Regulatory File Cy.


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ROBERT N. COE
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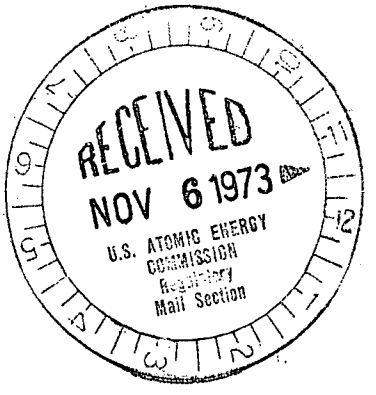
October 31, 1973




Mr. John F. O'Leary, Director
Directorate of Licensing
Regulation
U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. O'Leary:

Docket No. 50-206 San Onofre
Unit 1 Safety Injection Initiation
October 21, 1973

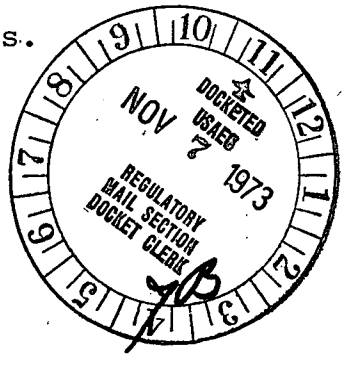
The following report is being submitted for your information and describes the subject noted above. This discussion will repeat and amplify the October 23, 1973 notification to the Region V Regulatory Operations Office. Changes are incorporated where investigation has provided more details.

The station incident occurred following a shutdown of the turbine generator. Turbine generator removal from service was necessitated by increased No. 4 turbine bearing vibration accompanied by high conductivity in the condensate and feedwater systems.

Briefly, the safety injection activation occurred as a result of excessive feedwater flow to the steam generators and consequent rapid cooldown of the reactor coolant system.

The following addendums are included with this letter.

1. A chronological sequence of events.
2. A summary of the reactor plant safety analysis.
3. Investigation and conclusions.
4. Corrective action.

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Repairs, inspections and procedural improvements are being or have been made. The intent of the total effort will be to minimize the possibility of recurrence and to verify system integrity.

Turbine inspections are underway. Preliminary analysis indicates that the incident resulted when one 10th stage blade on the generator end of the No. 1 low pressure turbine failed.

Sincerely,

David J. Fogarty

David J. Fogarty for Robert N. Coe

Enclosures
cc: R. H. Engelken, Director
Region V, Regulatory Operations Office

ADDENDUM 1

## SEQUENCE OF EVENTS

### October 20, 1973

11:52 PM A turbine vibration alarm on the Number 4 bearing of the Number 1 Low Pressure Turbine was detected. An investigation commenced immediately to determine the cause.

11:53 PM A major salt leak was indicated by high conductivity alarms. It appeared that the source of the leakage was the Number 2 condenser box. Investigation into the problem continued.

### October 21, 1973

12:15 AM Commenced blowdown on A, B and C steam generators. Concurrent with the blowdown, trisodium phosphate was fed to the steam generators in efforts to offset the effects of the saltwater leakage.

12:35 AM A load decrease of 5 MWe per minute was commenced. The turbine vibration and salt water contamination of the feedwater system continued.

12:51 AM The south circulating water pump was stopped in an attempt to mitigate the effects of salt water leakage.

1:05 AM The load decrease to off-line conditions continued. Rate of decrease of 20 MWe per minute was conducted.

1:10 AM (Time approximate) - Auxiliary load of 1A and 1B buses transferred from auxiliary transformers "1A" and "1B" to 138 KV transformer "C".

1:17 AM The unit turbine was in an unloaded status.

1:18 AM A no load trip alarm was received.

1:19 AM The turbine stop valves closed. It is noted that feedwater controls were on automatic at the time of the unit trip. Under these conditions, all feedwater regulator valves will go to 80% open ($T_{AVG} > 540^{\circ}F$) or 20% open ($T_{AVG} < 540^{\circ}F$). Reconstruction of events indicates that the valves automatically went to the 80% open condition.

1:20 AM Unit PCB's opened. Excitation field breaker opened.

October 21, 1973 (Cont.)

1:20 Plant Status Summary

1. Unit off line
2. TAVG 535°F but decreasing rapidly
3. Reactor controls on automatic
4. Feedwater controls remain in automatic
5. Excitation field breaker open

1:20:10AM It was noted that reactor coolant temperature and pressure were decreasing. Reactor controls placed in manual and CB-2 pulled to increase TAVG.

1:20:30AM Feedwater control changed to manual and flow control valves closed. It was observed that steam generator levels were rapidly increasing at this time. Also noted that pressurizer level had decreased to 10% and that letdown had secured (LVB 1112 closed).

1:20:45AM Feedwater block valves were closed by pushbutton actuation. (MOV's 20, 21 & 22). The valves were verified to have started closed.

1:20:50AM Alert to Block Safety Injection Alarm received.

1:21 AM Safety Injection Alarm. Safety injection initiated and the reactor tripped. At this time, level in all three steam generators was high.

1:28 AM The safety injection system WL relays were reset when the system had recovered.

1:29 AM The feedwater pumps were secured. MOV's 20, 21 and 22 were closed.

1:35 AM Charging and letdown flow established.

9:15 AM A sphere survey was accomplished. All conditions were found to be normal with the exception of the Loop B safety injection valve (MOV 850B) motor operator and pipe support equipment. The valve MOV 850B opened and operated properly on safety injection initiation based on valve position indication. However, when attempting to restore the system to a normal configuration, the valve traveled to approximately 2" of the fully closed position. Four bolts on the MOV 850B motor operator casing and one pipe hanger support were found failed. No damage to the valve itself was observed, but a complete investigation is being accomplished.

