Research Institute, 250 68 Rez., Near Prague, Czechoslovakia/Slovak FR)

49. **KWU Chemical Cleaning Process as a Remedial Measure to Improve Steam Generator Performance** - *Odar* (Germany): KWU's chemical cleaning of steam generators was summarized. It was noted that crevice cleaning requires a different cleaning technique than tube-sheet cleaning, which enables multiple solvent refreshment in the crevices. For this purpose, high temperature KWU iron solvent has proved effective in field experience. The KWU process has proven efficient for removal of corrosion products and salt impurities especially from the crevice areas. Other advantages claimed include its inherent safety, its minimum influence on critical path time during outage, its characteristics which make use of installed plant systems and equipment, and its easy waste handling and extensive field application experience. (Dr. S. Odar, Manager Head of Department, Siemens AG KWU, Hammerbacherstr 12_14, D-8520 Erlangen, Germany)

70. **Measurement of PWR Steam Generator Hideout Rates using Sodium 24** - *Fiquet* (France): Studies using a radioactive isotope, Na^{24}, showed that a circular-hole configuration for the tubes support plate leads to a hideout rate 3 to 5 times higher than that obtained with steam generators replaced by broached holes in the tube support plate, which leaves only a small contact surface between the plate and the tube. (Address not available)

77. **Performance Improvement of Precoat Type Condensate Filter** - *Maeda* (Japan): The performance of precoat-type condensate filters was improved to extend their useful life to as long as 200 days. This was accomplished through use of special ion exchange fiber material, low cross linkage cat-ion resins, a draft tube to improve the flow distribution in the filter vessel, a swelling operation in which cracks are generated on the surface of the precoat layer in order to release the suppressing force on the precoat layer and expand that layer, and finally, a continuous feed of a small quantity of precoat material during the operation of the condensate filter system. (Mr. K.M. Maeda, Toshiba Corporation, Isogo Nuclear Engineering Center, 8 Shinsugita-cho, Isogo-ku, Yokohama 235, Japan)

Poster Paper 12. **Elemental and Radiochemical Measurements Carried out on the Primary Coolant at German KWU and Other European PWRs** *Bridle* (U.K.): Mean reported steam generator channel head dose rates for European and East European PWRs was shown to increase about a factor of 4 for increases and measured soluble elemental cobalt concentrations of about a factor of 4 during steady state power operation. (Mr. D.A. Bridle, Manager, Water Chemistry, AEA Technology, Winfrith Technology Centre, Dorchester Dorset DT2 8DH, United Kingdom)

Poster Paper 14. **Exchanging Control Rod Pins and Rollers Made of Cobalt Alloys - Impact on Radiation Levels** - *Kelen* (Sweden): The ABB Atam computer code BKM-CRUD was used to study the effects of exchanging control rod pins and rollers made of cobalt-based alloys. It was concluded that cobalt-based alloys may contribute significantly to the radiation fields in a BWR. Concentration varies from moderate to dominating depending on conditions including neutron flux distribution over the core and water chemistry. After removal of the cobalt-based alloy pins and rollers, the contact dose rate on a vertical section of a primary recirculation loop tube will decrease gradually. Several years will be needed before the impact of the old pins and rollers is eliminated. (Mr. T. Kelen, ABB Atom AB, S0721 62 Vasteras, Sweden)

Comments on Future Meetings:

There will be a meeting on reactor water chemistry in France in April 1994. The next Bournemouth conference is planned for Fall of 1996. The international conference on water chemistry will be held in Japan in the autumn of 1998. The Bournemouth meetings are going to be planned for each four years in the future.