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Docket Nos. 50-508/509

50.55(e) Report

Washington Public Power Supply System

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REGION V

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Docket Numbers 50-508 and 50-509

April 16, 1982
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U. S. Nuclear Regulatory Commission, Region V
Office of Inspection and Enforcement
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Attention: Mr. T. W. Bishop
Chief, Reactor Construction Projects Branch

Subject: PROJECT NOS. 3 AND 5
10CFR50.55(e) REPORTABLE CONDITION
WELDING DEFICIENCIES IN RP PLATES (D/N #25)

In accordance with the provisions of 10CFR50.55(e), Region V was notified that the subject condition was potentially reportable. Subsequent investigation has determined that the deficiency is significant and were it to have remained uncorrected could have adversely affected the safety of operations of the facility.

Attached is the Supply System approved final report for the subject condition detailing a description of the deficiency, safety analysis and corrective/preventive actions taken.

Should you have any questions or desire further information, please contact me directly.

R S Leddick

R. S. Leddick, 760
Program Director, WNP-3

DRC/tt

Attachment

cc: J. Adams - NESCO
D. Smithpeter - BPA
Ebasco - New York
WNP-3/5 Files - Richland

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ATTACHMENT 1

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
DOCKET NUMBERS 50-508 AND 50-509
FINAL 10CFR50.55(e) REPORT
WELDING DEFICIENCIES IN RP PLATES (D/N #25)

INTRODUCTION

Fought Steel, Portland, Oregon, fabricated the type RP embed plates under Contract 3240-95 for WNP-3/5. The embed plates are designed for installation in concrete on the interior and exterior shear walls of the Reactor Auxiliary Buildings (RAB) to support the pipe rupture restraints and seismic interface restraints for main steam and feedwater piping.

RP is a designation given to identify these embed plates for the main steam and feedwater piping and is subdivided into a number of RP types. These embed plates are fabricated from ASTM A-36 steel to Quality Class I and the thickness of the plates varies from 1½ inches to 3 inches. Most of the RP plates have shear lugs welded on the back. In addition to these shear lugs, some of the RP plates have shear bars welded on the face of the plates. The thickness of these shear bars and shear lugs also varies from 1 inch to 3 inches.

Cracks were found in the welds placed at the corner joints where transverse and longitudinal shear lugs meet. These cracks were discovered during the course of the fabrication of the embed plates. The design does not require these two plates to be welded together, but Fought Steel welded across the corner with a thin pass weld.

During the course of the Engineering investigation of the cracks identified above, it was also found that the fabrication of these plates did not provide full penetration welds nor was post weld heat treatment performed as required by the design drawings and contract specifications. Failure to meet these requirements constitutes a significant breakdown in the Quality Assurance Program.

DESCRIPTION OF DEFICIENCY

The deficiencies can be categorized as follows:

Weld Crack: Welds were applied across the ends of the shear lugs and in corners formed at the intersection of the shear lugs. These welds were not shown on design drawings and cracks were found in these welds.

Partial Penetration Welds Instead of Full Penetration Welds: Shear lugs and bars were welded to the plate by partial penetration groove welds whereas design drawings required full penetration welds.

Lack of Post Weld Heat Treatment: The Project Specification required a post weld heat treatment of welds thicker than 1 1/2 inches; however this was not performed.

Breakdown in Quality Assurance Program: Failure to detect the material and fabrication deficiencies described above represents a breakdown in the Quality Assurance Program. This is evidenced by the following:

1. Vendor failure to adequately implement special process controls;

2. Vendor and Engineer failure to perform work in accordance with instructions, procedures or drawings;

3. Vendor failure to perform inspections to verify conformance to drawings.

SAFETY ANALYSIS

The type RP plates are provided to attach pipe rupture and seismic interface restraints for main steam and feedwater piping to building structure and are installed in the Reactor Auxiliary Building exterior and interior shear walls and on the roof. Rupture restraints are provided to support this piping during postulated pipe break.

All the questionable RP plates are on the outside face of the exterior shear wall. The piping restraints and embeds in this area will be exposed to the outside atmosphere.

Six RP-18 plates are provided to support the rupture restraints, three each on the north and south exterior shear walls. These restraints are located on the outside of exterior shear wall, immediately after the main steam and feedwater pipes exit the Reactor Auxiliary Building.

The Administrative Building on the north side, transformer and refueling tank area on the south side, and the RAB exterior walls could be exposed to the resulting jet impingement and impact loads due to the pipe rupture if the plates fail and allow the support to fail. Damage to these structures could result with attendant danger to plant personnel and equipment.

Because of the deficiencies previously identified, the structural integrity of the RP plates could not be assured during the postulated pipe breaks without implementing the corrective actions which were taken. Hence, the above deficiency is considered significant and reportable per 10CFR50.55(e).

CORRECTIVE ACTIONS

Weld Cracks

All plates were reinspected by Magnetic Particle testing method except those plates which were already installed. Based on the inspection results, corrective actions were taken as follows:

1) Where no defects were found, the filler weld metal at corner joints was removed back 1/4" to 3/4" from the corners until faying surfaces between intersecting lugs were visible down to the surface of the base plates.

2) When defects were found, the repairs were made as follows:

   a) When the defects were found entirely in the weld metal, the indications were completely removed. Weld metal at the corner was removed to the surface of the base metal. The reworked areas were reinspected using MT or PT techniques.

   b) When the defects were found to extend into the base plate, the defects were removed by excavating into the base plate. Defect removal was confirmed by PT or MT. The plate was repaired and the thickness of the plate was restored to its original thickness. The repaired area was UT examined to ascertain the soundness.

3) The four RP-29 plates which were installed in the concrete were UT examined. No cracks were found in these plates.

Weld cracks were found only in Types RP-33 and RP-28. Two RP-33 and eight RP-28 plates were involved.

Fought Steel used cold bending procedures to remove a slight warpage in the plates after weldup. Cold bending is a standard mill practice employed by steel mills to straighten rolled plates to comply with the shape and dimensional tolerances. Fabricators also use the same techniques. ASME Section NC and NF also allow cold bending in the case of steel plates.

Partial Penetration Welds

The plates which had partial penetration welds instead of full penetration welds were UT examined. On the basis of the UT results the plates were reanalyzed for the individual support design loads. All but Type RP-18 were found to be acceptable. Type RP-18 plates were redesigned to accommodate the load transfer to the supporting wall. A Design Change Notice was issued to rework the plates. The required rework has been completed.

CORRECTIVE ACTIONS (CONT'D)

Lack of Post Weld Heat Treatment

A comparative study was made of two Type RP plate samples (RP-16 and RP-38) as welded without post weld heat treatment and new welded sections with post weld heat treatment. The results and analysis are discussed in the following paragraphs:

Fabrication Conditions

The embedments of concern were fabricated by Fought, employing the flux cored arc welding process and a weld energy input of 72 kilojoules/inch. Preheats are reported to have ranged from 175°F-250°F for sections up to 2½" thick and 275°F-325°F for thickness over 2½", the preheat maintained until completion of welding. The preheats used by Fought were in excess of those required by AWS D1.1, which are, 150°F for up to 2½" thickness, 225°F for greater than 2½". The weld energy input used by Fought to fabricate the embeds, combined with the preheat and interpass temperatures used, developed a more favorable, slower cooling rate and a softer weld zone.

Hardness Testing

Sections from weldments produced by Fought were obtained from embedment RP16 (2" thick) and embedment RP38 (3" thick). Both are identical to the embedments of concern and were welded according to the same procedures. The carbon equivalent of both the RP16 and RP38 embedments steel material was found to be .47%.

The test cross-sections, supplied in the saw-cut condition, were prepared for as-welded hardness measurement by polishing and etching. Knoop hardness surveys were made at two locations in the weld, one at the toe, where higher hardnesses were expected because this region was not tempered by a subsequent weld bead, and in the throat approximately halfway through the weld. All Knoop readings were converted to Rockwell.

The maximum hardness values obtained in the weld zone of the 2" embedment (RP16) was 24 HRC for the weld toe; maximum hardness of the 3" embedment (RP38) weld toe was found to be 25 HRC. All other hardnesses in the RP16 and RP38 embedments were in the 90-95 HRB range.

CORRECTIVE ACTIONS (CONT'D)

Lack of Post Weld Heat Treatment (Cont'd)

Post Weld Heat Treatment
And Metallographic Evaluation

The Fought embedments test material weld zone maximum hardness of [illegible] and 25 HRC, was found to be in excess of the industry-accepted upper level which is considered suitable for installation without post weld heat treatment. Recent concerns for notch toughness of pipe rupture restraint materials by the industry prompted furnace treatment testing so as to dispel concerns over the 25 HRC hardness and its notch toughness. Accordingly, a section of Fought embedment, sample RP38, was furnace heat treated for 2½ hours at 1150°F. A hardness traverse, similar to that conducted on the as-welded RP38 test sample, was performed on the heat treated material. Maximum hardness of the material was found to have decreased from 24 HRC to 93 HRB.

The apparent need for an explanation regarding the suitability of material at nominal 25 HRC for service prompted a microstructural evaluation. The 25 HRC hardness of the as-welded material suggested that a minimal amount of martensite, a brittle constituent causing the weld zone hardness, may be present in the hard zone, on the order of 5%. Microscopy was conducted to provide credence for the 5% martensite estimate; this level known to have negligible effect of ductility. Examination of the structures at 1000X and lesser magnifications did not reveal any martensite. A minor amount of material, considered to be martensite at 300X magnification, was found to be a fine dense pearlite upon examination at higher magnification.

Summary

This evaluation has established that embedments composed of carbon steel materials and containing a moderate level of constituents affecting hardenability do not, when fabricated according to suitable conditions, experience significant hardening in the weld zone. This was confirmed by the relatively low hardness values obtained, 25 HRC maximum in the weld zones of duplicates of the welded embedment components.

CORRECTIVE ACTIONS (CONT'D)

Lack of Post Weld Heat Treatment (Cont'd)

Summary (Cont'd)

The results, as supported by the as-welded hardness values, also confirmed that the use of a relatively high heat input, in combination with the preheat/interpass temperature ranges applied, resulted in a cooling rate sufficiently slow to inhibit the formation of an undesirable transformation structure in the weld heat-affected zone. The reduction in hardness determined for the post weld heat treated material was found to have resulted from softening of dense early transformation products in the weld zone. This material is known to be more ductile in the as-welded condition than is the undesirable and more brittle structure, martensite, and does not require thermal treatment for achieving adequate service performance. The possibility for presence of the martensite phase in the weld zone, owing to the lack of weld process selection controls on fabricators, mandated the inclusion of a post weld heat treatment requirement in the component specification.

Based on the above analysis all plates covered by this report have been accepted without post weld heat treatment.

Breakdown in Quality Assurance Program

The contract for the supply of these components is being closed out. With no components being supplied in the future, no corrective action has been imposed on Fought. The supplier has been informed of these deficiencies.

The responsible Ebasco VQAR assigned to the Vendor's facility was removed from the WNP-3/5 Project activities. On site training sessions have been held for the Vendor Quality Assurance Representatives (VQARs). The training consisted of visual welding inspection requirements. Additionally, vendor inspection plans have been reviewed to assure the inclusion of post weld heat treatment verification, as required. The VQARs have been informed of these requirements.