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March 31, 1949

PILE OPERATION AT HIGHER POWER

ROSEBUSH OSTI

Introduction

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This memorandum presents a summary of current technical considerations on the feasibility of operating the piles at higher powers. These were reviewed by Messrs. Greninger, Gross, Maider, Lee, Woods and Wende on March 28, and are recorded here as a basis for further action to be taken by the Manufacturing Divisions.

Summary

Problems of safety control, water activity, and corrosion now appear to be well enough in hand to permit a cautious increase in the power level of the D Pile. Requirements for safety of operation during operation at higher levels are given, and a program for power increases over the next several months is outlined.

Discussion

1. Developments since the last report.
2. Choice of pile for advance in power.
3. Requirements for safety of operation at higher power.
4. Recommended course of action.

1. Developments since last report: In a review of the prospects for increasing pile power which was made last August, (Pile Operation at Higher Power, Wende to File, August 4, 1948, HW-10644) it was pointed out that the principal requirements were:

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- (1) An increase in safety control, which might be relatively slow-acting.
- (2) A means of reducing outlet water activity.
- (3) Further data on corrosion at higher temperatures.

These requirements are now very close to being satisfied, as follows:

(1) For emergency control, cadmium-plated splines have been made which were readily inserted in flow lab mockup tests and which gave satisfactory neutron absorption in the 303 Test Pile. After corrosion tests in the flow laboratory and final functional tests under a Production Test in a 103 Pile, it is expected that these splines will be ready for operation. Delivery of the required quantities of splines was scheduled for March 1, and is expected momentarily.

It is recognized that the current requirements for safety control are conservative, and may be subject to some relaxation after the power coefficients of a dry pile are measured late this year.

(2) Power Division tests on reduced silicate feed at the B Pile appeared to cut the activity of the effluent water nearly in half during several months of operation. During the last month, however, there has been an increase in both the sodium and the manganese activity. The sodium content of the river water is known to have seasonal variations, and the present high level has been tentatively ascribed to an abnormally high run-off in the Soap Lake region. The reason for increased manganese activity is not known.

Silicate reduction so far has shown no marked effect on the rate of film formation or corrosion, and a Production Test is in preparation to cover further reductions of silicate feed. It appears reasonably clear that outlet water activity will not limit the power output for normal conditions of operation. Data on this point have been summarized by U. M. Staebler in Document No. HW-12335.

(3) Corrosion tests performed under Production Test 103-103-P have shown that outlet water temperatures of at least 70°C. can be used with minor increases in corrosion rate. These tests were made by throttling the water flow; consequently the effect of an increased heat flux, with correspondingly higher temperatures at the interface between slug and film, is unknown. There is, however, no reason to expect an abrupt change; and there appears to be nothing in the corrosion picture which need delay a cautious advance to higher powers.

2. Choice of Pile: Considerations which enter the choosing of a particular pile to act as pilot for an advance in power are summarized below, and the D Pile is indicated as the logical candidate.

B Pile: The vertical rod system is in good shape, and the pile is distorted considerably less than D or F. It is so far continuing to expand at a measurable rate, and high power tests on this pile might give measurements of minor importance

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on the influence of temperature on the rate of "neutronic" annealing. Silicate feed is already reduced to 2.5 ppm., and outlet water activity would be minimized. There might be some benefit to a Production Test on film formation which is now in progress.

D Pile: Probably the greatest single advantage of the D Pile is that it is backed up by DR. It also has three extra pumps so that it can operate at 380 psi header pressure if desired, and has sufficient filter capacity to supply 41,000 gpm. It has better instrumentation for temperature and strain measurements, and will have a new retention basin available soon in the improbable event that difficulty with slug failures should develop.

F Pile: F Pile is in the worst shape of the three, and is the last pile on which any risk should be taken at present. It has been cleared policywise for operation at higher carbon dioxide concentrations, and it appears desirable to hold it at the present power level until information on higher power is available from experience at the D Pile.

Production Tests and Special Irradiations will be substantially unaffected regardless of which pile is taken to higher power.

3. Requirements for safety of operation at higher powers: A table of the expected characteristics of the D Pile at various power levels is given below. It is assumed that the carbon dioxide concentration will remain at 40%, that 20 in are allowed for startup, 40 in will be retained in the rods at turnaround, and 70 in will be retained during level operation for recovery from scrams up to 30 minutes in length.

Power level - MW	275	325	350	400
Min. shutdown time, hours (0% Push)	17.6	18.5	19.1	20.3
Max. shutdown time, hours (full level)	24.0	19.6	19.6	--*
Max. shutdown time, hours (reduced level)	29.0	24.6	23.7	22.3
	(125 MW)	(150 MW)	(150 MW)	(200 MW)
Residual flattening, in (70 in in rods)	450	400	375	325
Increase in cooling water temperature in flat zone (Δt_w) °C.				
Average for level operation	36	44	48	55
Maximum for level operation	43	53	57	66
Maximum during full power start up**	61	75	81	92
Central Graphite temperatures in flat zone - °C.				
Average for level operation***	240	284	306	350
Local max. for level operation***	290	343	369	421
Local max. during full power start up***	328	--	--	--
Vertical rod thimble temperatures in flat zone - °C.				
Average for level operation***	245	290	314	360
Max. for level operation***	296	330	379	432
Max. during full power start up**	335	--	--	--

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Temperature of central uranium slugs in flat zone - °C.

Average surface temperature, level operation	51	61	65	72
Max. surface temperature, level operation	60	70	74	81
Max. during full power start up**	75	--	--	--
Average axial temperature, level operation	152	172	182	196
Max. axial temperature, level operation	170	192	200	216
Max. during full power start up**	206	--	--	--

Thermal expansion of graphite packing
in inches (from shutdown to level
operation)

0.21 0.25 0.27 0.31

Average m/hr at 107 exit (both
basins without silicate reduction)

2.65 3.13 3.37 3.85

*Reduced level start-up required for reactivity reasons beyond 350 MW.

**Reduced level start-up required for the reason of excessive tube outlet temperatures beyond 275 MW.

*** No allowance has been made for probable annealing of the graphite thermal conductivity effect at elevated temperatures.

The following requirements are believed adequate to assure safety of operation:

1) Power should be increased stepwise, in small enough steps and with each step taken slowly enough to satisfy these conditions:

(a) Graphite temperature limits must not be exceeded. In view of recent data on stored energy, it will be well to stay within these limits by a wide margin.

(b) Changes in pile dimensions and temperatures should be followed closely.

(c) The power should be held at several levels, e.g., about 300 and 325 MW, long enough to obtain at least qualitative evaluations of corrosion and rate of film formation.

(d) The size of the steps will be governed in part by the necessity for adjusting the poison pattern. Steps of 15-20 MW appear practical. Depending on the outcome of further tube elevation traverses, it may be decided to load these columns so as to shift the flux upstream.

(e) Coefficient tests should be made at several levels, preferably about 300 and 325 MW.

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2) The 70-pound screw limit on header pressure should be reduced; or, at the option of the P and Power Divisions, the header pressure may be increased to 380 psi by using the three extra pumps. The latter course is preferable for safety reasons if no insurmountable operating difficulty is involved.

3) Replace the third safety solution with a high-boiling liquid as soon as one is available. This need not delay the advance to higher power.

4) Intensify the program of measuring increasing gunbarrel slope, curvature, and elevation, and increase the frequency of tube traverses. This may reduce the operating efficiency of the pile, but such reductions would be small in comparison to the gain in productivity achieved by higher power.

4. Recommended course of action: It appears quite reasonable to shoot for a goal of 330 MW on the D Pile over the next several months. Power increases can be begun as soon as the splines are ready for use.

With the pile leveled out at 275 MW, it is proposed that an increase of 15 MW be made over a period of 4-6 hours. This would be held till the next shutdown while the measurements indicated previously are made.

During the following shutdown, the poison would be adjusted; then an additional advance of 15 MW would be made during the next period of level operation. Operation at the new level of about 305 MW would then be continued for about two months, during which time a coefficient test would be made and more detailed data collected on expansion, corrosion, and the like.

On the basis of these data, the next advance to a level of about 330 MW could then be considered.

C. W. J. Wende
per L. B. Johnson

PILE TECHNOLOGY DIVISION

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