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ASSESSMENT OF THE CORRECTIVE ACTIONS TAKEN TO RESOLVE THE ELECTRICAL TECHNICAL ISSUES RELATED TO THE NOVEMBER 21, 1985 EVENT, SAN ONOFRE NUCLEAR GENERATING STATION, UNIT NO. 1

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ABSTRACT

This EG&G Idaho, Inc., report reviews specific technical issues regarding electrical, instrumentation and control system failures related to the November 21, 1985 event at Unit No. 1 of the San Onofre Nuclear Generating Station. The following areas are examined:

a) spurious safety injection indication on loss of power

b) spurious remote indication for safeguard load sequencers

c) impact of the diesel generator and reactor bypass breaker interlock on the reliability of the electric power system

d) reliability of the power to the vital buses

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FOREWORD

This report is supplied as part of the "Issues Related to the San Onofre Event," being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of PWR Licensing-A, by EG&G Idaho, Inc., NRC Technical Assistance Division.

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CONTENTS

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1. INTRODUCTION

On November 21, 1985, Unit No. 1 of the San Onofre Nuclêar Generating Station experienced a loss of offsite power event. This event was initiated by the protective relays associated with the unit's auxiliary transformer C that had detected a fault and, as a result, isolated the transformer from the 220 kV switchyard and from the 4160 VAC Class 1E bus 2C. With bus 2C and its associated loads de-energized, the reactor was tripped by the operators as required by procedures. As the redundant Class 1E bus 1C was receiving power from unit auxiliary transformer A at the time, bus 1C as well as the remaining in-plant AC loads were de-energized concurrent with the trip of the unit generator.

The event is described in NUREG-1190 (Reference 1). Southern California Edison Company, the licensee for the San Onofre Nuclear Generating Station, provided information concerning the above related failures in their submittal dated April 8, 1986 (Reference 2). Additional information was provided on May 1, 1986 (Reference 3). This report is based on the information presented in these references.

The initiation of the event was the failure of the 4160 V cable feeding bus 2C from transformer C. Germane to this event were several consequent failures. There was a spurious indication of a safety injection and a spurious remote indication of the safeguard load sequencers. 120 VAC vital bus 4 lost power. The reliability of the electric power distribution system was brought into question regarding the interlock between the diesel generator circuit breaker and the reactance bypass circuit breaker. The adequacy of the loss of voltage automatic transfer sequence (LOVATS) for restoring offsite power was questioned. This report will address these items and the licensee's corrective actions.

2. REVIEW REQUIREMENTS

The design of Unit No. 1 of the San Onofre Nuclear Generating Station was evaluated against the requirements and recommendations of the following documents.

1. Code of Federal Regulations, 10 CFR 50, Appendix A, General Design Criteria for Nuclear Power Plants
   - Criterion 13, "Instrumentation and Control"
   - Criterion 17, "Electric Power Systems"
   - Criterion 20, "Protection System Functions"
   - Criterion 24, "Separation of Protection and Control Systems"

2. Regulatory Guide 1.32, "Criteria for Safety-related Electric Power Systems for Nuclear Power Plants"

3. Regulatory Guide 1.53, "Application of the Single-failure Criterion to Nuclear Power Plant Protection Systems"

4. Regulatory Guide 1.75, "Physical Independence of Electric Systems"

5. Regulatory Guide 1.97, "Instrumentation for Light-water-cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident"

6. IEEE-std-279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations"

7. IEEE-std-308-1978, "Criteria for Class 1E Power Systems for Nuclear Power Generating Stations."

In general, these requirements and recommendations provide for instrumentation, power and protection systems that are free from the effects of single failures that could prevent the performance of any given safety function that mitigates a design basis accident. The protection and control systems are to be limited in interconnections to assure that there is no significant impairment of safety. Instrumentation should be functional during anticipated operational occurrences and accident conditions.

3. EVALUATION OF CORRECTIVE MEASURES

3.1 Adequacy of the Licensee's Design Changes to Eliminate the Spurious Indication of Safety Injection on Loss of Power

Window 2 of the reactor plant first-out annunciator alarmed (indicated a safety injection) when auxiliary transformer C was isolated. Plant parameters (containment pressure and pressurizer pressure) and equipment status verified that a safety injection had not been initiated, and the alarm was determined to be spurious.

