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Mr. R. H. Engelken	Southern Cal. Edison Company Rosemead, California J. B. Moore	12/08/77
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DESCRIPTION

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ENCLOSURE

Final Report concerning disposition of reinforcing steel for the offshore circulating water system intake terminal structure....

(5-P)

PLANT NAME : Offshore
RJL 12/19/77

FOR ACTION/INFORMATION

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December 8, 1977

Mr. R. H. Engelken, Director
Office of Inspection and Enforcement
U. S. Nuclear Regulatory Commission
Suite 202, Walnut Creek Plaza
1990 North California Boulevard
Walnut Creek, California 94596

Subject: Docket Nos. 50-361 and 50-362
San Onofre Nuclear Generating Station, Units 2&3

Dear Mr. Engelken:

Our letter of November 9, 1977 confirmed notification of a condition identified in the erection of a portion of the reinforcing steel for the Offshore Circulating Water System intake terminal structure which we consider to be reportable in accordance with 10CFR50.55(e). This structure falls within the provisions of regulatory positions C.2 and C.4 of Regulatory Guide 1.29.

Enclosed are 25 copies of the Final Report regarding this deficiency entitled, "Final Report Concerning Disposition of Reinforcing Steel for the Offshore Circulating Water System Intake Terminal Structure for San Onofre Nuclear Generating Station, Units 2 and 3".

If you require additional information, please let me know.

Very truly yours,

J. B. Moore

Attachment
cc: Dr. Ernst Volgenau (NRC, Director I & E)

FINAL REPORT CONCERNING DISPOSITION OF REINFORCING STEEL FOR THE OFFSHORE CIRCULATING WATER SYSTEM INTAKE TERMINAL STRUCTURE

SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3

I. INTRODUCTION

The purpose of this report is to provide information required by 10CFR50.55(e) (3) with respect to the deficiency reported on November 8, 1977. This report includes background information, a description of the deficiency, an analysis of the safety implications and the corrective action taken.

We have determined that welding performed on reinforcing steel intended for use in the base mat of the Offshore Circulating Water System (OCWS) intake structure for Unit 2 was not done in accordance with the appropriate codes or the design intent. This work was done by a subcontractor, G. F. Atkinson, Co., a contractor to SCE for erection of the OCWS.

Although the major function is not safety-related in itself, the OCWS intake structure is encompassed by positions C.2 and C.4 of Regulatory Guide 1.29, Revision 2, in that its continued function as part of the Circulating Water System is not required but its failure could possibly reduce the functioning of the plant safety-related cooling water system to an unacceptable level. It is therefore designed to resist failure in the unlikely event of a safe shutdown earthquake, and certain aspects of 10CFR50, Appendix B, are applied to its construction.

II. BACKGROUND

The OCWS intake structure consists of a riser composed of precast concrete rings which are placed on a cast-in-place foundation. The rings are connected to the foundation by six reinforced columns which are cast into circular blockouts within the rings following assembly of the structure. The original design of the structure utilized an unreinforced foundation to facilitate underwater placement of the concrete. Only the column dowels were to be included in the base mat pour.

It was recently required that SCE Engineering perform a re-analysis of the structure to provide the NRC with a comparison of the design of this structure with the NRC standard review plans. As a result of this re-analysis, two mats of reinforcing steel were added to the foundation to increase its capability to withstand a seismic load. The size of the column steel was also increased for the same seismic considerations. Due to the restricted size of the column block-out,it was not possible to use a lap splice. Therefore, the column steel was fabricated for the full height of the structure, approximately 37 feet to facilitate construction. The mats and columns were fabricated on shore and transported to the end of the offshore trestle and lowered to the ocean floor. The full weight of the reinforcing steel cage was greater than 50 tons even though ASTM A615 Grade 60 steel was used to reduce the weight while achieving the desired strength.

Inspection of the OCWS is conducted by the SCE Construction and Material Inspection (CMI) organization. The program CMI conducts consists of in-progress surveillance inspection of contractor activities and document review to provide assurance that certain records are filed in the Project Document Control Center.

III. DESCRIPTION OF THE DEFICIENCY

When the reinforcing steel was added to the OCWS intake structure, the designer did not specify construction methodology for placement of the steel. Due to the handling requirements in placing the mat, the contractor determined that welding must be used to achieve sufficient rigidity. Spacers made up of smaller reinforcing bars were used to space and support the two mats, and pipe rings were used to provide support for the column bars. It was estimated that approximately 1000 tack welds were performed on the mat and 700 welds were used on the columns.

