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AI-Memo-1684

Page 1 of 10

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ADDITIONAL ANALYSIS OF SRE SAFETY

by

W. T. Morgan

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I. Conclusions

A. No unsafe condition will exist due to power oscillations between the reactor and the steam plant. There is no direct feedback from the steam plant to the reactor control rods, so the only way the steam plant can affect the reactor is by changing the temperature of the returned sodium. Because of the large thermal capacities of the sodium system, any temperature changes seen by the reactor will be extremely slow. Such changes can be easily handled by the reactor operator.

B. The feeding of cold water into an excessively hot steam generator will be prevented by a high temperature relay that will trip and lock out the feedpumps if the sodium outlet temperature exceeds 600°F. Operating procedure will provide protection in the range from normal 440°F to 600°F.

II. Power oscillations between SRE and the steam plant.

A. General

1. It appears that the likelihood of power oscillations postulated in W. D. Gilbert's letter of June 18, 1956, is small since the steam plant is operated purely as a power sink. There is no feedback between the steam plant and the reactor except that due to temperature changes in the sodium returned to the reactor. Any such temperature fluctuations produced by the steam plant will be greatly attenuated by the heat capacity of the sodium system. Back-up alarms and scrams provide further protection, as described in a following paragraph.
2. If, however, the reactor were to be controlled to follow the demand of the steam plant (as in a conventional generating

plant), then the problem referred to might be of an entirely different magnitude. Such operation is not now planned.

B. Controls

1. The reactor regulating rods are controlled directly by the reactor operator or by the automatic flux controller. While on hand control, the operator will attempt to hold fuel channel outlet temperature constant. The flux controller will attempt to maintain flux constant at its set point, which is adjusted manually by the reactor operator.
2. The sodium pumps are automatically regulated to hold constant speed at their set point. These set points may be manually adjusted by the reactor operator.
3. The steam plant is controlled to return sodium to the reactor at a constant temperature. This control is automatic except during startup and very low loads, when the control is manual.
4. Report AI-1612 and NAA-SR-Memo-1639 describe these systems in further detail.

C. Possible power oscillations between reactor and steam plant.

1. Initiated by reactor
 - a. Because of the large upper plenum and the large heat capacities of the reactor, any temperature oscillations produced by the reactor will be small and of very low frequency. Any operation of the reactor control rods can produce only temperature changes, not flow changes. Simulator studies indicate that the reactor operator can control temperatures quite easily by manipulating the

cont.

rods

b. Although power oscillations can be produced more easily by flow changes than by temperature changes, no problems are anticipated. Ordinarily the pump controllers will hold the flow constant. If the controllers were to fail to operate correctly, a flow transient could result. Such flow transients are not likely to be oscillatory in nature. Instead, component failure would probably cause either high or low flow. Flow transients from other causes seem unlikely. The capacities of the upper plenum and the secondary expansion tank will reduce the magnitude of any surges.

2. Initiated by steam plant

- a. The steam plant can not affect sodium flow unless indirectly through influencing the actions of the reactor operator.
- b. The steam plant will control the secondary sodium cold leg temperature directly. The following situations might cause fluctuations in the temperature of the sodium returned to the reactor:
 - 1) Misoperation of the feedwater control instruments.
 - 2) Misoperation by the Edison operator while on hand control.
 - 3) Operating the automatic feedwater control system near the lower limit of its control range.
 - 4) Pressure surges or load swings could cause steam flow oscillations as the turbine admission valves

open and close. Resulting temperature changes in the sodium outlet might cause the feedwater valve to oscillate.

- 5) Operation of the safety valve on the steam generator could cause temperature fluctuations in the sodium. When the valve pops off, there will be a rush of steam, reducing the steam pressure, increasing the steam flow and cooling the sodium. The valve will then close at some lower pressure, allowing pressure and temperature to build up again.

D. Reaction to oscillations which might be produced by the situations described in Part C.

1. Initiated by reactor

- a. Temperature transients - The upper plenum with its 200 second time constant will attenuate all but very slow temperature changes.

b. Flow transients

- 1) Anticipatory action of the feedwater system controls will allow the boiler to follow fairly rapidly. Sodium outlet temperature from the boiler may vary slightly.
- 2) While on hand feedwater control by the Edison operator, no anticipation is provided. Because of the time lags in the boiler, the operator probably will be unable to hold the sodium temperature constant. Ordinarily, hand operation will only be used at low values of power and flow. At such low flows, any

temperature variations will be extremely damped since the time constants of the expansion tank and the plenums are inversely proportional to flow.

