

CR-PNP-2006-03499

Condition Description:

During a walkdown of the plant Fire Protection noted that several hoses were stored or routed through the combustible free zone on 23' of the Reactor Auxiliary Building. This area is identified in ENN-DC-161 as "combustible free".

Immediate Action Description:

Notified Operations

Suggested Action Description:

Remove all unattended combustible materials from within the area identified as "Combustible Free".

Originated: 09/21/2006 by Burke, Stephen E

Originator's Group: Eng P&C Plant Programs Staff

Equipment: **Component** **System:** **Reference Item:**

<u>Problem Code</u>	<u>Work Group</u>	<u>Problem Code</u>	<u>Work Group</u>	<u>Problem Code</u>	<u>Work Group</u>
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Keywords

Keywords KW-HU Event KW-HU Error KW-HU Precursor KW-HU LOW KW-Equipment

Report Weight: (1) self identified (2) internal oversight (3) external oversight (4) self revealing

Significance Code: CAQ Non-CAQ

CAT-A (RCA) Justification

CAT-B: HIGHER-TIER ACE LOWER-TIER ACE MAINT RULE

CAT-C

CAT-D (Admin) Close to Normal Supv Oversight Close to Actions Taken and Trend

Close to MR #: Close to ER#

Close to MSTP Close to CR#

Close to

CR Owner Group/Manager:

OPERATING EXPERIENCE ISSUE: INTERNAL OE EXTERNAL OE

Directed Action:

Comments: EquipClass: RTF NRTF-Non Critical NRTF-Critical

TOP CLASSIFICATION: UNCLASSIFIED
NRC INSP./TEAM: 05000293/2006-007
DOCUMENT SOURCE: Licensee Record as of Date Printed
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ADAMS PROFILE INFORMATION

PROFILE TAB:

Document Date: May 9, 2003

Document Type: [BLANK]

Availability: Non-Publicly Available (ALWAYS)

Title: CR-PNP-2006-03499, Visible corrosion noted on torus saddle support tie down anchor bolt assemblies.

Keyword [MV]: SUNSI Review Complete: Yes (ALWAYS)
+Template: RGN-001

Document Sensitivity: Non-Sensitive (Licensee Document)

SECURITY TAB:

RI DRS-BS as Owner
DPC as Owner
OGC as Author
NRR as Viewer
RI as Viewer

Once saved, copy to DPC under Normal Processing
Move Processed Document into ADAMS Profiling Complete Folder in WP
Profile Complete Date: _____ Initials: _____

Originator: Harizi, Philip D

Originator Phone: 5088307726

Originator Group: Eng DE Mech Civil Struct Staff

Operability Required: N

Supervisor Name: Pace, Raymond M

Reportability Required: N

Discovered Date: 05/09/2003 04:45

Initiated Date: 05/09/2003 05:03

Condition Description:

Visible corrosion has been noted on several of the torus saddle support tie down anchor bolt assemblies. This CR was written to acknowledge this condition and to initiate actions to correct the condition and prevent accelerated corrosion from becoming a problem in the future. The existing condition is not causing any significant degradation of the torus saddle support for performing its design function.

The "Torus Saddle Support Assemblies" are structural additions made to the torus under PDC 81-04A to provide additional restraint to the torus structure. There are 16-torus saddle support tie down plates, each attached to the foundation with 8 anchor bolts (total 128 anchor bolts). The anchor bolts are 2"-6UN expansion type concrete anchors with an embedment depth that varies from 2'-6" to 3'-5". The anchor bolts were set and preloaded using a nut and bearing plate on the concrete surface. Subsequent to that, a 2"-6UN extension piece was added to the anchor bolt to secure the saddle via the tie down clamp plates and another 2"-6UN nut that was torqued to preload the entire saddle arrangement.

