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EFFECTS OF 100-K WATER PLANT EXPANSION ON PANELLITS AND ORIFICES

I. INTRODUCTION

The information reported here was requested by M. H. Schack, Facilities Engineering Operation. It pertains to the 100-K water plant expansion Project CG-775. In this project, cooling water pumping capacity will be increased from 178,000 GPM existing to 188,000 GPM and 200,000 GPM for five and six modified pumps respectively.

Effects of increased through-put on process tube flow metering elements and on the reactor Panellit gauges have been examined. This information was required to determine cost of modifications if any were required. It was understood the precision of the cost estimate was to be about ± 40 percent.

II. CONCLUSIONS

As a result of the increased process water flow through K reactors, no modifications are necessary to the orifices or venturis. The Panellits will require a mechanical adjustment. The need for such an adjustment already exists and the work has already been planned.(1) If the maintenance proposal is approved, no expenditure of money for Panellits should be required in conjunction with

(1) Verbal communication from W. E. Vetter.

II. CONCLUSIONS (Continued)

the pump expansion. If approval is not obtained, $20.00 per Panellit or a total cost of $128,800 from CG-775 funds would be required to pay for the work.

In some cases it appears that a TAI limit of 130°C may not be met by existing orifices with increased flow rates. However, in all these cases, the 130°C TAI limit could not be met by existing flow rates. From the standpoint of other orifice criteria checked, critical flow, minimum Panellit pressure on cap or pigtail failure, and velocity to cause errosion, the existing orifices and venturis appear adequate.

III. DISCUSSION

A. Analysis

The expected Panellit pressure increases were estimated on this basis: the flow through an orifice is given by $F = K(\Delta P)^{0.5}$ where

F = flow, gpm.
K = constant determined by properties and geometry of system.
ΔP = front crossheader pressure minus Panellit pressure, psig.

Increasing flow from 178,000 to 200,000 GPM is a 12 percent increase or $1.12\ F = K(1.26\ \Delta P)^{0.5}$. Thus pressure drop is increased by 26 percent. The increase in front crossheader pressure, P_F, for a 12 percent increase in flow through the same resistance is approximated by $(1.12)^{1.8} = 1.22$ or a 22 percent increase. The new conditions are related to existing conditions by $1.26\ \Delta P = 1.22\ P_F - NP_p$. The coefficient of the Panellit pressure N was evaluated by substituting actual values for ΔP and P_F from KW reactor operating data.(2) Calculated values for a number of tubes in each orificing zone are given in the Appendix. The value of N is about 1.20 or Panellit pressures are expected to increase by about 20 percent across the board using six pumps. Five pumps result in an estimated 9 percent increase in Panellit pressure.

B. Adequacy of Existing Panellits

Existing Panellit pressures, tabulated in the Appendix, range from 187 to 242 psig. Corresponding Panellit pressures for the new cases are 203 to 292 psig; the increases are around 20 and 50 psig for five and six pumps respectively. Thus the highest anticipated base pressure is around 242 lbs. The existing Bourdon tubes can handle base pressures of ± 100 psig centered around a maximum initial base of 320 psig. The Panellit gauges can be "rolled" to change base for a range of ± 100 psi around the initially chosen base point. Rolling the gauges beyond these limits tend to cause mechanical binding and loss of sensitivity. Because many of the Panellits on K reactors are already near the upper limit of base pressure changes, a proposal has been initiated to extend operating range. To extend the range, mechanical adjustment is required to relieve the binding. The gauges must be removed from the panel board to do the work.

(2) Jones, S. S., "KW Reactor Operating Limits," HW-61726, dated October 12, 1959.

III. DISCUSSION (Continued)

B. Adequacy of Existing Panellits (Continued)

At that time the gauges can be adjusted to anticipate the rise in Panellit pressure coincident with the pump capacity expansion. The pump project is expected to be completed in 1962. If for any reason the Panellit maintenance plans fail to materialize by then, the work will have to be done for the express purposes of the water plant expansion.

The above information relative to Panellits was obtained from W. E. Vetter, Components Testing.

C. Adequacy of Existing Orifices

To determine suitability of the existing orifices and venturi meters, the following criteria were checked:

(1) Critical flow through the orifice assembly.
(2) Minimum Panellit pressure in case of cap or pigtail failure.
(3) TAI pressure limit.
(4) Orifice errosion.

These criteria all appear to be satisfactorily met by the existing metering elements and the new flow conditions. The exception is orifice errosion where a firm criterion was not found. Evaluation is given below.

(a) Critical Flow

The Panellit pressure associated with critical flow was evaluated from experimental and analytical work on K reactor orifice assemblies.(3)(4) A cavitation constant was evaluated from experimental data for orifice zones 2, 3, and 4 from the expression, $K = \frac{P_F - P_c}{P_F + 15}$, where Pc is critical pressure at Panellit. The cavitation constant was then used to solve for Pc using the new front crossheader pressure accompanying the flow increase. Results are given in Table I.

A cavitation constant is not available for the venturis because cavitation has not been observed in the range of velocities and pressures used for reactor flow tests. The new flow rates fall within that range.

Table I shows that the new flow rates with existing orifice assemblies will not result in a pressure drop great enough to produce critical flow conditions. The anticipated Panellit pressure is well above critical values for both five and six modified pumps.

(3) Waters, E. D., HW-48768, "Status Report on K Reactor Re-Orificing Studies," dated February 25, 1957.
(4) Waters, E. D., Undocumented, "Flow Tests of Vendors L.B. Secondary Orifices - K Reactors."

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III. DISCUSSION

C. Adequacy of Existing Orifices (Continued)

(a) Critical Flow (Continued)

The two values given in the table for flow and pressure represent the high flow extremes for the particular crossheader picked as typical of the zone.