ADDENDUM 2

## SAFETY ANALYSIS

A comparison of reactor parameters and their corresponding Technical Specification limits prior to and after the trip was accomplished as per Station Order S-A-7. The following items were verified as not exceeding technical specification limits:

a. Reactor coolant system pressure
b. Combined pressure and temperature versus power level
c. Reactor coolant and pressurizer heatup and cooldown rates
d. Reactor coolant activity
e. Control rod insertion limits

Following reactor shutdown due to safety injection initiation, reactor shutdown margin was greater than 3% $\Delta$ K/K.

A review of the primary system pressure transient indicates that injection of borated water to the RCS could only have taken place via the charging path to Loop A. System pressure did not decrease below the shutoff head (1150 psig) of the main feed pumps (for either safety injection or feedwater service). The minimum pressure of the reactor coolant system was 1400 psig.

The thermal effects of injection of cool water via the charging path to Loop A has been analyzed previously. It has been shown (reference SCE letter from Mr. William R. Gould to Directorate of Licensing, Attention: Mr. John F. O'Leary, dated August 31, 1972) that the reactor vessel beltline region, reactor vessel inlet nozzle, and safety injection nozzle can accommodate in excess of $10^6$ such transients. For the charging line nozzle thermal liner, the allowable number of such injection cycles was found to be 140; for the charging line nozzle, the allowable number was 5600.

The movement of the Loop B safety injection piping resulted in the failure of the motor operator on MOV 850B, the Loop B safety injection valve. Reconstruction of events indicates that the MOV 850B valve opened during safety injection initiation. This is supported by valve position indication. The piping movement did not functionally disrupt safety injection system operation. Primary integrity was not affected. When attempting to close the valve, it traveled to within 2" of being fully closed.

The safety injection system design includes allowance for single component failure. Had a break occurred in Loop B and the flow comparator signaled for closure of MOV 850B, the valve would presumably have failed to fully close. Failure of a valve in the "spilling" line to close has been analyzed and the injection system capacity is sufficient to fulfill design requirements for this condition. If the valve had failed to open, proper core protection would still have been afforded. Thisffailure has also been analyzed. (reference SCE letter from Mr. Jack B. Moore to Directorate of Licensing dated May 12, 1972.)

## INVESTIGATION AND CONCLUSIONS

1. The Safety Injection system functioned in a manner that would have afforded core protection in accordance with the safety injection system design.

2. Safety injection initiated when a rapid reactor coolant system cooldown occurred following removal of the unit from service to investigate a turbine associated problem.

3. The reactor coolant system cooldown resulted when the turbine was tripped with steam generator feed control on automatic. With feedwater control on automatic, a turbine trip will result in the feedwater regulating valves going to 80% open ($T_{AVG} > 540^{\circ}F$) or 20% open ($T_{AVG} < 540^{\circ}F$). The rapid filling of the steam generators caused a rapid primary system cooldown. The cooldown and shrinkage produced the conditions necessary to actuate safety injection (low pressurizer level $\leq$ 5% and reactor coolant system pressure $\leq$ 1685 psig). Normal operating practice requires that the feedwater controls be placed on manual before tripping the turbine.

4. A safety analysis conducted indicated that no safety limits had been exceeded, or Technical Specifications had been violated.

5. Following the safety injection initiation, a normal sphere equipment inspection revealed that motion of the Loop B safety injection piping inside the secondary shield had occurred. Further inspection of the Loop B line indicated that a pipe hanger was damaged and that the Loop B safety injection valve was disabled.

6. The Loop B safety injection valve was disabled by the failure of four (4) .170" diameter bolts holding the motor casing in place. Failure of these bolts resulted in the casing, stator and end bell dropping from their mounting.

7. Post-occurrence investigation revealed that an air pocket existed in Loop B safety injection piping. This was determined by manually venting the safety injection piping. The investigation indicated that the movement of the Loop B safety injection piping was caused by water hammer.

   Inspection of Loops A and C safety injection piping revealed that no pipe movement had occurred.

8. The investigation indicated that pipe motion caused by water hammer generated sufficient movement to cause failure of the four (4) MOV 850 B motor housing bolts. This is supported by noting that the motor housing bolt failure was tensile in nature.

## CORRECTIVE ACTION

A. The following items will be accomplished prior to Unit startup:

1. The evolutions which may result in the introduction of air into the safety injection system piping are being investigated. Vent piping changes are being incorporated to facilitate on-line venting of the applicable sections of safety injection piping. Procedures will be developed and implemented which specify frequent venting of the safety injection piping. These procedures will be utilized until the confirmatory analyses specified in B.2 below are completed. This will provide reasonable assurance that air pockets will not exist in this piping.

2. The section of safety injection Loop B piping between the containment penetration and reactor coolant system Loop B will be replaced. Preliminary non-destructive testing indicates that there is no apparent damage; however, this will assure that the Loop B safety injection piping meets original design requirements.

3. High pressure safety injection piping welds and main coolant loop penetration welds on Loops A and C are being non-destructively examined. Although no movement was indicated on Loops A and C safety injection piping, a conservative approach was adopted and these examinations are being conducted.

4. The valve MOV 850B will be disassembled, thoroughly tested, evaluated and inspected for any further signs of distress. The motor casing bolts on valves MOV 850A and Mov 850C will be examined.

B. Additional Items

1. The importance of placing feedwater controls in manual prior to removing the turbine from service will be emphasized in training sessions. In addition, the advisability of modifying the automatic loading of steam generators upon turbine trip will be studied. Changes will be proposed and incorporated if appropriate.

2. Analysis to confirm design adequacy of the safety injection piping for water hammer loading are being conducted. These analyses will cover Loops A, B, and C safety injection piping.

3. An investigation relative to water hammer phenomena will also be made of other safety related systems not in continuous service.