The specification for the work (SO23-211 "Offshore Circulating Water System", Appendix A, "Technical Specification for the Work") Section 2.1, "Scope" invokes ACI-318-71, "Building Code Requirements for Reinforced Concrete". ACI-318-71, Section 3.5.3 under "Metal Reinforcement" states:

> "Reinforcement to be welded shall be indicated on the drawings and the welding procedure to be

> used shall be specified. The ASTM specifications shall be supplemented by requirements assuring satisfactory weldability by this procedure in conformity with 'Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction' (AWS D12.1)."

The current edition of AWS D12.1 specifies required preheat temperatures based on the composition of the reinforcing steel, particularly the percentages of carbon and manganese. The required preheat temperatures for the alloys used in the subject reinforcing cage were 200 degrees F for the mat bars and 400 degrees F for the columns. Furthermore, tack welding is prohibited unless approved by the engineer. The contractor was therefore in violation of the contract when welding was commenced since proper controls were not imposed and engineering approval was not obtained.

During a routine in-process inspection by CMI, the unauthorized welding activities on the base mat reinforcing steel were discovered. Following the discovery of the deficiency, tests were conducted to determine the effect of this welding on material properties. In general, yield strengths and ultimate strengths were adequate under steady load application in a standard test machine. One specimen did fail immediately after yield at 77.2 ksi. In all cases, elongation was considerably lower than the required 7 percent, ranging from 1.0 percent to 3.5 percent. The fractures were brittle in nature and initiated at the point of weld. Examination by Material Sciences Center, a metallurgical consultant, confirmed the formation of a brittle martensitic grain structure in the vicinity of the weld.

The loss of ductility exhibited in these tests limit the ability of the steel to withstand impact loadings and to absorb energy which would be imparted by seismic loading. Under impact, brittle failure occurs near the weld, leading to failure of the bar with minimum stress redistribution. Depending of the magnitude of the impact loadings, sudden failure of the bar may occur considerably below the overall yield strength.

IV. ANALYSIS OF SAFETY IMPLICATIONS

No safety impact will result from the welding of the original OCWS intake structure reinforcing cage since this cage was rejected and will not be used. Use of this cage in its original condition would have seriously altered the behavior of the structure during extreme seismic events. Severe cracking of the foundation may have occurred under this loading condition, as well as separation of the body of the structure from its foundation due to brittle fracture of the column steel under impact loadings. The lower 31 feet of the structure is buried in a select gravel backfill of high permeability so it is difficult to assess the degree of disruption of normal flow which would have resulted from this failure. Since only 4 percent of total flow is required for emergency cooling of both units, and since a similar failure would not be expected of the Unit 3 intake structure, no safety impact would be anticipated. However, margins against flow blockage would be reduced to an unacceptable level.

V. CORRECTIVE ACTION

Although tests have demonstrated that post heat treatment of the welded areas of the original mat can restore the ductility with little or no loss of strength, it was determined that a new cage would be fabricated. A more readily weldable steel (ASTM A706, Grade 60W) was utilized to allow sufficient welding to achieve necessary strength for handling. This welding was performed under continuous surveillance by inspection personnel and proper preheat requirements were imposed where necessary.

Test results conclusively showed that all A706 mat steel could be tack welded together either in a "cross" or "parallel" configuration. The tests, conducted by U. S. Testing Co., were coordinated by SCE Engineering and monitored by CMI. The contractor conservatively chose to only weld the No. 8 construction aid bars parallel to the No. 11's. The No. 14 to No. 14 column steel welding was allowed and performed with preheating to 200 degrees - 300 degrees F.

In order to minimize welding of the new reinforcing cage, a tubular frame was made to provide the basic rigidity and spacing for the reinforcing bars.

Because test result margins were too narrow to allow column steel to mat steel welding, clamp fasteners were used to fasten the column reinforcing steel to the base mat. Test results would also not permit cross welding the No. 11 mat steel to the tubular frame. Therefore, mechanical cross connections were made using either wire or clamp fasteners.

Surveillance inspection by CMI was conducted on 100% of the new Unit 2 intake structure reinforcing steel fabrication operations. CMI will also conduct similar inspections of the Unit 3 intake structure to prevent unauthorized erection methods by the contractor.

Due to a breakdown in the distribution of design documents, CMI did not immediately receive the drawing change which added the reinforcing steel to the base mat. Prior notification of the design change would have prompted CMI inspection at the beginning of the reinforcing steel fabrication activity and probable earlier discovery of the welding deficiency. To assure prompt notification of design changes in the future, CMI has been placed on the automatic distribution matrix for all OCWS design disclosure and procurement documents.