| Document<br>Title: Quad Cities ERV Actuator Vibration Test Plan - Production Actuator |
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Criteria Interface Report Specification Other [x] Drawing

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|---|---|
| Project Name: | Quad Cities ERVs |
| Job No.: | 06Q4568 |
| Client: | Exelon |

This document has been prepared in accordance with the S&A Quality Assurance Program Manual, Revision 15 and project requirements.

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|---|---|
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| Reviewed by: Walter Djordjevic | Date: 3/15/06 |
| Approved by: Walter Djordjevic | Date: 3/15/06 |

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| | | |
|---|---|---|
| S&A Stevenson & Associates | DOCUMENT APPROVAL SHEET Figure 2.8 | CONTRACT NO. **06Q4568** |

## TABLE OF CONTENTS

# 1 INTRODUCTION

The purpose of this document is to provide the testing requirements for a second series of vibration aging testing of the Electromatic Relief Valve (ERV) pilot valve actuator at the Quad Cities Nuclear Plant.

Three actuators were previously tested (see References 1, 2):

Dresser #1: The design used at the Quad Cities Nuclear Plant prior to January 2006 (Inconel posts and bushings).

Dresser #2: The design currently installed at the Quad Cities Nuclear Plant (same as Actuator #1 plus a tight tolerance hardened steel washer placed on the guidepost between the spring and the bushing).

Dresser #3: A modification of the Dresser design developed by GE. The actuator was provided by GE.

(A fourth actuator - a Target Rock pilot valve / actuator unit - was also tested, but was eliminated from consideration.)

Based on these tests, it was concluded that the Dresser #3 actuator was a significant improvement over the prior designs, particularly in guide post wear. However, several potential weaknesses in the design of Dresser #3 were identified:

- By the end of the testing, the pivot plate pin had worn to the extent that the contact switch did not lift when the plunger was actuated. Pivot pin wear was a problem on all three test actuators; not surprising, as all three had the same pivot plate design.

- The angles connecting the solenoid frame to the base plate developed cracks. These cracks were weld repaired and gusset plates were added. The gusset plates prevented further cracking, even when the actuator was tested at higher acceleration levels. Dresser #1 and #2 did not develop these cracks. The cracking was attributed to the fact that (1) Dresser #3 had a heavier guide post support structure, and (2) Dresser #3 had a rubber pad inserted between the base angles and the base plate.

- The covers on all three actuators developed cracks around the bolt holes. Plates were welded over the bolt holes - the plates stopped the covers from cracking, but several bolts sheared in subsequent tests.

Using these results, GE has developed a production design for installation in the plant. The purpose of this test is to determine if the production design is capable of sustaining the operating condition vibrations.

Three actuators shall be tested:

Dresser #1A: The design used at the Quad Cities Nuclear Plant prior to January 2006, rebuilt in accordance with the procedures in effect at that time. This actuator functions as the control - the damage sustained by this actuator provides the basis for comparing this aging test to the previous aging test, and to the operational vibrations.

Dresser #3A: A rebuilt version of Dresser #3, with the same (improved) pivot plate pin design as Dresser #4. This actuator will be dismantled and reassembled as the testing proceeds in order to measure the rate of pivot pin wear. This will allow the Dresser #4 actuator to remain undisturbed.

Dresser #4: The production version of the new GE design.

In addition to the aging tests, testing will be performed to demonstrate the seismic ruggedness of Dresser #4.

**Revision 1**

This revision consists of the following:

1. Additional documentation and surveillance requirements to support a Quality Assurance oversight of the testing to be provided by MPR Associates. These additions are shown in red.
2. Addition of a signature block for the Exelon Corporate Design Engineering Director to the cover sheet for the daily test report in Attachment B.
3. Remove the requirement to perform swept sine test on Dresser #1A and Dresser #3A. Swept sine tests were performed for these actuators during the previous test sequence. Swept sine tests are still to be performed for Dresser #4.
4. Minor changes to the inspection sheets in Attachment B.