The corrosion is predominantly on the bearing plate and, to a lesser extent, on the anchor bolt and nut. This issue was recently addressed under a contract with Duke Engineering in 1999 (SUDDSRF #99-134). The corrosion was determined to be from groundwater intrusion up through the grouted anchor bolt hole. As a result of leaching up through the anchor bolt hole, the water was found to be alkaline and expected to contain a high concentration of calcium carbonate (lime) from the concrete. The corrosion rate for steel in alkaline fresh water is low, as described in the previous report.

Immediate Action Description:

The existing conditions were reviewed relative to the 1999 report. Based on this review, it was decided that remedial actions should begin to prevent this from becoming a problem in the future. A suitable "cold galvanizing compound" was found that will provide a metallic zinc coating that is anodic to the base metal, thereby providing true galvanic protection as opposed to a barrier type paint coating.

Suggested Action Description:

The current condition shows at least one anchor bolt where the corrosion of the bearing plate has become more aggressive than was previously observed. As such, it is necessary to take remedial action to stop or slow down the corrosion process. It is recommended that the following be performed for any anchor bolt where there is visible corrosion of the bearing plate or bleed out of rust through the original coating:

1. Remove all corrosion products from the bearing plate, nut, and anchor bolt. An aggressive method such as sand-blasting and/or a needle gun may be used for the bearing plate, but only manual sanding or filing should be performed on the anchor bolt or nut. Remove all loose, poorly adhered coatings.
2. Remove all residue and water from the bearing plate area. Apply heat if necessary to evaporate all remaining moisture from the bearing plate and surrounding area.
3. Coat all the exposed metal surfaces with a "Cold Galvanizing Compound" that can produce a dried coating that is 90% or greater metallic zinc. Apply two coats. A suitable product is Z.R.C. Zero-VOC Zinc Cold Galvanizing Compound.

TRENDING (For Reference Purposes Only):

Trend Type

Trend Code

PI=SI

CRT=EF

Initiated Date: 5/9/2003 5:03**Owner Group :**Eng Design Mgmt**Current Contact:** R. HUNNEFELD**Current Significance:** C - CORRECTION**Closed by:** Buckley,Patricia A

9/3/2003 7:42

Summary Description:**Remarks Description:****Closure Description:**

Work can be don on-line.

All CA's associated with this CR were reviewed by the responsible manager. Upon the manager's recommendation, this CR is being closed.

Per ENN-LI-102, Para. 5.8.2.3: Independent reviews are not required for non-significant condition reports. The documented closeout verification performed by the Responsible Management is adequate authorization for closure of the CR.

Version: 1

Significance Code: C - CORRECTION

Classification Code: NON-SIGNIFICANT

Owner Group: Eng Design Mgmt

Performed By: Buckley,Patricia A

05/09/2003 10:31

Assignment Description:

Responsible Manager: R. Pace

CA Number: 1

Group	Name
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Assigned By: CRG Mgmt

Assigned To: Eng Design Mgmt

Pace, Raymond M

Subassigned To : Eng DE Mech Civil Struct Staff

Harizi, Philip D

Originated By: Buckley, Patricia A

5/9/2003 10:33:01

Performed By: Pace, Raymond M

6/3/2003 13:12:41

Subperformed By: Harizi, Philip D

6/3/2003 08:38:50

Approved By:

Closed By: Pace, Raymond M

6/3/2003 13:12:41

Current Due Date: 07/08/2003

Initial Due Date: 07/08/2003

CA Type: CORRECTIVE ACTION

Plant Constraint: NONE

CA Description:

"As the Responsible Manager, validate the problem statement and determine corrective actions as needed to resolve the adverse condition(s). NOTE: Category 'C' corrective actions may be closed out to MR's without CRG approval provided the MR does not resolve a GL 91-18 deficiency. If a Corrective action is closed out to a MR, the responsible manager is responsible to ensure the CR number is included in the MR references section. CA closure statements are expected to confirm this action has been completed."

Response:

The sub-response is adequate for closure of the EFA. Two additional action items have been assigned to update the coating spec. and to provide guidance to maintenance and planning for repair work.