(b) Panellit Pressure in Case of Cap or Pigtail Failure

It is desired that the minimum pressure to which the Panellit pressure sensing point falls is some value well below normal operating range. This is not a problem for the venturis and zone 2 orifices where the Panellit pressure tap is at the vena contracta. In those zones pigtail or cap failure could cause a decrease in Panellit pressure all the way down to zero psig. Zones 3 and 4, however, contain both a primary and secondary orifice with the Panellit sensing line in-between the two. Thus, even if the pigtail or cap should rupture, a pressure reading is possible on the Panellit due to the pressure drop through the second orifice. To provide an adequate safety factor it is desirable that normal operating pressure is at least 100 lbs. greater than the minimum. That is, minimum expected pressure should be at least 50 lbs. below zero on the Panellit. The minimum is raised by the proposed flow rates, however, the condition is still met by both zones as shown in Table II. The values were calculated by evaluating a constant from experimental data (3)(4) based on existing conditions in the same manner that the cavitation constants were evaluated.

(c) TAI Limit

The "Trip After Instability" tube outlet temperature limit is 130°C for the K reactor normal Panellit operating range of 65 psi. Corresponding to these conditions, Panellit low trip pressure must not be less than 200 psig. (5)

Table IA in the Appendix gives estimates for Panellit pressures for both 5 and 6 pumps. The particular tubes listed are extremes in flow for each crossheader picked and are either extremes in flow for the entire orificing zone or are only about 1 gpm away from the minimum or maximum. Low trip would be, in general, equal to the tabulated pressures minus 25 psig. assuming the Panellit is reading mid scale. It is apparent that Tube No. 2848 does not meet TAI requirements for 6 pumps and Tubes 2848 and 176 fail for 5 pumps. However, at existing flow rates, some 215 tubes do not meet the TAI limit of 130°C. (This assumes that all Panellits

(3) Waters, E. D., HW-48768, "Status Report on K Reactor Re-Orificing Studies," dated February 25, 1957.

(4) Waters, E. D., Undocumented, "Flow Tests of Vendors L.B. Secondary Orifices - K Reactors."

(5) HW-46000K, "Process Standards - Reactor," August 1957, Pages 2-4.

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III. DISCUSSION

C. Adequacy of Existing Orifices (Continued)

(c) TAI Limit (Continued)

were properly rolled so that actual Panellit pressure is given by base pressure as reported in HW-61726, plus 50 psig.) The increased flow rates undoubtedly improves the situation since Panellit pressure has been raised as a result of the flow increase. At the present time, bulk outlet temperature limits are reached before TAI limits which represent an ultimate. If the situation changes so that TAI limits become truly limiting, then more orifices would need to be modified with the existing pumps than with the new pumps.

(d) Errosion

The new flow rates result in orifice linear velocity increases of 5.5 and 12 percent for five and six pumps respectively. Ranges of velocities are given in Table III on Page 7. In the case of zones 3 and 4, the velocities listed are through the primary orifices which are limiting.

A firm criterion for orifice errosion was not found. However, E. D. Waters stated that existing velocities do not cause an errosion problem in K reactors. Based on this statement and the relatively modest increases, it is assumed orifice errosion will not become a problem.

D D Stepnewski

Reactor Design Analysis
Process Design Sub-Section
NPR PROJECT SECTION

DD Stepnewski:vls

TABLE I

Orifice Zone	Six Pumps			Five Pumps		
	Flow Rate GPM	Panellit Pressure, Psig	Panellit Critical Pressure, Psig	Flow Rate GPM	Panellit Pressure, Psig	Panellit Critical Pressure, Psig
4	32.8	292	169	30.8	264	152
	36.2	244	169	34.1	221	152
3	36.8	286	174	34.7	260	155
	40.0	262	174	37.8	238	155
2	45.0	264	184	42.5	240	164
	42.5	291	184	40.0	263	164

APPENDIX - TABLE IA

Orifice Zone	Fuel Element	Cross Header No.	Tube No.	Crossheader Pressure, Psig			Panellit Pressure, Psig			Panellit Pressure Percent Increase	
				Existing	5 Pumps	6 Pumps	Existing*	5 Pumps	6 Pumps	5 Pumps	6 Pumps
4	0	1	150	394	434	483	242	264	292	20	9
4	0	1	176	394	434	483	204	221	244	20	8
3	0	2	263	390	430	478	238	260	286	20	9
3	0	2	277	390	430	478	218	238	262	20	9
2	0	3	370	383	422	470	220	240	264	20	9
2	0	3	360	383	422	470	241	263	291	21	9
1	2KNC	4	465	382	421	468	235	256	283	20	9
1	2KNC	4	475	382	421	468	213	232	255	20	9
1	2KNC	28	2848	361	398	443	187	203	221	19	8.5
1	2KNC	28	2859	361	398	443	235	257	282	20	9.2
1	2KNC	55	5566	381	420	468	236	258	284	20	9
1	2KNC	55	5575	381	420	467	219	239	263	20	9

* 50 psi was added to base pressures reported in HW-61726.

TABLE II

Zone	Panellit Pressure Psig			Panellit Pressure On Failure of Pigtail Or Cap, Psig		
	Existing	5 Pumps	6 Pumps	5 Pumps	6 Pumps	Existing
4	204-242	221-264	244-292	112	127	78
3	218-238	238-260	262-286	94	106	89

TABLE III

VELOCITY THROUGH ORIFICES FT./SEC.

	Existing	5 Modified Pumps	6 Modifed Pumps
Zone 4	161-178	170-138	180-199
Zone 3	160-174	169-184	179-195
Zone 2	155-164	164-173	174-184
Zone 1	139-153	136-161	145-171

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