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TITLE

100-B AREA FLOW ANALYSIS

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100-B AREA FLOW ANALYSIS

by

W. D. Bainard *WDB*
Systems Design Operation

June 1, 1957

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100-B AREA FLOW ANALYSIS

INTRODUCTION

Results of experimental programs indicate that it might be desirable in the future to modify the existing reactors by replacing the aluminum process tubes with tubes made of a zirconium alloy. The zirconium tubes would be more corrosion resistant than the aluminum ones and would also be stronger at higher temperatures. These new tubes would have the same outer diameter as the present tubes (for ease of handling and in order to provide adequate graphite cooling) but would have a thinner wall (since zirconium alloy is both stronger and more expensive than aluminum). The inner diameter of the new tubes would, therefore, be greater than in the present tubes.

In addition to the tube change, it might also be desirable to replace the existing solid fuel elements with those known as "I&E" elements. These pieces would be similar to the present elements except for a longitudinal hole which would allow the passage of cooling water through the center. The element would then be Inter-nally and Ex-ternally cooled, and would have a more uniform temperature distribution.

The combination of the larger tube inside diameter and the central hole in the fuel element would result in reduced friction loss for the reactor cooling water with a resulting increase in flow.

The 100-B process water system was chosen arbitrarily for analysis and this analysis was undertaken to determine if the process water system would be capable of providing the additional flow required by the modification.

CONCLUSIONS

A. Spare Pump in Each Pumphouse

If present practice of maintaining one installed pumping unit in each pumphouse as a spare were continued, the present process water system would be capable of supplying a process flow of not more than 76,000 gpm after the installation of zirconium tubes and I&E slugs.

B. No Spare Pumps Available

If the spare pump philosophy of operation were abandoned and all pumps were utilized, the pumping system would be capable of providing a process flow of not more than 83,000 gpm after the installation of zirconium tubes and I&E slugs. Other portions of the system, however, would require modifications. It would be necessary to install another main transformer and associated equipment in the 151 Building at a cost of about \$800,000.* It might be necessary to make modifications to the filter plant effluent piping and controllers at a cost of about \$100,000.*

* Preliminary estimates - order of magnitude only.

RECOMMENDATION

A simple draw-down test should be made on one of the 183 filters with the flow controller blocked wide open. It is necessary to know the hydraulic capacity of a filter in order to accurately predict filter plant capabilities.

DISCUSSION

General

The 100-B flow system consists of eight separate parts, each with a source of energy and an energy requirement. These parts are:

1. 181 to 183 Building by pump.
2. 183 to clearwell by gravity.
3. Clearwell to 190 by pump.
4. 190 to reactor rear face by pump.
5. Top of rear face to bottom of downcomer by gravity.
6. 105 to 107 by gravity.
7. 107 to 1904 by gravity.
8. 1904 to river by gravity.

Step 4 is the controlling step; all other parts must provide the flow needed by Step 4. Each part has been studied separately for maximum capacity.

Equivalent lengths of fittings were determined from a Tube-Turns chart.

The head losses were determined by the empirical Williams and Hazen formula using a surface roughness factor, C , of 100. A ten percent upward correction to head loss was made for viscosity correction for cold water (approx. 32°F) and a ten percent downward correction was made for hot water (approx. 180°F).

An additional head loss of ten feet was added to all pumped flows as a nominal control valve loss since it is not common practice to run pumps unthrottled.

190 to Reactor Rear Face

The pump characteristic curve, shown in Figure 1, is a curve of pump discharge pressure versus flow. The curve is plotted from data taken during a pump test at 100-F Area on April 27, 1957. The test pump had the modified wear ring and trimmed impeller which have been proposed for installation at 100-B. The discharge pressure curve was corrected to a suction pressure of 35 feet (15 psig).