Ray Pace

Subresponse :

See the attached response that was done using the Equipment Failure Analysis format.

The conclusion is that it is necessary to take remedial action to stop or slow down the corrosion process. It is recommended that such remedial actions be performed for any anchor bolt where there is significant visible corrosion of the bearing plate or bleed out of rust through the original paint coating. The number of locations that are to be worked must take ALARA considerations into account such that only those locations with significant corrosion should be likely candidates. Locations where the paint retains adherence to sound metal need not be reworked. See attachment for additional information.

There are two additional Corrective Actions Required as follows:

Action Required/New CA Number: CA Number 2

Revise Specification C-93-ER-NQ based on the information in this CR to include Carboline Carbozinc 11 WB or equivalent.

Action Required/New CA Number: CA Number 3

Initiate a Work Plan based on the information in this CR to clean and recoat as-needed the torus saddle anchor bolt assemblies.

Closure Comments:

Attachments:

- Subresp Description
- Equipment Failure Analysis

Attachment Header

Document Name:

CR-PNP-2003-02009 CA-00001

Document Location

Subresp Description

Attach Title:

Equipment Failure Analysis

CONDITION REPORT No. CR-PNP-2003-02009 CA #1

1. **Problem Description:** Visible corrosion has been noted on several of the torus saddle support tie-down anchor bolt assemblies. This CR was written to acknowledge this condition and to initiate actions to correct the condition and prevent accelerated corrosion from becoming a problem in the future. The existing conditions are not causing significant degradation of the torus saddle support for performing its design function at the present time.

These observations are for the worst-case anchor bolt location that exhibits considerably more severe corrosion than all other locations. The most aggressive visible corrosion is occurring on the "Keyhole Plate" that served as the bearing plate for the original installation and prestressing of the anchor bolt. The Keyhole Plate is a 12" x 9" x 1" thick carbon steel plate (ASME SA-36) with a clearance hole for the 2" anchor bolt that also includes a notch, or "keyhole" that was used to inject grout into the bolt hole. The 2" prestressing hex nut (ASTM A-194 Gr 2H Heavy Hex) and hardened steel washer (ASTM F-436) also show significant corrosion. The 2" anchor bolt has some corrosion on the exposed threads just above the prestressing hex nut but does not exhibit significant wastage.

2. **Direct Cause:** The corrosion is caused by groundwater seepage through the foundation that has established a path through several of the anchor bolt embedments. The bearing plate corrosion is exacerbated by the installation configuration in which the plate is directly on the foundation floor rather than elevated by a grout pad. As a result, the plates at the worst locations are constantly in a puddle from groundwater seepage.

The continual seepage and evaporation of groundwater at the worst locations has resulted in the concentration of salt and minerals on the affected bearing plates. It is apparent from the visible crystallization that various salts and minerals (e.g. sodium, calcium, magnesium) have accumulated to high concentrations and this accelerates the corrosion by making a more aggressive electrolyte at the surface. The source of the various salts is from groundwater in which the concentrations are low but have accumulated by evaporation over many years.

The corrosion that is occurring at the bearing plate does not provide any direct indication of the conditions for the embedded anchor bolt. This is because the localized "corrosion chemistry" is completely different below the bearing plate. At the surface, the groundwater seepage contacts the atmosphere and can absorb oxygen, which is the driving force for the corrosion reaction, and carbon dioxide, which lowers the pH. The accumulated salts and minerals on the plate provide the concentrated electrolyte solution for the corrosion reaction. The pH of the groundwater seepage is expected to be high due to the calcium hydroxide alkalinity picked up from the passage through concrete, but the pH can be considerably lower at the surface where carbon dioxide reacts with the water. The embedded anchor bolt is expected to be in a more favorable environment of alkaline fresh water such that the rate of corrosion and wastage remains low.

