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CONTROL ASPECTS OF OLD PILE EXPANSION PROGRAM

D. E. Simpson
Reactor Design Analysis Unit
Process Design Sub-Section

November 3, 1959

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November 3, 1959

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CONTROL ASPECTS OF OLD PILE EXPANSION PROGRAM

A brief look has been taken at the control aspects of proposed conditions for increasing the production capacity of the existing Hanford piles. It appears that the present control and safety systems of B, D, F and DR will be adequate for coolant flows up to 105,000 gpm with bulk outlet temperature up to 105°C with the present Al tubes or Zr tubes of present or 200 mil greater OD; for flows of 120,000 gpm and a bulk outlet of 95°C, the present systems are adequate except the speed of control operation may be insufficient if active zone pressure drops are below 200-300 psi with present OD process tubes of either Zr or Al. Control systems of C and H are adequate for flows up to 120,000 and bulk outlets up to 105°C; selective poison placement or some reduction in flattening efficiency may be required at C with present OD tubes. The K control system should also be satisfactory for all proposed conditions although selective poison placement or a flattening reduction may be required with the present OD tubes.

It is emphasized that this study has been necessarily short and is, therefore, sufficient only to indicate that the proposed operating conditions are generally feasible from a reactor control standpoint with the present control and safety systems.

W. S. Nechodom of PARDES has undertaken a somewhat more complete study of this program which will cover the operational and speed of control aspects, in particular, more fully. Since he expects to complete his study in mid-November, there seems to be no point in my going further.

A detailed analysis of all of the proposed possibilities, including evaluation of relationships between fuel size, exposure, power, flattening efficiency, and requirements upon the control and safety systems and supplementary control devices, would require several months of full time effort. It seems doubtful that such a survey study would be justifiable.

Reactor control aspects are discussed below in terms of (a) total control, (b) operational control, and (c) speed of control.

Total Control

Prior to this study, L. W. Lang had computed fuel element dimensions for a wide range of B, D, F pile operating conditions. Additional calculations were made to determine cold pile wet and dry reactivities for a number of these cases. Wet and dry calculated reactivities were normalized to agree with experimental values for

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solid-fueled old piles, and changes in control capacity from current values were estimated. The net differences between dry reactivity and available control capacity (including rods and poison used to control the wet pile) was used as a measure of the total control difficulties to be anticipated. The normalized values which were calculated are shown in the attached table. Although the required control is shown to be greater than that available, a moderate increase in control capacity can be gained by selectively locating the normal wet pile poison charges. The B, D, F piles now require this selective charging to gain about 4 mk of additional strength. The worst case shown in the table requires about 8 mk. This added requirement could probably be met by a reduction in flattening efficiency along with selective poisoning; more important, however, is the fact that a gain in assumed safety system strength of about 6 mk is quite likely in the future. This change will require only that the ball system strength be shown to be as much stronger than the VSR strength (used in this study) as calculations have indicated. It is concluded then that in all of the cases considered, the present safety and control systems will in all likelihood be adequate to satisfy the total control requirements.

The DR reactor has a stronger safety system than B, D, and F, so with similar loadings, the total control limits will be less restrictive. H and C have much stronger safety systems and can thus support large enrichment rings and high flattening efficiency. None of the cases considered will present any total control problem at H. Selective poison charging and possibly a flattening reduction may be required at C for cases with a significantly larger water volume than the present conditions and with present OD process tubes of either Al or Zr; apparently no problem would exist with the larger Zr tubes. The K pile situation is quite similar to that of C.

In this entire discussion, it has been assumed that the worst conditions from a total control standpoint are when the pile is cold and xenon free. A positive net temperature coefficient in the dry pile would make this no longer true. According to calculations made some time ago by W. E. Weimuth, the temperature effect is positive above the Al melting point at fuel exposures above 600 MWD/T and is positive near the U melting point for exposures of about 420 MWD/T. With Al process tubes, it is sufficient to keep the dry pile subcritical only until it reaches the Al melting point; no decision has been made with respect to Al slug cladding and Zr tubes. If in the latter case, the pile must be held subcritical until reaching the uranium melting point, it appears that the present safety systems are adequate only if average fuel exposures are restricted to a value not much greater than 420 MWD/T.

Operational Control

Control of reactor flux distributions will undoubtedly become more difficult with increasing power levels. Historically, though, power increases have never resulted in lasting reductions in control efficiency and nothing is foreseen which would cause such a loss now. Given reasonable success in developing satisfactory spline systems and perhaps poison displacement columns, operating control should not be a particular problem.

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Speed of Control

Only a very short look has been taken at the speed of control aspects of the cases considered. It appears that at the highest power levels considered, the maximum permissible reactivity gain on water loss in the hot pile is roughly 18 mk for the B, D, F and DR piles. It is estimated that the effect of high graphite temperature in the operating reactor will reduce the wet to dry reactivity gains by about 15-20 mk below its value in the cold pile. Thus, the only cases considered in which the speed of control criterion would appear not to be satisfied are the cases with present OD Al or Zr process tubes, 200 psi pressure drop, and 120,000 gpm flow with a 95°C bulk outlet.

For a flow like this, a 200 psi pressure drop sounds improbably small.

Any failure to satisfy the speed of control criterion at H, C, or the K piles appears highly unlikely.

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Reactor Design Analysis Unit
Process Design Sub-Section

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CALCULATED REACTIVITIES - B, D, F FILES*

Process Tube	Case	Pressure Drop (psi)	Δk Wet to Dry (mk)	Cold, Wet Reactivity (mk)	Total Control Capacity (mk)	Control Required Minus Capacity (mk)
Al, + 000 mils added to OD	B	200	28.9	28.2	50.7	6.4
		300	24.7	30.5	50.4	4.4
		400	24.2	24.2	50.8	7.0
	D	200	33.6	26.9	50.3	5.0
		300	28.4	28.4	49.9	3.9
		400	25.4	21.3	50.6	7.7
	G	200	37.0	24.1	50.1	5.0
		300	31.0	25.7	49.7	3.9
		400	27.9			
	E	200	25.5	30.2	49.0	6.7
		300	21.6	32.1	49.5	4.2
		400	29.5	26.3	49.8	6.0
Zr, + 000 mils added to OD	B	200	29.5	26.3	49.8	6.0
		300	24.9	28.2	49.2	3.9
		400	24.9	28.2	49.2	3.9
	D	200	33.4	24.5	50.2	7.7
		300	27.4	26.5	49.5	4.4
		400	24.4	27.9	48.9	7.4
	E	200	15.6	30.8	43.3	3.2
		300	13.1	32.6	43.0	2.7
		400	18.3	28.9	43.7	3.5
	G	200	15.3	30.4	43.1	2.6
		300	13.4	31.2	42.9	1.7
		400	17.9	28.5	43.5	2.9
Zr, + 200 mils added to OD	B	200	14.9	30.0	43.0	1.9
		300	20.4	26.8	43.5	3.7
		400	17.0	28.9	43.2	2.7
	D	200	15.2	29.5	42.7	2.0
		300				
		400				
	E	200				
		300				
		400				
	G	200				
		300				
		400				

The accuracy of these calculations is no better than 3-4 mk; the extra significant figure is included only to give a better idea of the relative standings of the various cases.

* Including normal wet pile control with correction for shadowing by safety system.
(0.3 times cold, wet reactivity)

Case	Bulk Outlet (°C)	Flow (gpm)
B	95	85,000
D	95	105,000
E	105	105,000
G	95	120,000

DATE

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END