This alarm normally occurs when either or both safeguard load sequencing system sequencers operate, depriving the annunciator auxiliary relay of power. The operation of either sequencer opens the auxiliary relay contact in the contact string that operates the annunciator. Due to the loss of power, the normal power source (MCC 3A) to the contact string was lost. The annunciator then operated as designed, as if power to the auxiliary relay was disrupted by the sequencers.

To correct this deficiency, the licensee has stated that, prior to startup from the current refueling outage, power to the contact string for the safety injection (window 2) annunciator will be provided by a source backed up by an uninterruptable power supply (UPS). Reference 3 provided details on this modification. The annunciator itself is powered by the Unit 1 dc power system. The annunciator window is operated by a contact of the auxiliary relay. The auxiliary relay is de-energized when either safety injection sequencer operates. The auxiliary relay will receive its power from a Unit 2/3 non-Class 1E UPS via the security distribution system. This UPS is powered by batteries and a battery charger that is backed up by a Unit 2/3 diesel generator. Should the inverter fail, an automatic transfer switch will transfer the power source to a Unit 1 120 V motor control center (MCC) that is powered by a self-regulating transformer. Divisional independence of the sequencers is maintained with this modification. A later modification will power this contact string from the Unit 1 vital bus 4 (see Section 3.4 for a description of its modified power sources).

We find that the proposed change to either power source will correct the identified deficiency (i.e., the spurious indication of a safety injection on loss of offsite power), and that this change is in conformance with the applicable regulations and regulatory guides. Therefore, we find this modification acceptable.

3.2 Spurious Remote Indication for Safeguard Load Sequencers

The safeguard load sequencer is a safety-related system that monitors the availability of offsite power and the plant conditions requiring the operation of the safety injection system. With offsite power available, the diesel generators are not automatically loaded. Only with a safety injection signal concurrent with a loss of offsite power are the diesel generators automatically loaded, by groups of safety injection loads.

Following the loss of offsite power, the load sequencing lights (A, B, C, and D of the remote surveillance panels) that show the status of the safeguard load sequencers extinguished. As no safety injection had taken place, only the extinguishment of the A light was appropriate. These neon lights are powered by 125 VDC and operated by the sequencer subchannel output relays. Lights E and F, which are spares, remained lit. Lights B, C and D relit without a system reset. This was also an abnormal indication in that once extinguished, a reset should occur before the lamps will light again.

Operating Instruction SO1-12.3-7, "Monthly Sequencer Test," was used on sequencer nos. 1 and 2. This test revealed no cause for the faulty indication. The abnormal indication could not be recreated. Loss of voltage was ruled out as lights E & F remained lit throughout the event, while the others were extinguished. Testing on a spare sequencer logic board also showed no cause for the faulty indication.

During the event, the sequencer itself operated as designed. Only the remote indication was faulty. The licensee could not find a cause for the spurious indication, and concluded that it was caused directly by the loss of power event. No corrective actions were taken.

Only faulty indication of the remote surveillance panels occurred. No mechanism for this failure was evident or subsequently found. Thus, no corrective actions could be taken. As the sequencers did function as designed, we find this matter acceptable for unit restart. However, the licensee should continue to investigate the circuit design and components, identify any deficiency that could cause the identified spurious indication and correct that deficiency.

3.3 Impact of the Diesel Generator and Reactance Bypass Breaker Interlock on the Reliability of the Electric Power System

To ensure that the available fault current to the Class 1E loads is kept within allowable design limits, the electrical distribution system has current limiting reactors in the feeders between Auxiliary Transformer C and the Class 1E buses. These reactors are normally bypassed by the reactance bypass breakers. However, during testing where the diesel generators are operated in parallel with the offsite source, the reactance is needed in the circuit to limit the available fault current. To manually close the diesel-generator breaker, the reactance bypass breaker associated with that bus is interlocked with the diesel generator breaker such that the diesel generator breaker will close only when the reactance bypass breaker is open (i.e., the reactance is in the circuit). However, this design affects the Class 1E buses regardless of whether or not the offsite source is supplying power to the bus.