The corrosion behavior of the anchor bolt system is similar to that of both reinforcing steel in concrete and steel piles in soil and groundwater, about which there is considerable literature. It is known that the corrosive attack is greatest at the location of the groundwater to atmosphere interface and is much lower within the embedded portion of the steel below the groundwater surface. There is a consideration that is relevant to the anchor bolt situation and requires attention to prevent problems in the long term. The most significant wastage of steel piles is known to occur at or in the vicinity of the groundwater surface due to "oxygen concentration cell" corrosion. This type of attack is relevant to the anchor bolt components and the eventual corrosion attack that will occur, as described below, if no remedial action is taken.

The anchor bolts, plates, and nuts were all painted at the original installation. The paint coating on the bearing plates in the worst locations has been completely compromised and is exfoliating. The attack mechanism at these locations where the paint is bubbled and exfoliating is "oxygen concentration cell" corrosion. Active corrosion occurs at sites where there is no oxygen, which are the sites under the paint that become the anode, while the driving force occurs elsewhere on the exposed steel surface within the electrolyte where dissolved oxygen is present, forming the cathode. The anodic locations form rust tubercles, which is the familiar bubbling and lifting of the paint that is seen. This is a very localized attack that is occurring on the bearing plate and is essentially limited to the plate so long as sufficient anodic sites can be established. Anodic sites preferentially locate as close as possible to the cathodic reaction (where oxygen is present) and must be directly linked via the liquid electrolyte, which is why they initially form on the plate surface under the paint. At some point, the advancing corrosion of the bearing plate will be such that the anchor bolt will become the anode and begin actively corroding at the closest location just below the nut where it is shielded from the atmospheric oxygen. This will lead to the eventual localized wastage of the bolt at this location.

It is necessary to take remedial action to prevent the progression of the corrosive attack as described above. Note that the primary concern is the eventual attack of the anchor bolt and not wastage of the bearing plate. This is because that bearing plate function was to allow for the initial prestressing (preloading) of the anchor bolt and subsequent grouting (refer to Dwg C1A173). Once the saddle installation was completed, the anchor bolt extension was preloaded by torquing of the clamping nut to tension the entire assembly against the saddle sole plate. From that point on, the function of the bearing plate was essentially negated. The preload on the anchor bolt cannot completely relax because the short extension added to the bolt has also been preloaded with the reaction load acting against the entire saddle sole plate.

3. Contributing Causes: See above, no separate contributing cause description is necessary.
4. Maintenance Rule Failure: YES NO N/A: No

5. Extent of Problem: The "Torus Saddle Support Assemblies" are structural additions made to the torus under PDC 81-04A to provide additional restraint to the torus structure. There are 16-torus saddle support tie down plates, each attached to the foundation with 8 anchor bolts (total 128 anchor bolts). The anchor bolts are 2"-6UN expansion type concrete anchors with an embedment depth that varies from 2'-6" to 3'-5". The anchor bolts were installed and prestressed (preloaded) using a nut and bearing plate on the concrete surface prior to grouting. Subsequent to that, a 2"-6UN extension piece was added to the anchor bolt to secure the saddle via the tie down clamp plates and another 2"-6UN nut that was torqued to preload the entire saddle arrangement.

The corrosion is predominantly on the bearing plate for several of the anchor bolts. This issue was recently addressed under a contract with Duke Engineering in 1999 (SUDDSRF #99-134). The corrosion was determined to be from groundwater intrusion up through the grouted anchor bolt hole. As a result of leaching up through the anchor bolt hole, the water was found to be alkaline and expected to contain a high concentration of calcium hydroxide (lime) from the concrete. The corrosion rate for steel in alkaline fresh water is low, as described in the referenced report.

The existing condition includes at least one anchor bolt where the corrosion of the bearing plate has become more aggressive than was previously observed. As such, it is necessary to take remedial action to stop or slow down the corrosion process. It is recommended that such remedial actions be performed for any anchor bolt where there is significant visible corrosion of the bearing plate or bleed out of rust through the original paint coating. The number of locations that are to be worked must take ALARA considerations into account such that only those locations with significant corrosion should be likely candidates. Locations where the paint retains adherence to sound metal need not be reworked.