The pressure-flow curve for the piping from the pump discharge to the bottom of the front face riser was obtained by calculation, using the piping from the furthest pump. For simplicity, it was assumed that flow valves would be adjusted so that the flow from all operating pumps would be equal.

The pile pressure-flow characteristic for both cold and hot conditions were plotted from data obtained from K. W. Hess, Reactor Engineering Operation. (See Figure 5, Page 11). The piping friction curve was added to the zirconium tube - I&E slug condition curves to give the total system curves as shown in Figure 1.

Figure 1 shows a hot flow of 83,000 gpm with 8 pump operation (no spare) and a flow of 81,000 gpm with 7 pump operation. Design Engineering recently made a study* of the electrical requirements of the 190-B Building for a proposed flow increase to 80,000 gpm. This study showed that no electrical modifications would be required. Examination of the background calculations has shown that the electrical requirements for the 83,000 gpm flow can also be carried by the existing 190-B equipment.

181 to 183

The system considered for this portion of the analysis consisted of pumps B-8, B-9, B-10, and B-11, (see Page 12) all discharging through the old 42 inch raw water line, around the 182 Building by-pass, and discharging into the north side of the filter plant through the fully open cone valve and its by-pass. It was assumed that pumps B-12, B-13, B-14, and B-15 would discharge through the new 48 inch line into the south half of the filter plant and would be throttled at the 183 cone valve to give a flow equal to the north half. Pumps C-14, B-7, and B-17 are intended primarily to supply water to the 182 Building for export to the 200 Areas. Should a separate supply be provided for the 200 Areas, these pumps could be utilized to assist in pumping to 183-B. These pumps were not included in this analysis.

Figure 2 gives the pump curves and system curves for 7 and 8 pump operation and for high and low river elevations. The pumping capacity of the 181 pump house varies from a high of 99,000 gpm with 8 pump operation (no spare) at a high river elevation to a low of 85,000 gpm with 7 pump operation at low river elevation. Although the flow per pump would be increased some ten percent over the design point at a flow of 92,000 gpm, the electrical requirements to the 181 Building would not increase since the power requirement curve is quite flat for this type of pump in this range.

183 to Clearwells

Because of the large number of variables and unknowns involved, the filters do not lend themselves to calculation of capacity. Originally designed for a flow rate of 2.6 gpm per square foot of filter area, they are now operating at about 6.2 gpm per square foot. Since flow rates of 2.0 gpm per square foot are common commercial and municipal practice, and rates greater than 3.0 gpm per square foot are forbidden by law in many states for municipal water plants, there have been no methods devised for computing filter pressure losses at the filter rates used as Hanford.

* HW-48415, "Budget Study Report, Increased Electrical Power Capacity - Reactor Water Plants", W. R. Thorsen, E. L. Etheridge, Unclassified, dated February 12, 1957, Page 5.

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The flow resistance through a filter as used at Hanford is due to three parts; the filter media itself, the filter effluent piping, and the filter flow controller. Any or all of these resistances may be reduced.

It is possible to reduce pressure drop through a sand and/or anthracite filter bed by using a coarser grade of media. This results, however, in lower quality water. Experiments currently being conducted by Research and Engineering Operation indicate that an intermediate layer of powdered graphite may enable high quality at low pressure drops. Because of the many variables involved, the full results of this investigation will not be obtainable for some time.

The pressure loss in the filter effluent piping may be reduced only by replacing the present piping with a larger size. It appears that the advantage gained here would be small in relation to the cost involved.

The present flow rate controllers necessitate two 90-degree elbows, a venturi with a fairly high pressure loss, a guillotine valve, and a five foot horizontal run. All this could be replaced by one 90-degree elbow and a butterfly valve. The conversion of twelve rate controllers in this manner would cost on the order of \$100,000 and would result in an increase of 12,000 to 15,000 gpm for the filter plant.

