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POWER CALCULATION ACCURACY WITH DUAL
DOWNCOMER OPERATION

by

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September 11, 1961

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POWER CALCULATION ACCURACY WITH DUAL DOWNCOMER OPERATION

INTRODUCTION

The C reactor is presently operating with all process water discharging through one downcomer. Pressure measurements at the downcomer lid show the top tray is nearly flooded, thus prohibiting further flow increases until the downcomer is modified or both downcomers are used simultaneously.

Operation with two downcomers can result in two sources of error in the power calculation:

1. Errors in measured outlet temperature can occur, apparently due to the increased venting capacity⁽¹⁾. The magnitude of the effect is probably unpredictable and could not be compensated for in the power calculation. Since the temperature error occurs only downstream of the downcomer vents, the logical solution is to move the outlet temperature devices to the risers. The method of administering bulk temperature limits will have to be changed to account for the thermal shield flow entering downstream of the outlet thermohms.
2. Simultaneous flow and temperature unbalances can result in power calculation errors since there is no way of knowing the actual flow through each downcomer. It is assumed that the power calculation would have to be made from the total flow and the average of the two outlet temperatures.

The primary purpose of this study was to determine whether the power calculation errors due to flow and temperature unbalances would be significant.

CONCLUSIONS

The following table summarizes the results of the error calculations:

<u>Condition</u>	<u>% of Total Flow in Near Downcomer</u>	<u>% of Flow in Far Downcomer</u>	<u>Outlet Temp. Near</u>	<u>Outlet Temp. Far</u>	<u>% Error in Power Calculation</u>
Equilibrium typical	50%	50%	95°	95°	0%
Equilibrium, assumed worst case	45%	55%	95°	88°	0.5%
Startup typical	50%	50%	Any	Any	0%
Startup, assumed worst case	45%	55%	85°	30°	7.9%

(1) Observed at DR and reported in verbal communication with S. S. Jones.

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All cases are based on a 20°C inlet temperature. Since the estimated "worst" case at equilibrium amounts to only about 10 MW at C reactor and the "worst" case at startup is within the requirements of Process Standard C-020, use of both downcomers is not expected to give large enough power calculation errors (due to flow and temperature unbalance) to be operationally significant.

DISCUSSION

A. Power Level Error During Periods of Equilibrium Operation

Since the outlet piping on the near and far sides is identical, it seems unlikely there would be any flow unbalance and therefore no error in the power calculation. If flow unbalances should occur, they probably would not exceed a 45-55 split. Assuming that split and the 45 per cent flow side operating at the bulk limit of 95°, a temperature as low as 88° on the other downcomer would make only 0.5 per cent error in the power calculation.

B. Power Level Error During Unbalanced Flux Conditions

The unbalanced flux conditions shortly after a startup when combined with a flow unbalance through the downcomer would represent the most probable time for significant errors in the power calculation. Assuming a "worst case" flow split of 45 per cent near, 55 per cent far, and a severe outlet temperature unbalance of 85° near and 30° far; the power calculation error is 7.9 per cent. Power calculation errors up to 10 per cent are permitted during startup by Process Standard C-020.

Calculation Method

Actual power level.

$$P_{ACT} = .2635 (F_N)(T_{ON}-T_1) + .2635 (F_F)(T_{OF}-T_1) \quad \#1$$

Calculated power level (from average outlet temperature of near and far downcomers)

$$P_{CALC} = .2635 (F_T) \left(\frac{T_{ON} + T_{OF}}{2} - T_1 \right) \quad \#2$$

Where:

F_N = Flow through near downcomer

F_F = Flow through far downcomer

F_T = Total flow (Reactor + Shield)

T_{ON} = Outlet temp. in near downcomer

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T_{of} = Outlet temp. in far downcomer.

T_i = Bulk inlet temperature.

The per cent error in any power calculation is:

$$\% \text{ error} = 100 \left(\frac{\text{Calculated power level}}{\text{Actual power level}} - 1 \right) \quad \#3$$

Or substituting equations 1 and 2 into 3

$$\% \text{ error} = 100 \left(\frac{.2635 (F_T) \left(\frac{T_{on} + T_{of}}{2} - T_i \right)}{.2635 (F_N) (T_{on} - T_i) + .2635 (F_F) (T_{of} - T_i) - 1} \right) \quad \#4$$

Canceling constants and dividing by F_T

$$\% \text{ error} = 100 \left(\frac{\left(\frac{T_{on} + T_{of}}{2} - T_i \right)}{\left(\frac{F_N}{F_T} (T_{on} - T_i) + \frac{F_F}{F_T} (T_{of} - T_i) \right) - 1} \right) \quad \#5$$

The equation #5 allows determine of the power calculation error due to dual downcomer operation.

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APPENDIX

The Figure 1 shows the affect of various flow and temperature unbalances on the power calculation error. Since the actual flow split between the downcomers is never known, the curve is useful only to show that the power calculation errors are small; even with larger flow splits than would reasonably be predicted.

FIGURE - 1
POWER CALCULATION ERROR

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Assume $T_{ON} = 95^{\circ}\text{C}$
 $T_i = 20^{\circ}\text{C}$

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