It is necessary to stop or significantly slow the corrosion reaction occurring at several of the anchor bolt locations. Restoration of the original paint coating is not recommended as this will result in a similar failure and exfoliation of the new paint. It is preferred to apply anodic zinc coatings, after mechanical cleaning to remove all rust, to provide galvanic protection of the anchor bolts. The following readily available types of zinc coating were considered:

Solvent-Based Inorganic Zinc Silicate

Water-Based (Zero VOC) Inorganic Zinc Silicate

Solvent-Based Organic (Epoxy, Alkyd) Zinc

Water-Based Organic (Urethane) Zinc

The recommended product is a Water-Based (Zero VOC) Inorganic Zinc Silicate coating. This was selected based on a comparison of the available materials and their characteristics. It is also preferred to use a coating with zero volatile organic chemicals within secondary containment. The organic zinc coatings are typically used where ease of application and final

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appearance considerations are governing. The best actual galvanic protection is obtained with the inorganic zinc silicate coatings.

A particular product that is suitable and recommended for this application is the following:

Carboline Carbozinc 11 WB

The Z.R.C. Zero-VOC product given in the Originator's Report is a Water-Based Organic Zinc that is also suitable but is not the preferred product based on the above considerations.

References:

PNPS Specification C-93-ER-NQ "Furnishing, Delivery, Storage, and Application of Field Painting Outside the Primary Containment"

SUDDS/RF # 99-134 "Corrosion Assessment of Torus Saddle Tiedown Concrete Anchor Bolt Assembly", Duke Engineering & Services, April 11, 1999.

Karakasch, Nick, "Zinc Coating Review - 2000 and Beyond", Corrosion Management, May 2001.

Camitz, Goran, "Corrosion and Protection of Steel Piles and Sheet Piles in Soil and Water", www.geoforum.com.

PNPS Dwg C1A173 Torus Saddle Plate Tiedown Details and Gusset Locations

PNPS Dwg C1A175 SH 1& 2 Torus Saddle Support Assembly

PNPS Dwg C1A180 Torus Saddle Tiedown 2" Concrete Anchor Bolt Assembly with Extension

6. Corrective Actions Completed (include Dates if possible) None.

7. Corrective Actions Required (if not required, state "N/R")

The following should be performed for any anchor bolt where there is significant visible corrosion of the bearing plate or bleed out of rust through the original coating:

1. Remove all corrosion products from the bearing plate, nut, and washer using an aggressive method such as sand-blasting or a needle gun. Remove all remaining paint, deposits, rust, and scale from these surfaces. Residues of rust or paint may be left in the bottom of pits or grooves. The anchor bolt threaded portion between the bearing plate nut and the extension sleeve nut/jam nut should be cleaned by manual sanding, wire brushing, or filing to remove all loose paint, rust, and scale.

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2. If the bearing plate nut becomes loose during this work, the nut should be tightened securely against the washer and plate.
3. Remove all water and residue from the bearing plate area. Apply heat if necessary to evaporate all remaining moisture from the bearing plate and surrounding area prior to coating.
4. Coat the exposed metal surfaces with Carboline Carbozinc 11 WB or equivalent. Apply the heaviest coating thickness that is consistent with the product instructions.

Action Required/New CA Number: CA Number 2

Revise Specification C-93-ER-NQ based on the information in this CR to include Carboline Carbozinc 11 WB or equivalent.

Action Required/New CA Number: CA Number 3

Initiate a Work Plan based on the information in this CR to clean and recoat as-needed the torus saddle anchor bolt assemblies.

8. Corrective Actions required to eliminate and/or reduce the likelihood of recurrence of identified cause(s) and contributing cause(s).

Only the Corrective Actions given above are required. These corrosion protection remedial actions may have to be repeated in the future. The cause of the corrosion is groundwater seepage through the foundation, which is not affected by this work. It is not feasible nor is it considered necessary to stop the groundwater seepage.

