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CHEMICAL DECONTAMINATION OF HANFORD PRODUCTION REACTORS

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CHEMICAL DECONTAMINATION OF HANFORD PRODUCTION REACTORS

INTRODUCTION

The conduct of outage work in the discharge areas of the Hanford production reactors has always been complicated by personnel exposure to radiation from the contaminants which accumulate in the effluent water piping in the course of normal operations. These contaminants represent trace impurities in the cooling water, together with corrosion products, which are irradiated in passing through the reactor and then deposit in the unshielded rear face piping. Radioactive residues also accumulate on the external surfaces of this same complex and congested hardware. The radiation from these depositions increased as power levels and effluent water temperatures were raised, and by 1956 it was apparent that corrective steps would be essential to effective future maintenance work in the discharge areas.

It is the purpose of this report to summarize the subsequent development and application of the chemical process for rear face piping decontamination which is being used so effectively in connection with the tube replacement program and other major outage work.

SUMMARY

By late 1961 a chemical process for the internal and external decontamination of rear face piping had been developed and used successfully at all eight production reactors. Existing equipment for reactor purging was readily adapted for this purpose, and the decontaminants used introduced no significant corrosion or disposal problems. Rear face radiation levels were reduced 50-85 per cent by this process, thus enabling extended outage work to be performed with greatly improved utilization of personnel. These gains were worth far more than the decontamination costs for chemicals, labor, and outage time. For the month-long rear face maintenance outage at each K Reactor in the winter of 1958-59, decontamination was estimated to have effected a combined savings of about \$750,000 in critical manpower at a cost of about \$40,000 plus 40 hours of outage time.

This chemical decontamination of rear face piping has proved invaluable to the large-scale program for process tube replacement which was initiated in January 1962. Last year, with 24 such outages, the resultant exposure savings with associated personnel totaled 445 roentgen, enabling this important work to be accomplished with 120 fewer people (critical crafts) than otherwise would have been required. This represented an estimated salary saving of about \$950,000 for the 12-month period. Moreover, tube replacement efficiency was increased greatly. Other rear face work done during these outages also benefited. The total cost of the decontaminations involved was \$161,000 for chemicals and labor, plus 264 hours of reactor outage time. The latter, equivalent to 5 per cent of the total tube replacement time, was more than offset by improved work effectiveness under the lowered radiation levels.

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In 1963 through May there have been nine tube replacement outages, including three at the K Reactors for the installation of Zircaloy tubes. Full rear face chemical decontamination preceded each of these nine outages. The resultant 40-80 per cent reduction in rear face radiation levels represented a total personnel exposure savings of 295 roentgen during tube replacement. With a total of 22 outages involving tube replacement crews scheduled for 1963, including two more at each K Reactor, it is estimated that exposure savings for these personnel will total 670 roentgen. This is equivalent to 200 people in the critical crafts, and an estimated salary saving of \$1,600,000 this year. Decontamination cost is expected to total \$200,000 for chemicals and labor, plus 300 hours of outage time.

While the outlook is for much reduced tube replacement work after the current program is completed early next year, chemical decontamination will continue to be exploited in preparation for these and any other reactor outages involving extensive work at the rear face. Significant further improvements in the process are expected, particularly in its application through refinement of process control and reduction of costs for chemicals, labor, and outage time.

DISCUSSION

Process Development and Application Pre-1962

In late 1956 an Irradiation Processing Department projection of radiation exposure accumulation by certain crafts indicated that, within a few years, they would be subject to receiving more exposure than the annual operational control limit (3 roentgen) would permit. These so-called "critical" crafts are the radiation monitors, pipefitters, millwrights, and reactor operators. Sixty to seventy per cent of their radiation exposure was, and still is, received in the reactor discharge areas performing rear face maintenance and other outage work. Their total exposures had increased each year as a result of (1) higher radiation levels in the discharge areas, and (2) more time being spent in those areas. As noted, the radiation there comes principally from activated impurities and corrosion products in the reactor effluent water which deposit on the inside surfaces of the rear face piping (the crossheaders, connectors, nozzles, and the spacers in the nozzles). Some external accumulation also occurs. The intensity of this radiation was increasing with time, as reactor power levels and effluent water temperatures were raised. This upward trend is shown on the appended Figure 1.