100-B Area is currently operating with one-half filter producing sanitary water only. This arrangement will remain in effect until Separan is approved for sanitary water treatment or until a separate source of sanitary water is provided. This leaves 11.5 filters for filtered water production. The loss of this half filter from process service results in a capacity reduction of 3500 to 4500 gpm. The half filter produces, instead, about 200 gpm of sanitary water.

Of the filtered water produced at least 90 percent goes to the reactor with less than 10 percent being used for filter backwash, shield cooling, chemical make-up, and other non-process uses. In order, therefore, to provide the 83,000 gpm maximum flow to the reactor, as shown on Figure 1, a filter plant flow of about 92,000 gpm would be necessary. This would require an average filter flow rate of 8,000 gpm and an instantaneous flow rate of 8400 gpm (allowing a 5 percent "down time" for filter backwash). Flow rates of 7200 gpm have been maintained for filter runs of about 10 hours with the controllers now installed. With a spool piece installed in place of the controller in a filter at 100-H, a flow rate of 8300 gpm was obtained. Filter runs of 5 to 10 hours can be obtained at these flow rates and are practical.

Since the time of this test, the filter media used at Hanford has been changed slightly and it is believed that flow rates of 8500 gpm per filter would be obtainable if the flow controllers were fully open. In order to operate at this flow rate, the flow controllers would no longer be controlled by the filter flow rate but only by the clearwell level.

Should a test show that the present filters cannot pass flows in this range, the replacement of the present rate controllers with butterfly valves, as discussed above, appears to be the most practical method of obtaining the flows required.

183 to Pump Room to 190 Storage Tanks

The pump characteristic curves, shown in Figure 3, were taken from manufacturer's test data. The system curve was calculated assuming equal flows from each oper-

ating pump and equal flows through each of the two lines between the 183 and 190 Buildings.

A flow of 86,000 gpm could be delivered using 6 pumps (no spare) while only 80,000 gpm would be possible with 5 pumps.

The 183 clearwells were assumed to be filled to a depth of 15.0 feet and the 190 storage tanks to a depth of 39.0 feet. The static head change is 56.0 feet for these two levels.

The 190 tank cone valves were assumed to be open or nearly so.

Effluent System

The downcomer consists of a vertical pipe, rectangular in cross-section, with horizontal shelves on alternate sides. The reactor effluent cascades from one shelf to the next as it flows down the downcomer. A flow increase, such as discussed in this analysis, would result in raising the water level in the bottom of the downcomer two to three feet above the top of the effluent pipe. No modifications would be required to handle the increased flow.

The pressure-flow curves for the remaining three portions of the effluent system are shown in Figure 4.

It will be seen that flows up to the limit of the pumping system could be handled without modification to the systems. All data used in these calculations were conservative.

Electrical Requirements

The additional electrical load of running all connected pumps continuously would bring the main area transformers dangerously close to overload, especially in the summer when transformer cooling is reduced. The cost of a fourth transformer, installed and operating, would be approximately \$800,000.*

REFERENCES

The pump characteristic curves were obtained from the blueprint files.

181 pumps	BPF 8858
183 pumps	BPF 8828
190 pumps	BPF 8834

The actual 190 pump discharge pressure curve was obtained by personal communication with M. H. Schack.

Pile characteristic curves were obtained from HW-49651, "Reactor Flow Capabilities," K. W. Hess.

ACKNOWLEDGEMENTS

The author would like to express appreciation to the 100-B Power Operation, and to W. R. Conley, M. H. Schack, and E. L. Etheridge for their assistance in making this study.

* Author's estimate - Order of magnitude only.

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10 X 10 TO THE INCH 359-5
 NEWFEL & ASSOCIATES, INC.
 BALTIMORE, M.D.

FIGURE 1

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10 X 10 TO THE INCH 359-S
NEUFFEL & ENSEN CO. MADE IN U.S.A.

FIGURE 2

K&E 10x10 TO THE INCH 359-5
NEUFELDEN CO. MAINTENANCE

FIGURE 5

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