CA Number: 2

Group**Name**

Assigned By: Eng DE Mech Civil Struct Staff

Harizi, Philip D

Assigned To: Eng DE Mech Civil Struct Staff

Pitts, Charles T

Subassigned To :

Originated By: Harizi, Philip D

6/3/2003 09:51:57

Performed By: Pitts, Charles T

8/28/2003 14:50:36

Subperformed By:

Approved By:

Closed By: Harizi, Philip D

8/29/2003 14:34:52

Current Due Date: 09/30/2003

Initial Due Date: 09/30/2003

CA Type: CORRECTIVE ACTION

Plant Constraint: NONE

CA Description:

Revise Specification C-93-ER-NQ based on the information in this CR to include Carboline Carbozinc 11 WB or equivalent. This CA is based on the conclusions from the CA #1 evaluation that it is necessary to take remedial action to stop or slow down the corrosion process noted on several of the torus saddle support tie down anchor bolt assemblies.

Response:

Specification C93-ER-NQ has been revised to include the use of Carboline Carbozinc 11 WB for the specific application of remediation of corrosion of Torus Saddle Support tie down anchor bolt assemblies. The specification was issued on 08/28/03. Surface preparation and application instructions are also included. The following Chemical Control numbers are applicable: Carboline Carbozinc 11 WB Primer - 000766 and Carboline Zinc Filler - 900392. This action provides a complete response to CR-PNP-2003-2009 CA2. CR-PNP-2003-2009 CA2 should be closed.

Subresponse :**Closure Comments:**

CA Number: 3

Group	Name
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Assigned By: Eng DE Mech Civil Struct Staff

Harizi,Philip D

Assigned To: Eng DE Mech Civil Struct Staff

Kalb,Jeffrey A

Subassigned To :

Originated By: Harizi,Philip D

6/3/2003 09:55:50

Performed By: Kalb,Jeffrey A

6/9/2003 08:39:40

Subperformed By:

Approved By:

Closed By: Kalb,Jeffrey A

6/9/2003 08:39:40

Current Due Date: 09/30/2003

Initial Due Date: 09/30/2003

CA Type: CORRECTIVE ACTION

Plant Constraint: NONE

CA Description:

Initiate a Work Plan based on the information in this CR to clean and recoat as-needed the torus saddle anchor bolt assemblies.

This CA is based on the conclusions from the CA #1 evaluation that it is necessary to take remedial action to stop or slow down the corrosion process noted on several of the torus saddle support tie down anchor bolt assemblies.

Response:

MR # 03111153 was written on 6/6/03 to clean and recoat, as needed, the Torus Saddle Anchor Bolt Assemblies. I recommend that this action item be closed to the MR. Maximo has been updated.

Subresponse :

Closure Comments:

CA Number: 4

Group

Name

Assigned By: CA&A Staff

Assigned To: Eng Design Mgmt

Pace, Raymond M

Subassigned To :

Originated By: Buckley, Patricia A

9/2/2003 07:50:06

Performed By: Pace, Raymond M

9/2/2003 15:18:01

Subperformed By:

Approved By:

Closed By: Pace, Raymond M

9/2/2003 15:18:01

Current Due Date: 09/17/2003

Initial Due Date: 09/17/2003

CA Type: CR CLOSURE REQUEST

Plant Constraint: NONE

CA Description:

Please review the closed corrective action(s) to verify adequacy and completeness to remedy the identified condition, by using the guidance in Section 5.8.1 of LI-102. If the CR is appropriate for closure, please indicate your concurrence by closure of this action. Should the closure not be satisfactory, issue a new action item to correct the deficiency.

Response:

This is a Cat. C CR and may be closed to the MR generated in CA-0003. Therefore in accordance with the requirements of LI-102 the actions are adequate and the CR may be closed.

Ray Pace 09/02/03

Subresponse :

Closure Comments: