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PROGRESS IN REACTOR WATER PLANT OPERATION

FY-1958 THROUGH FY-1962

by

T. W. Hauff and P. G. McDougal

Manufacturing Operation
Irradiation Processing Department
Hanford Atomic Products Operation

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PROGRESS IN REACTOR WATER PLANT OPERATION

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INTRODUCTION

The water plants and associated steam back-up facilities which supply coolant to Hanford's eight production reactors are large and vital facilities. Their reliability is essential to the safety and continuity of reactor operation. Their output and efficiency are important to reactor productivity and to the unit cost of plutonium and other irradiation products.

In the fiscal year just ended, the cost of operating the reactor water and steam plants was \$16,000,000, which represented a major fraction (37%) of the total irradiation cost for the same period. Substantial improvements in water plant capacity and operating economy over an extended period are reflected in this operating cost figure. The purpose of this report is to highlight the capacity increases and cost reductions achieved during the five fiscal years 1958 through 1962.

As background for this five-year review, two important and interrelated water plant improvements completed by June 30, 1957 should be noted: (1) A new concept in filter plant operation had been devised and applied which has permitted water flow rates through existing filters more than two-three times those possible with conventional filter plant practices, and (2) the steam turbine and electric process water pumps used in series in the five older plants were replaced with higher capacity motor-driven units. These new pumps, coupled with associated pump and piping enlargements elsewhere in the plants, provided a 42% increase in coolant flow to the five reactors at a project cost of about \$37,000,000.

It should be noted also that successful performance of the I&E fuel element has enabled and provided incentive for the substantial further increases in coolant flow which have been achieved during the five-year period reviewed in this report.

SUMMARY

The major accomplishments in reactor water plant operation during FY's 1958 through 1962 can be summarized as follows:

1. Total water flow to the eight reactors during equilibrium full-power operation was raised from 743,000 gpm to 925,000 gpm. Under current reactor conditions, with coolant limiting power level, this 24% flow increase can be considered to represent a corresponding gain in production capability.

2. Continued development effort on the new water filtration process enabled these increased water flows to be handled by the existing filter plants with only minor modifications in filter media and piping. By the end of the review period, open publication of this new process and its great advantages had resulted in its adoption by several municipal water treatment plants.
3. Economies in water and steam plant operations and materials have resulted in cost savings exceeding \$10,000,000 in the five-year period. These savings resulted principally from chemical and coal cost reductions, personnel reductions, maintenance economies, and savings in purchased electricity through peak power control measures.
4. The foregoing water flow and cost achievements were accomplished without compromise or lapse of reactor coolant continuity. The emergency coolant back-up systems performed effectively on the occasions when unexpected loss or disturbance of primary electrical power caused the main process water pumps to trip out.

DISCUSSION

Increases in Reactor Coolant Flows

The substantial increases effected in coolant water flows to the reactors during equilibrium full-power operation are evident in the following tabulation (expressed as gpm in thousands):

<u>Date</u>	<u>5 Oldest Reactors</u>	<u>C Reactor</u>	<u>K Reactors</u>	<u>Total</u>
Mid-1957	353	84	306	743
" -1958	372	95	345	812
" -1959	402	95	352	849
" -1960	423	95	362	880
" -1961	436	99	366	901
" -1962	436	100	389	925

These equilibrium flow increases total 24% over the five-year period. With coolant limiting power level, as at present, this additional flow represents a corresponding gain in reactor production capability.

At all eight water plants, the flow increases were accompanied and/or permitted by appropriate changes in the hydraulic characteristics of the reactors. For example, substantial flow increases attended the replacement of solid

fuel elements with I&E type during the period Nov. 1957 through Dec. 1958. Further gains were achieved in all plants through continued improvement of filter flow rates, as described below, and by discontinuance of the practice of holding one process water pump in reserve as a standby spare.

At the individual plants, equipment changes which increased flow capacity included the following:

- (1) In C plant, a \$750,000 project completed in 1958 provided higher-capacity impellers for the process water pumps and associated other changes.
- (2) The B and C filtered water storages were interconnected in 1958, at a cost of \$104,000, permitting C's excess filtration capacity to supplement the overtaxed B filter plant.
- (3) Two additional river pumps were installed in the B-C Area in 1960 at a cost of \$240,000. These pumps enabled B and C Reactor flow increases, and allowed B-C to relieve the D-DR Area of water export to the chemical separation areas -- thus making more water available to the D and DR Reactors.
- (4) At the two K plants, work on a \$4,530,000 flow capacity expansion project was started in May 1960 and was 90% complete as of June 30, 1962. This project is providing additional river pumps, enlarged process water pumps, and associated changes which will raise the combined equilibrium flow at the two K Reactors to 400,000 gpm.

Improved Filter Plant Operation

As noted, achievement of these reactor coolant flow increases without filter plant expansion has been permitted by the development of a radically new water filtration process which replaced the alum-activated silica process at all eight water plants in the spring of 1957. Utilizing this new process, current maximum filter flow rates are about 7.5 gpm/sq. ft., as contrasted to the 5.5 gpm/sq. ft. which had been realized with alum and activated silica, and the 2.5 gpm/sq. ft. for conventional filter plant designs. The filter plant additions otherwise necessary during the last five years would have required the expenditure of about \$9,000,000 in capital funds, exclusive of the additional settling basins which might have been needed.

The new Hanford filter process differs from other alum processes in that no activated silica is used, and an organic polyelectrolyte (e.g., Separan) is added just prior to filtration. This additive serves to bind the floc together and thereby control floc shearing at the high velocities. In addition, the filter media has been changed by using especially graded sand and filter coal which allows the floc to be collected throughout the sand and coal beds, thereby allowing the filter to hold a much larger quantity of floc.

These water filtration developments have changed the process from one requiring pre-filter settling of most of the floc and impurities, with final

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- clarification in the filters, to one in which no prior settling is required and all of the floc and impurities are collected within the filter media. Moreover, longer filter runs between backwashes and reduced chemical costs have been achieved. The cost of polyelectrolyte in the first four years of the review period was about \$1,000,000 less than would have been spent for activated silica. Cost savings creditable to the use of polyelectrolyte in FY-1962 were substantial but are not shown because of the tripled alum feed rates used (for reactor effluent activity control) and the uncertainty that these high alum rates would be possible with activated silica. These gains have been realized with improved water quality, and closer control of quality, with resultant reduction of filming problems in the reactor process tubes. The added flexibility afforded by the new process has made it possible to maintain current high filter rates despite the tripling of alum feed.

Open publication of the technology and advantages of the new filtration process is permitting this development to be utilized by municipal and commercial water treatment plants to increase capacity and reduce operating cost in their existing plants, and to reduce the capital cost of new plants. In 1956 the very promising results obtained in a model water filter plant were given first publication, and in 1960 the highly successful full-scale experiments in the reactor water plants were described in the Journal of the American Water Works Association.

• The first municipal plant to adopt the Hanford process was Pasco, Washington, and Richland's new water treatment plant has been designed on this improved basis. Recent application of the Hanford process in the Eugene, Oregon, municipal filter plant has avoided about \$700,000 of capital cost which otherwise would have been required to provide the increased capacity. This Eugene application is described in the February 1962 issue of The American City, in which it states that this process is "the first major breakthrough in the science of water clarification since Fuller developed the rapid-sand filtration process in 1895". Currently off-project application of the improved Hanford process is proceeding rapidly, especially in the Pacific Northwest. It is noteworthy that in addition to the plant capacity and cost advantages, the municipal users expect to achieve improved control of certain viruses, eggs, and protozoa. A variation of the Hanford process, in which lime is used, allows a substantial reduction of water hardness.

Economies in Operating Cost

Continual cost reduction effort throughout the five-year period enabled the complete offsetting of general escalation and the higher costs of purchased power, materials, and other costs associated with the increased water flows. As shown in the following table, these operating cost economies have totaled almost \$10,000,000 in the last four fiscal years:

Fiscal Year	Water Pumped to Reactors (Million Gals.)	Total Operating Cost (M\$)		Oper. Cost Savings (M\$)
		Actual	At FY-1958 Unit Cost	
1958	340,000	15,689	15,689	--
1959	372,000	15,155	17,164	2,009
1960	399,000	15,855	18,410	2,555
1961	406,000	15,583	18,733	3,150
1962	390,000	<u>15,817</u>	<u>17,995</u>	<u>2,178</u>
Totals		78,099	87,991	9,892

FY-1958 is used as the base for this savings derivation because it was the first full year of operation following water plant expansion work in the five older plants. The significant cost economies effected during that year are in addition to the 4-year total shown. The FY-1962 drop in total reactor water pumped reflects reactor downtime for tube replacement.

The specific cost reduction achievements most responsible for these very substantial savings are summarized below.

(1) Decreased Chemical Costs

Prior to the period covered by this report, dry aluminum sulphate (alum) was the standard filter plant coagulant chemical used in the six older plants, and liquid alum was standard in the two K plants. Efforts were begun in 1957 to develop a continuous process using crude bauxite and sulfuric acid as an economical substitute for alum. By January 1961 two water plants were using this new process successfully. Meanwhile the other four older plants had modified existing dry alum equipment and changed to the lower-cost liquid. In July 1961 these four plants adopted the new bauxite-sulfuric acid process.

In FY-1962, the first year with all six of the older water plants using the new coagulant process, and with tripled coagulant feeds being used for reactor effluent activity control, a saving of about \$550,000 was realized over what dry alum would have cost at mid-1957 prices. Reductions in liquid alum prices over the five-year period yielded a savings of about \$280,000, including \$150,000 saved at the two K plants in FY-1962 with the tripled alum feed rates and the \$10/ton alum price reduction induced by the competitive nature of the new bauxite-sulfuric acid process.