Recognition of this mounting radiation problem stimulated development of a procedure which would enable decontamination of the rear face piping, internally and externally, with a chemically active purge solution. The through-reactor diatomaceous earth purges used periodically for film removal were known to be relatively ineffectual. With the aid of the Hanford Laboratories, a large number of chemicals were evaluated for effectiveness of decontamination vs. corrosion of reactor components, personnel health problems with noxious fumes or skin irritation, and disposal of the spent solutions to the Columbia River. These studies proved very promising and led to the selection of a chemical cleaning compound consisting principally of sulfamic acid, chloride,

and bilge. The first full-reactor flushing of rear face piping was conducted successfully with this material at H Reactor in 1957. A 37 per cent reduction in average rear face radiation level was realized, and it was evident that 50-plus per cent could have been obtained.

The decontamination process used in that first trial has continued in use without basic change (see flow diagrams in Figures 2 and 3, appended). Stepwise it can be summarized as follows:

- 1) The dry chemical is dissolved in existing purge tank facilities and heated to about 85 C.
- 2) On the rear face of the reactor, starting at the top, nozzle caps on several rows of tubes are loosened and the crossheaders for these rows are valved to the relief riser. At the C and K Reactors it is necessary to remove the nozzle caps completely in this step, and apply orificed snap-on caps. Figure 4 shows specially-clothed operators doing this work.
- 3) The heated chemical solution then is pumped into the relief riser from which it flows back through the selected crossheaders and tube connectors.
- 4) With a low flow of cooling water still passing through the process tubes, the chemical solution is forced to mix with the coolant in the nozzles and exit through the loosened or orificed caps, spraying from them onto the rear face and draining down into the storage basin as pictured in Figures 5 and 6. If removed, the nozzle caps are decontaminated simultaneously in trays placed on the work platform. These can be seen in Figure 6.
- 5) The chemical back-flush is continued for about ten minutes. The treated piping then is water-flushed, the crossheader valving is returned to normal, and the nozzle caps are replaced.
- 6) Steps 1 through 5 then are repeated until the entire rear face has been decontaminated.

Early in 1958 it was foreseen that the month-long outages being planned for very extensive rear face maintenance at both K Reactors would have prohibitive manpower requirements with the high radiation levels then prevailing in the discharge areas. Accordingly the decontamination process demonstrated at H Reactor was adapted for use at the larger K Reactors, and the required purge system changes and additions were made. KW Reactor was decontaminated in late 1958 and KE in early 1959. Both operations were highly successful, effecting rear face radiation level reductions of 75-85 per cent. The resultant manpower economy during the two outages was estimated to represent a combined savings of \$750,000. The very thorough decontaminations each cost about \$20,000 for chemicals and labor, plus 20 hours of outage time.

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From mid-1959 through 1961, full rear face decontamination was practiced on the relatively few occasions that a reactor was shut down for an extended outage involving substantial work in the discharge area. Good reductions in radiation levels were realized, and control problems with loose contamination in the discharge areas (including the general requirement for respiratory protection) were virtually eliminated. Procedures and equipment were further improved, particularly in preparation for the large-scale tube replacement program scheduled to start in January 1962.

During that same period, from screening work done by Hanford Laboratories, the two cleaning chemicals now in use were adopted. One is a modification of the original, with the advantages that (1) it contains no halides and hence is less suspect from a stress corrosion standpoint, and (2) it does not attack Zircaloy. The second new compound is a competitive bisulfate formulation. Reactor trials demonstrated both to be effective and safe decontaminants.

Studies showed that the decontamination waste can be released into the Columbia River without adverse effects. The spent cleaning solution cascades down the rear face of the reactor into the storage basin, the overflow from which joins the main reactor coolant effluent line to the Retention Basin. There are no river toxicity problems because the potentially toxic ingredients in the chemicals used are adequately diluted en route. The rate at which radionuclides enter the river during decontamination is less than that at which they enter when the reactor is operating.

