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SUMMARY OF K REACTOR OUTLET TEMPERATURE
LIMITS

AUTHOR

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SUMMARY OF K REACTOR OUTLET TEMPERATURE LIMITS

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INTRODUCTION:

The purpose of this report is to summarize all actual and potential power level limits under which the K Reactors may be forced to operate during the next year. In addition, a summary of the methods being followed to eliminate each is to be discussed along with a graphical presentation of the relationship of the various limits. For the purpose of this report, it was assumed that all power levels will be attainable from a physics aspect since these problems are discussed elsewhere.¹ It is not the intent of this report to recommend that these power levels be attained but only to indicate what production levels are possible through operation on any one limit.

SUMMARY:

Seven outlet temperature limits govern operation at the K Reactors. They are:

1. TBI Limit
2. "Crosstie" Limit
3. Rear Header Saturation Limit
4. Bulk Outlet Temperature Limit
5. Tube Corrosion Limit
6. Temperature Monitor Limit
7. Rupture Control Point

Operation during the summer months of 1957 will require cuts in power in order to remain within these limits unless modes of circumventing a few are found. The limits are shown graphically in the appendix at the various flow rates probable. From these curves it is evident that the Low Trip TBI Limit, the "Crosstie" Limit, and the "90 Bulk" Limit must be relaxed in order to continue the stepwise approach to a Rupture Control Point. Current plans call for a flow increase to 155,000 gpm on about June 1, 1957, in order to operate at 1225 KW/tube. On July 1, 1957, plans call for increasing flow to 167,000 gpm and raising tube powers to 1300 KW/tube, until about November 1 when flow will again be reduced to 155,000 gpm without reducing level.

DISCUSSION:

I. General

The seven basically tube outlet temperature limits under which the K Reactors operate are the Trip Before Instability Limit (TBI), the "Crosstie" Limit, the Rear Header Saturation Limit, the Bulk Outlet Temperature Limit, the Temperature Monitor Limitation, the Tube Corrosion Limit, and the Rupture Control Point. Each of these are discussed below and shown graphically in the appendix. A short description of the procedure being followed to eliminate each limit is also outlined. It must be emphasized that the discussions are "dated" and that the curves imply many basic assumptions. However, the mode of calculation has been fairly accurate many times in the past. All curves in the appendix are plotted on the same ordinates relating possible tube power levels to inlet water temperature. To relate the inlet water temperature to month, Figure 2 is provided which shows the average river temperature history for the past 10 years. The dashed line indicates the history for this last year. Figure 3 is also provided to relate tube power to total Reactor power level.

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One mode of increasing the attainable power levels through operation on any limit is to increase the total Process Water Flow Rate. Current coolant flow rates at each reactor are approximately 150,000 gpm under operating conditions. Should favorable results be obtained from the secondary pump cavitation test at 165-KE, operation with 5 pump sets at full speed should permit reactor flow rates on the order of 155,000 gpm. In addition, short term operation of six pump sets, i.e., no operational spare, should permit flow rates of from 165,000 gpm to 167,000 gpm⁷ at each reactor. Operation at these flow rates, however, will require the replacement of the downcomer orifice plate since the one currently installed has a maximum capacity of 160,000 gpm.⁸ (Replacement time has been estimated at approximately 24 hours by K Maintenance personnel). It is assumed that an orifice design suitable for the flow range 140,000 gpm to 180,000 gpm will be available so that the change only need be made once. Operation without a spare pumping unit poses certain problems since the reactor must always be shut down upon loss of a pump and if the pump set cannot be repaired during the outage, the unit must start up at a lower flow rate with attendant problems of Panellit readjustment. It is hoped, however, that production gains at the high flow rates will outweigh the production losses for short term (3-4 months) operation.

II. Trip Before Instability Limit

As flow is reduced to a constant power producing process tube, the tube outlet temperature will rise to the point where vapor formation in the downstream fittings begins to occur. If flow is further reduced, the overall resistance to flow is increased, thereby further decreasing flow in a vicious circle. The Trip Before Instability Limit restricts tube outlet temperatures to the point where a reduction in flow will give a Panellit trip before unstable boiling can occur. This limit is shown graphically in the appendix.

Revision of the TBI limits must involve a change in philosophy. Since the TBI limit is based on a series of steady-state tests, it does bear some conservatism. Hesson and Thorne² indicate that dynamic type tests will provide much higher limits which would not be restrictive within the near future. These limits are being investigated and prepared by K. W. Hess of Process and Reactor Development Operation. Target date for a relaxation, if justified, is June 1, 1957.