The licensee is removing this interlock to enhance the manual closing of the diesel generator circuit breaker following a loss of offsite power event. This will allow the diesel generator circuit breaker to be closed independent of the positions of the reactance breaker and the reactance bypass breaker. An alarm will sound in the control room after 10 seconds should any two power sources (auxiliary transformers A, B, and C and the diesel generators) be applied to either Class 1E bus simultaneously (except when the diesel generator is parallelled with auxiliary transformer C with the respective reactor in the circuit). This alarm will direct the operator to, via procedure, open the reactance bypass breaker or remove the parallel sources of power. This modification and procedure is to be incorporated by June 1, 1986.

Section 5.2 of Reference 1 determined that a design deficiency exists in that when the reactance bypass breaker is racked out (physically removed) from the switchgear, the interlock with the diesel generator circuit breaker would prevent the diesel generator circuit breaker from closing. This would effectively prevent the use of the diesel generator to power the Class 1E bus.

The removal of the interlock between the reactance bypass breaker and the diesel generator breaker will allow the use of the diesel generator to power the Class 1E bus irregardless of the position or the condition(i.e., racked in or out) of the reactance bypass breaker.

We find that this modification will enhance the restoration of power for a loss of offsite power event, and the alarm will limit the period of time that power sources can be operated in parallel resulting in potential excessive available fault current. Therefore, this modification is acceptable. However, the licensee should verify that the requirement to have the reactance in the circuit for periodic load testing of the diesel generators remains a procedural requirement.

3.4 Reliability of the Power to the Vital Buses

The 120 VAC vital buses supply power to instrumentation, controls and alarms. Of the seven vital buses at San Onofre 1, only bus 4 was not powered by an inverter powered by battery backed direct current (125 VDC) power. Vital bus 4 is normally powered by a 7.5 kVA regulating transformer, or alternately, by a 37.5 kVA transformer, by automatic transfer. However, both transformers are energized by the same manual transfer switch, from either 480 V motor control center (MCC)1 or 480 V MCC2. Thus, when offsite power was lost, vital bus 4 was lost.

The licensee states that this situation will be corrected by installing an uninterruptable power supply (UPS) as one of the power sources for vital bus 4. This modification is scheduled to be complete during the first refueling outages following the return to service following the current outages and it will provide a 7.5 kVA inverter that will be the normal power source for vital bus 4. An automatic transfer switch will connect the present power source should the inverter fail. The inverter receives its power from 125V dc bus 1, that is powered by a battery charger with float charged batteries available should AC power be lost. The battery charger can be powered by its associated diesel generator. The inverter is stated to be sized to exceed present load requirements and planned future load additions.

Based on the licensee's description, we find that this modification will provide reliable power to 120 V vital bus 4, and that it is in conformance with the applicable regulations and regulatory guides. Therefore, we find the proposed modification acceptable, however, it is not required for startup.

4. CONCLUSIONS

We find that the investigative actions, modifications and corrective actions identified for the items reviewed in this report are acceptable for unit restart. However, the licensee should verify that the procedures for the periodic load testing of the diesel generators still require that the reactance be in circuit before a diesel generator is connected to the Class 1E bus. Also, the licensee should investigate the circuit design of the remote indicators for the safeguard load sequencers, identify any deficiency that could cause the spurious indication and correct that deficiency.

5. REFERENCES

1. Loss of Power and Water Hammer Event at San Onofre, Unit 1 on November 21, 1985, NUREG-1190, U.S. Nuclear Regulatory Commission, January 1986.

2. Southern California Edison Company letter, M. O. Medford to A. E. Chafee, NRC Region V, "Investigation Report of November 21, 1985 Water Hammer Event, San Onofre Nuclear Generating Station, Unit 1," April 8, 1986.

3. Southern California Edison Company letter, M. O. Medford to Director, Office of Nuclear Regulation, "Requests for Additional Information," May 1, 1986, AD12, SO1, NRC.

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