Utilization in Tube Replacement Program

By the end of 1961, plans were firm for a mass replacement of process tubes in kind at the six smaller reactors, with the probability that Zircaloy tubes would be placed in the two K Reactors. It was evident that rear face piping decontamination would be essential in minimizing the manpower and reactor outage time required for this large effort. Program planning therefore was based on performing this decontamination at the start of each tube replacement outage. Methods engineering was applied to the repetitive procedural steps involved, and to the training of personnel in their use.

- In 1962 there were 22 such outages at the six smaller reactors, plus one at each K Reactor late in the year for testing tooling and methods to be used with Zircaloy tube installation in 1963. Pertinent data averages for the associated rear face decontaminations were:

	<u>Smaller Reactors</u>	<u>KE & KW Reactors</u>
Reduction in Radiation Levels - %	56	54
Outage Time Required - Hours	10	20
Chemicals Used - Lbs.	19,000	34,000
Manpower Used - Man-hours	160	420
Cost (Materials and Labor) - \$	6,000	11,500

The typical ranges of rear face radiation levels before and after decontamination are shown in Figure 1. Between cleanings the K Reactors reach substantially higher radiation levels than do the smaller reactors.

The total radiation exposure savings which resulted from these decontaminations was an estimated 445 roentgen for personnel involved in tube replacement work. This exposure savings made it possible to avoid hiring and training about 120 people in the critical crafts who otherwise would have been required. This represented an estimated salary cost savings of about \$950,000 for the year.

Decontamination expense for the year totaled \$161,000 for chemicals and manpower, and 264 outage hours were required. This time represented 5% of that spent in replacing tubes. As always, substantial benefits from these decontaminations also were realized in the performance of other outage work in the discharge areas (e.g., charge-discharge and regular maintenance).

The tube replacement program is continuing through 1963, and by June 1 there had been nine more such outages: Six at the smaller reactors and three at the K's. Full rear face decontamination preceded each, effecting personnel radiation exposure savings totaling 295 roentgen during tube replacement. This is an average of 32.8 R/outage as compared to 18.5 R/outage in 1962. Most of the additional savings were at the K Reactors, where the decontaminations were made especially thorough (73% reduction vs. 56% at the smaller reactors) to facilitate the more extensive rear face work involved with the installation of Zircaloy tubes. Moreover, for this work an extra shift crew was used and crew sizes were larger. The intensive K Reactor cleanings (which included debris from a failed fuel element) are reflected in the 9-outage cost total of \$83,400 for chemicals and labor, plus 141 hours of outage time.

With 13 outages involving tube replacement crews scheduled for the last seven months of 1963, including two at each K Reactor for Zircaloy tubes, it is estimated that exposure savings for these personnel this year will total 670 roentgen. This means that the work will have been accomplished with about 200 less people (in the critical crafts) than otherwise would have been required, and an estimated salary saving of about \$1,600,000 will have been realized. The cost of the 22 decontaminations is expected to total about \$200,000 for chemicals and labor, plus 300 hours of reactor outage time.

In addition to the large direct savings in outage work manpower which have been noted, rear face decontamination has been an important contributor to the high efficiency achieved in tube replacement. With relatively low exposure rates thus assured, it has been possible to plan and schedule this work with an over-all effectiveness never before attained. The crew sizes for unit operations and for each shift could be based on the work involved instead of on exposure time limits, and personnel could be assigned on a firm schedule. Moreover, the manpower normally could be utilized on a straight-time basis. In pre-decontamination practice, numbers of extra personnel had to be kept available for exposure purposes, many of whom were present on an overtime basis.

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Plans for Continued Process Use and Refinement

While the outlook is for much reduced tube replacement work after the current program is completed early next year, chemical decontamination will continue to be exploited in preparation for these and any other reactor outages involving extensive work at the rear face. Significant further improvements in the process are expected, particularly in its application through refinement of process control and reduction of costs for chemicals, labor, and outage time.

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FIGURE 1

Rear Face Piping Decontamination
Effects on Radiation Levels

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FIGURE 2
Rear Face Piping Decontamination
Schematic Flow Sheet

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FIGURE 1

Rear Face Piping Decontamination
Flow Through Connector and Nozzle

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After 100 Firing Decontamination
Cap Removal Operation

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PLATE 2

NOAR FACE PIPING DECONTAMINATION
Discharge From Loosened Japs

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FIGURE C

Rear Face Piping Decontamination
Discharge from Critical Caps

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