III. "Crosstie" Limit

The so-called "Crosstie" Limit presented in reference 3 is based upon providing adequate protection during the shutdown of an operating reactor if all electrical power were lost to its process water pumps, both BPA and emergency; and all BPA power were lost to the process water pumps at the sister reactor. This limit is shown in the appendix, and is relatively independent of total flow.

Relaxation of this limit may follow a number of paths. First, and the method currently being followed, establishment of an acceptable degree of reliability of the emergency generating system through proof testing and operation of the system so that the two generators are essentially separate of one another may establish reliability of the system such that the limit may be relaxed on this basis alone. This, coupled with a preventative maintenance program and a routine, random, testing program will continue to guarantee the high degree of reliability. The current attack on the "Crosstie" Limit is accelerated generator testing coupled with a high level preventative maintenance program. The testing involves separating the

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generator system from BPA, causing it to assume load. This test is performed twice per reactor outage and recently it has been performed during operation just prior to shutdown. It is hoped that sufficient training and equipment reliability may be obtained to make practicable an accelerated testing program during reactor operation on a daily basis. In addition, a system study by R. J. Brebrick, of Electrical Development Operation is being conducted to establish the safest mode of system operation. Also, the theory of statistical economics as outlined in reference 9 is being applied to determine whether the limit is economically justifiable. The results of this study are to be included in a report to be issued.

If sufficient reliability is not deemed available to justify relaxation, a few of the alternate methods of increasing backup are:

1. Different modes of operation
2. Electrical crosstie
3. Second high pressure crosstie
4. Independent diesel powered pumping plant for backing up both areas
5. High tanks
6. Additional 165 pumping capacity on standby

IV. Saturation Temperature Limit

Current Process Standards⁴ require that no temperature monitor trip be set closer than 8° to the rear cross header saturation temperature. This effectively requires that no trip may be set above 105°C in the top third of the reactor, since the trips may only be set at 5° intervals. The purpose of this limit is to insure that during transient periods of flow reduction to an operating reactor, no outlet temperatures will exceed the rear header saturation temperature.

Process Standards Operation is currently considering relaxation of the "8° below" to "5° below". This will, in effect, permit the trips to be set at 110°C on all tubes except a few top headers. In addition, a preliminary rear-header orifice has been designed and as soon as laboratory facilities are modified and available, testing will proceed. It is thought that this orifice will not be required during the immediate future.

V. Bulk Outlet Temperature Limit

Process Standards⁵ currently limit the Bulk Outlet Temperature from the K Reactors to 90°C. As shown on the figures in the appendix, this limit is one of those most restrictive, and also may be the one hardest to get relaxed. The intent of the limit is to restrict the water temperature in the rear face piping to such a value that during transient periods of flow reduction to an operation reactor, e.g., opening of the V-73 valve or loss of BPA power, boiling will not occur in the rear face piping causing a restriction to flow.

An analysis of the 90°C Bulk Limit is being made by S. S. Jones of Process and Reactor Development Operation and his results are to be contained in a document to be issued.

VI. Tube Corrosion Limit

Currently no tube corrosion limit is specified in Process Standards. However, since the rate of corrosion of aluminum doubles with an increase of approximately 10°C in outlet temperatures, it is well to bear in mind that tube corrosion may become a limit. Steps are already being taken to prevent this however, e.g., zirconium

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tubes, M-388 corrosion resistant aluminum slug cans etc.

VII. Temperature Monitor Limit

Even though there is no limit entitled "Temperature Monitor Limit", it must be kept in mind that the maximum possible trip setting on the present temperature monitor equipment is 115°C. Since operation must be restricted to some value wherein numerous trips are not occurring, a reasonable limit for this equipment may be 110°C. It is realized however, that equipment modifications may be made to permit operation at higher temperatures.

VIII. Rupture Control Point

The current program for approaching a Rupture Control Point is to increase reactor power levels stepwise until the optimum number of ruptures is surpassed and then reducing level to optimize production. Satisfactory experience was obtained at 1125 KW/tube levels and the step to 1225 KW/tube was taken on Feb. 5, 1957. Since that date, 9 ruptures have been experienced. Based on curves calculated from reference 6, no excessive rupture rates have occurred. As soon as practical after July 1, 1957, the limit will be increased to 1300 KW/tube provided that no abnormal experiences occur prior to that date, and other limits permit.

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Figure 1A - Graphical Presentation of Limits
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FIGURE 2 - RIVER WATER TEMPERATURE HISTORY
AS A FUNCTION OF MONTHS

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FIGURE - 3 CONVERSION OF TUBE POWER TO TOTAL POWER LEVEL

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