Since 1957 all of the six older water plants have changed from the use of dry sodium dichromate to the liquid form as a process water additive. The K plants were equipped initially to use liquid

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chemicals exclusively. Stimulation of keener competition from foreign and domestic dichromate sources, together with substantial reductions in transportation costs achieved by the Traffic Operation, resulted in a four-year savings of about \$160,000 (using FY-1958 as base). In FY-1962, a substantial reduction in dichromate addition rates reduced expenditures for this corrosion inhibitor by about \$220,000. Other lesser reductions in addition rate saved a total of \$125,000 in the previous three fiscal years.

(2) Reduced Coal Costs and Inventory

Since 1957 increasing emphasis has been placed on value and quality in the steam coal purchased for Hanford. Compared with FY-1957, a cumulative coal cost savings of about \$1,180,000 was realized in the six older water plants based on actual steam generation for the five-year period. Comparable steam cost benefits were realized during the same period in the other HAPO departments.

This cost reduction was brought about mainly by the following: A wider selection of prospective suppliers resulted in a 20% increase in BTU's per dollar of coal cost; a revision in specifications resulted in more uniform sizing of the coal purchased; a change in sampling methods and locations yielded better quality control; a more realistic premium-penalty clause was inserted in the coal contracts; and a substantial increase in boiler house efficiency was accomplished by operating personnel.

Coal stockpiles in the reactor areas were reduced by about 50,000 tons during the five-year period, representing \$460,000 less investment in inventory.

(3) Reduced Personnel

Water and steam plant personnel were reduced from 485 on 7/1/57 to 411 on 6/30/62. Over the five-year period, this personnel reduction has saved a total of about \$2,270,000. At current rates, this reduction represents an annual payroll saving of about \$635,000. Approximately half of the reduction was accomplished in FY-1958, as related mainly to personnel economies permitted by the water plant changes made the previous year. The balance of the force reduction resulted from operational economies such as the elimination and combination of operator functions, and the reduction of relief personnel.

(4) Reduced Maintenance Costs

Substantial economies in water and steam plant maintenance costs have been effected during the review period. Using the FY-1958 expenditure level as a base, savings totaling about \$1,740,000

have been achieved during the ensuing four fiscal years. A substantial factor in these savings has been the reduced maintenance associated with (a) the new and larger pumping facilities which in FY-1957 replaced the original multiple units in the five older water plants, and (b) the attendant reduction in boiler plant steam loads. The other principal factor has been the improvement in maintenance work efficiency through better manpower utilization, closer planning and scheduling, and the extension of preventive maintenance effort.

(5) Electrical Peak Power Control

During the period under review, the power contract for HAPCO was based on a demand rate which provides for paying demand charges for a period of eleven months following a new firm power peak. Recognizing that the plant load was highly variable due to reactor outages, the use of supplementary interruptible energy for cost control was initiated in 1956.

Commencing with plant startups following the water plant expansion project in FY-1957, a program of closely regulating electrical usage was adopted to minimize out-of-pocket costs for electrical energy. This program combined use of available generation in the K water plants, judicious purchase of interruptible power, and scheduling of significant loads to effect savings over the comparable cost of firm power alone. Net savings from this program have totaled about \$800,000 for the five-year period. The reduction of the firm power base resulting from this program was of special value in FY-1962 because of the reduced plant load which attended extensive process tube maintenance in the reactors.

Continuity of Coolant Flow

It is important to note that the water flow increases and cost reductions described above were achieved without compromise or lapse of reactor coolant continuity. Moreover, the emergency coolant back-up systems and the operating personnel performed effectively on the fourteen occasions when unexpected loss or disturbance of primary electrical power at one or more of the water plants caused the main process water pumps to trip out. The loss of primary power in April 1962 affected all eight reactor water plants for the first time in Hanford history. The emergency back-up systems all functioned well again in early July when a voltage surge in the BPA system tripped out all process water pumps in the eight plants.

At the close of the review period, work was under way on two water plant projects for further improvement of coolant back-up reliability: (1) In the K plants a \$2,000,000 project is essentially complete which provides a

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central diesel-powered pumping station supplying either reactor, and steam-driven back-up pumps at each reactor; and (2) in the six older water plants a \$391,000 project has just been started to modify the inter-area water connections and the reactor high-tank systems. In addition, miscellaneous work is in progress in the four older areas to improve protective relaying and steam boiler response characteristics.

Prepared By:

T. W. Hauff
T. W. Hauff, Specialist - Plant Programs
& Practices

P. G. McDougal
P. G. McDougal, Engineer - Power Operations

Manufacturing Operation
Irradiation Processing Department
Hanford Atomic Products Operation

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