- 3) The end result may be some oscillations in the sodium outlet temperature from the boiler.

2. Initiated by steam plant

- a. The only effect of any operation of the steam plant is to change the temperature of the sodium returned to the reactor.

3. Reaction of reactor system to oscillations in return sodium temperature from the boiler.

- a. The heat capacity of the secondary expansion tank will attenuate all fast oscillations in temperature. The time constant of the tank is about 20 seconds at full flow.
- b. Heat capacities of the intermediate heat exchanger and the lower plenum will also attenuate temperature oscillations seen by the reactor. The estimated time constants are 15 seconds and 60 seconds, respectively.
- c. Thus, if the oscillations in the sodium return temperature are slow, some fluctuations at this frequency may be seen at the reactor fuel channel inlet.
 - 1) When operating on hand control, the reactor negative temperature coefficient will reduce the temperature changes seen by the upper plenum. (The negative temperature coefficient has a fast time constant - one or two seconds.) If the fuel channel temperature

does vary, the reactor operator may try to correct by using the control rods. Since the frequency of the disturbance is very slow, he will be able to reduce the outlet temperature swing.

- 2) When the flux controller is used, it will tend to oppose the effect of the negative temperature coefficient and hold the flux constant. This will tend to make the fuel channel outlet temperature follow the oscillations of the fuel channel inlet temperature.

- d. Any temperature oscillations appearing at the fuel channel outlet will be attenuated in the upper plenum.

- e. On the basis of the considerations enumerated above, it appears that only very small, very slow variations in temperature should appear at the reactor outlet for any operation of the steam plant.

E. Protective devices

1. The following protection is used to prevent excessive temperatures or power levels being reached:

- a. Sodium flow

Alarm C @ 95% set flow

Scram C @ 90% set flow

- b. Fuel channel outlet temperature*

Alarm C 1010°F

Setback C 1030°F

Delayed scram C 1040°F

Delayed scram C 1050°F

* Temperature settings given are for full power operation

c. Primary sodium hot leg*

Alarm @ 1000°F

d. Primary sodium cold leg*

Alarm @ >550°F or <450°F

Scram @ >600°F

e. Secondary sodium cold leg*

Alarm @ >490°F or <400°F

Scram @ >550°F

III. Loss of feedwater to steam generator

Reference is made to Atomics International Report AI-1612 of April 30, 1956, Part IV, Sections "A" and "B", and to Figure 5, "Electrical Single Line Diagram".

Section A of the above reference lists the conditions which may result in the complete loss of auxiliary power at the Experimental Steam Station.

Section B of the above reference outlines the effects resulting from the loss of feedwater.

Any adverse conditions which would result in a protective relay operation at the Experimental Station, exclusive of an out-of-step condition, would trip the 66Kv O.C.B. at the Chatsworth Substation and result in the subsequent loss of auxiliary power.

The tripping of all circuit breakers from a differential or over-current relay operation is accomplished by a hand-reset auxiliary relay which prevents any reclosing operation until it has been reset.

The 66Kv O.C.B. at Chatsworth Substation is tripped on 480 volt auxiliary power undervoltage directly from the 480 volt auxiliary bus

* Temperature settings given are for full power operation.

undervoltage relay, which must be taken out of service before the 66Kv O.C.B. can be reclosed.

It is to be specified in the operating instructions for the Experimental Station that the 66Kv O.C.B. at the Chatsworth Substation shall not be closed, or reclosed after any relay operation, until the Boiler Feed Pump 480 volt A.C.B.'s have been opened.

One exception to the above instruction may be allowed following an out-of-step operation. If the 66Kv O.C.B. has been tripped on undervoltage, and the 480 volt auxiliary bus has been picked up by the generator following an out-of-step operation, the generator breaker may be opened and the 66Kv O.C.B. closed to permit synchronizing the generator to the system.

A positive feedwater blocking scheme will be provided by an interlock switch actuated by the temperature of the outlet sodium from the steam generator. If this temperature exceeds 600°, the interlock will trip and lock out both feed pumps. This introduces no hazard to the reactor, since the reactor will have automatically scrammed when the sodium temperature reached 550°. This excess temperature can only occur when the feedwater system has already failed.

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