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BACKUP WATER SUPPLIES TO K REACTORS - 1963

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BACKUP WATER SUPPLIES TO K REACTORS - 1963

INTRODUCTION

The K Reactors were originally scoped⁽¹⁾ to have three independent electrical power supplies and to be able to transfer process water, filtered water, raw water and electrical power from one K Plant to the other. It was required that shutdown flow to each reactor be available from at least four separate pumping stations. The originally scoped power level was 1300 MW, yet a plentitude of coolant supply means were provided, as can be seen from the above statements.

(1) HW-26687 "Design Scope, 100-K Area Water Plant Design", 12-18-52

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INTRODUCTION (Continued)

Today, 1963, the K Reactors operate at 4400 MW (administrative limit) and are capable of operating in the vicinity of 5000 MW during low inlet water temperature conditions. Requirements on coolant supply systems are more extensively defined today as a result of this larger potential liability and because of improved technology.

This document discusses modifications to the K Reactors' secondary backup systems' equipment arrangement that will improve backup adequacy and reliability while permitting greater operating convenience as regards backup equipment maintenance. The modified secondary system⁽²⁾ proposed by K Maintenance Engineering is endorsed, provided a reliable means of avoiding overloading a boiler is included and provided the independence of the emergency generators can be reasonably assured. Preliminary discussions⁽³⁾ indicate that a control circuit to prevent overloading a boiler is feasible, and a preliminary report⁽⁴⁾ did support a conclusion that the emergency generators are sufficiently independent of BPA power.

DISCUSSION

The K Reactors, since completion of CGI-844 and CGI-883, have increased total reactor flow and have improved and increased the flow available from their backup systems. The secondary system is presently composed of a steam driven pump, which is independent of BPA power and equivalent to slightly more than one low lift pump, and two primary low lift pumps which each receive motive electrical power from their emergency generator. This secondary system arrangement is necessary to ensure adequate coolant flow to the non-stricken* reactor when one component of the secondary system fails, and is necessary to provide hydraulic counterbalance to ensure sufficient last ditch system flow to the stricken** reactor.

* The non-stricken reactor loses its primary system but retains all or a major part of its secondary water supply system.

** The stricken reactor loses all primary system and all secondary system pumping ability and last ditch water is its sole supply.

A modified secondary system arrangement has been proposed⁽²⁾ which would normally be composed of two boilers, two emergency generators and four low lift pumps. The steam driven pump would only be signaled to start if either pair of emergency buses (B-E or C-F) had their voltage drop below the #27 undervoltage relay trip setting or the supply riser pressure dropped below a pre-set value. The strength of this modified secondary system, as well as the strength of the presently employed system, depends on the ability of the oil-fired boilers to carry an overload. The boiler overload could occur with the present setup if either of the two low lifts, purposely signaled to trip off when BPA power is interrupted, failed to trip. The boiler overload with the modified secondary system⁽²⁾ could occur if bus voltage dropped on the side with a boiler feeding just an emergency generator which would result in the other boiler carrying a generator with two low lift pumps and the steam driven pump.

An improvement to the reliability of this modified secondary system will

(2) HW-75724, "Proposed Control Circuit Modification, Steam Driven and Electric driven Low Lift Pump, 190-KE and KW Buildings", 12-5-62.

(3) Discussion, PE Lindstrom and RD Hickman, 3-29-63.

(4) Letter, "K Bus Separation", VG Blanchette to RW Reid, dated 12-17-62.

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DISCUSSION (Continued)

result if the probability of overloading a boiler is reduced to nearly zero. This can be accomplished by employing a control circuit that would signal the steam driven pump to start only when a boiler overload would not result. The successful development of such a control circuit is germane to the discussion which follows.

The modified secondary system discussed in the two preceding paragraphs can definitely improve the K Reactors' ability to comply with the backup coolant criteria in regard to a single component failure.

Component That Fails When BPA Power is Interrupted	Number of Pumps Remaining in Operation	
	Present System	Modified System
1. One low lift pump	2	3
2. One generator on least loaded boiler.	2	2*
3. One generator on most loaded boiler.	2	3
4. One least loaded boiler.	2	2
5. One most loaded boiler.	1	2

NOTE: The least loaded boiler supplies just one generator. The most loaded boiler is valved to supply one generator and the steam driven pump.

* It is possible in this situation to manually transfer the steam driven pump to the other boiler which would then increase the number of pumps in operation to three.

The above table indicates that better assurance of having adequate secondary and last ditch flow to the non-stricken and stricken reactors respectively, is obtained with the modified secondary system when one component fails simultaneously with a BPA power interruption. With no component failures in the modified system at the non-stricken reactor, secondary and last ditch flows at the respective reactors should be higher than those attainable from the present system.

The last ditch system for the K Plants is now composed of three diesel driven pumps located in a separate pumphouse and capable of supplying flow to either K Reactor. The flow available from this system is dependent on the following factors:

1. The number of diesel driven pumps operating at rated conditions;
2. The number of pumps (low lift or steam) providing reactor flow or the process water supply pressure at the non-stricken reactor;
3. The interior condition of the last ditch system piping.

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DISCUSSION (Continued)

The diesel driven pumps were sized such that two pumps would supply the coolant flow required to maintain bulk outlet temperature below 90°C at the stricken reactor provided three pumps are operating at the non-stricken reactor. Present requirements in Process Standards are that three diesel pumps be held ready on automatic backup at all times when either or both K Reactors are operating, since a reliability of 100 per cent that two-out-of-two diesels will start cannot be achieved. It must be further recognized that the diesel system will require maintenance to ensure a highly reliable system; therefore, provisions for taking one diesel driven pump out of service must be provided. A severe production penalty or a general system degradation would occur if it were required that both K Reactors be shut down each time a diesel pump unit needed maintenance.

PROPOSED BACKUP REQUIREMENTS

The purpose of this section is to present the envisioned Process Standards revisions associated with the modified secondary system. These requirements presuppose that the present secondary system can be modified as proposed⁽²⁾ with controls that will automatically avoid overloading a boiler. Some advantage is taken of the secondary backup systems' backup water supply from the steam driven pump.

I. NORMAL BACKUP

The normal backup water supply requirements during reactor operation will be revised in Process Standards - Water Plant, 190-B-090, and Process Standard - Reactor, A-080. These proposed Standards requirements are presented here as follows:

- A. Two operating mechanically isolated oil-fired boilers prepared to pick up the steam load attending a BPA power interruption;
- B. Two emergency turbine generators electrically isolated operating at minimum load, or greater, and set to support bus voltage should BPA power be removed from that bus;
- C. Four operating low lift pumps set to receive emergency generator power should BPA power be interrupted;
- D. One steam driven pump prepared to start if motive power to either pair of low lift pumps (1 and 3 or 4 and 6) fails, and provided a boiler overload will not result, or if supply riser pressure decreases below a set value;

(2) Ibid

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PROPOSED BACKUP REQUIREMENTS (Continued)

I. NORMAL BACKUP (Continued)

- E. Three diesel driven pumps prepared to start if BPA power is interrupted at the 13.8 or 4.16 kv levels or if supply riser pressure falls below a pre-determined value.

II. STEAM PUMP MAINTENANCE

Should it be necessary to remove the steam driven pump from service during reactor operation, the following requirements must be met:

- A. The normal secondary system (2 boilers, 2 generators, 4 low lift pumps) is fully operative;
- B. Normal last ditch system backup (3 diesels on automatic backup) is available;
- C. No critical power conditions may exist on the transmission lines or at the Midway distribution station which could adversely affect the continuity of BPA power to the operating K Reactor(s);
- D. The steam pump may be out of service for a maximum of 30 hours in any 48 hour period.

It should be noted that steam pump maintenance may proceed during reactor shutdown after four hours, provided two independent water supply systems are in service. Two low lift pumps can satisfy this requirement provided one is on bus B-E and the other is on bus C-F and two emergency generators are appropriately in service. Another means of meeting this requirement is by having the reactor sufficiently throttled*and opening the V-72 valve which makes the last ditch system available as backup to the low lift pump(s) supplying shutdown flow.

* See NOTE under III, C, 2.

III. DIESEL PUMP MAINTENANCE

Whenever it is necessary to remove a diesel driven pump from service for maintenance, the following requirements must be met:

- A. Both Reactors Operating - (Diesel out of service < 20 hours)
 - 1. Full secondary system backup (2 boilers, 2 generators, 4 low lift pumps) must be operating at each reactor;
 - 2. The steam driven pump at each reactor must be in service on automatic backup;
 - 3. No critical power conditions may exist on the transmission lines or at the Midway distribution station which could adversely affect the continuity of BPA power to the K Reactors;
 - 4. One diesel driven pump may be out of service for a maximum of 20 hours in any 48 hour period.

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PROPOSED BACKUP REQUIREMENTS (Continued)

III. DIESEL PUMP MAINTENANCE (Continued)

B. Both Reactors Operating - (Diesel out of service > 20 hours)

1. Full secondary system backup (2 boilers, 2 generators, 4 low lift pumps) must be operating at each reactor;
2. The steam driven pump at each reactor must be operating on steam supplied from the third boiler;
3. No critical power conditions may exist on the transmission lines or at Midway distribution station which could adversely affect the continuity of BPA power to the K Reactors.

C. One Reactor Operating (Diesel out of service < 20 hours)

1. Conditions under A 1, 2, 3, and 4 must be met at the operating reactor;
2. The shutdown reactor must have its V-72 valve closed, or 4 low lift pumps supplying reactor flow, or the reactor sufficiently throttled.

NOTE: The reactor sufficiently throttled will normally mean all front crossheaders throttled to < 100" ΔP.

D. One Reactor Operating - (Diesel out of service > 20 hours)

1. Conditions under B 1, 2 and 3 must be met at the operating reactor;
2. Conditions under C 2 must be met at the down reactor.

E. Both Reactors Shut Down

1. The entire last ditch system or any part thereof, may be removed from service after both reactors have been shut down for four hours or more provided the steam driven pump is on automatic backup at each reactor and one or more low lift pumps, backed up with generator power, are supplying shutdown flow.

IV. BACKUP DURING FLUSHING

A. Steam Pump Discharge Line - (Flush duration < 1 hour)

The steam pump discharge line may be flushed during any period when an alternate backup system or systems is in service, i.e. during reactor operation with full secondary and full last ditch system backup, or during shutdown with low lift pump or diesel pumps as backup.

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PROPOSED BACKUP REQUIREMENTS (Continued)

IV. BACKUP DURING FLUSHING (Continued)

B. Steam Pump Discharge Line - (Flush duration > 1 hour)

If the line flushing is for longer than one hour, the steam driven pump should be considered out of service for maintenance and conditions under II A, B, C, and D must be met.

C. Diesel Pumps Discharge Line

Flushing the diesel pumps discharge line must always be accomplished when one reactor is shut down in order that maximum line velocity may be obtained by flushing through the V-71 and the V-74 simultaneously. The backup requirements are therefore identical to III C, 1 and 2, under Diesel Pump Maintenance. The diesels are effectively out of service during flushing since electrically closing the flush valves is too slow and since manual action to obtain last ditch flow would take far too long.

V. INADEQUATE BACKUP

Safe operation of a reactor is contingent on having several alternate or backup water supply systems each with a very high degree of adequacy from both capacity and reliability standpoints. Provisions must be included to permit maintenance on backup equipment to ensure having maximum reliability and maximum backup adequacy. It must be recognized though that failure to meet the backup requirements peculiar to the mode of operation (i.e., normal backup; steam pump out of service for maintenance; etc.) is cause for shutting down the affected reactor(s). The following list of events are some, but not all, of those which are definitely cause for shutting down:

1. Loss of a boiler leaving only one operating boiler;
2. Loss of a generator leaving only one operating generator;
3. Loss of one leg of the transmission system or obtaining a critical power condition which could adversely affect BPA power supply to the operating K Reactor(s) while either a steam driven pump or a diesel pump is out of service for maintenance;
4. Determining that inadequate last ditch system backup exists when the steam driven pump is out of service for maintenance;
5. Determining that inadequate steam pump backup exists when a diesel pump is out of service for maintenance.

CONCLUSIONS

Acceptance of the proposals herein will result in greater assured adequacy and reliability of the secondary and last ditch water supply systems while permitting more flexibility to do maintenance on individual backup equipment. The basis for these proposals is the improved modified secondary system⁽²⁾. This system would be composed of two boilers, two emergency generators, four low lift pumps, and a steam driven pump which would automatically start if either pair of low lift

(2) Ibid

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CONCLUSIONS (Continued)

pumps (#1 and #3, or #4 and #6) loses motive power and provided a boiler overload would not result. Acceptance of this modified system is dependent on successful development of a control circuit to avoid a boiler overload and on the conclusions which can be drawn from the study being conducted by FEO concerning the independence of the emergency generators⁽⁵⁾. Preliminary discussions⁽³⁾ indicate that a control circuit to prevent overloading a boiler is feasible and a preliminary report⁽⁴⁾ did support a conclusion that the emergency generators are sufficiently independent of BPA power.

Greater flexibility as regards equipment maintenance will benefit the steam driven pump primarily with a lesser benefit for the diesel driven pumps. It must be recognized that requirements on diesel pump maintenance need to be more restrictive since two-out-of-two pumps must start if a reactor requires last ditch flow when one diesel is out of service and also, since no further backup system can come into play if the last ditch system fails when needed.

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- (3) Discussion, PE Lindstrom and RD Hickman, 3-29-63.
- (4) Letter, "K Bus Separation", VG Blanchette to RW Reid, dated 12-17-62.
- (5) HW-76391, "A Study of the Independence and Reliability of the 165-K Generator Bus", (to be issued).

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