# 2 TESTING PLAN & REQUIREMENTS

## 2.1 Purpose

The purpose of this document is to provide the vibration aging test requirements for the pilot valve actuator of a Dresser 6"-1525VX-3-XFB11-NC120 Electromatic Relief Valve (ERV). Three actuators will be tested:

Dresser #1A: The design used at the Quad Cities Nuclear Plant prior to January 2006, rebuilt in accordance with the procedures in effect at that time.

Dresser #3A: A rebuilt version of the GE prototype (designated as Dresser #3 in Reference 2), with the same pivot plate pin design as Dresser #4.

Dresser #4: The production version of the new GE design.

## 2.2 Prerequisites

Prior to testing, the following shall be performed:

- The forms in the Prerequisites section of Attachment B shall be completed to identify applicable equipment/instruments utilized and calibrations, including identification of applicable software/computer equipment used for data acquisition. All monitoring and test equipment must be within their current calibration interval.

- All test personnel involved shall read and understand the test procedure. The sign-off sheet in the Prerequisites section of Attachment B shall be completed by all test personnel involved prior to start of testing.

- Confirm proper operation of the test rig including checks for proper operation of accelerometers and synchronization of computer/Data acquisition clocks. NOTE: Confirmation of proper equipment operation shall be repeated prior to any further session if the test equipment or instruments were modified.

- The MPR Inspector shall sign-off in the space provided in the Prerequisites section of Attachment B to confirm that the prerequisites have been completed and that testing may begin.

## 2.3 Mounting of the Test Specimens

The test lab will be provided with three test specimens consisting of a pilot valve actuator mounted to a support stand using the bolts which normally attach the actuator to the pilot valve yoke.

Mount the test specimens by bolting the support stands to the test table. Orient all test specimens so that the plungers are vertical. See Sections 2.5.1 and 2.6.1 for the horizontal orientations.

All specimens are to be tested with the cover installed.

### 2.4 Electrical Requirements

125 V DC power is required to operate the actuators.

### 2.5 Swept Sine Tests

Swept sine tests shall be performed only for the Dresser #4 actuator.

*2.5.1 Test Specimen Mounting*

For one horizontal test, mount the actuator so that the plane of the guideposts is parallel to the direction of table motion. For the other horizontal test, mount the actuator so that the plane of the guideposts is normal to the direction of table motion.

*2.5.2 Vibration Instrumentation*

Instrument the actuator with:

- a triaxial accelerometer at or near the top of the guide posts (if this is not practical, place the accelerometer on the support plate near the base of the guidepost.)
- a triaxial accelerometer near the top of the solenoid frame,
- a triaxial accelerometer near the projecting end of the base plate.

Record the instrumentation information as specified in the Data Channel Section of Attachment B.

*2.5.3 Excitation*

Direction: Test the actuator in all three directions of table motion. Separate tests are to be performed for each direction of table motion.

Frequency: Swept sine, 2 Hz – 200 Hz, 2 minute / octave or slower

Amplitude: 0.2g

*2.5.4 Data Collection Requirements*

Response plot (g versus frequency) for each accelerometer.

## 2.6 Vibration Aging Tests

### *2.6.1 Test Specimen Mounting*

For the horizontal tests, mount the Dresser actuators so that the plane defined by the two guideposts is at 45 degrees to the direction of the table motion.

### *2.6.2 Vibration Instrumentation*

Instrument each Dresser actuator with two accelerometers. Install one accelerometer on the base plate between the electric penetrations, oriented in the vertical direction, and the other accelerometer on or near the top of the plunger, oriented approximately normal to the plane of the guide posts and at 45 degrees off vertical. Record the instrumentation information as specified in the Data Channel Section of Attachment B.

### *2.6.3 Excitation*

The test motion is based on the motions used in the previous test. The intent is to produce a similar level of damage on Dresser #1, the control actuator.

| Day # | Test Motion | Direction | Duration |
|---|---|---|---|
| 1 | 0.8g rms 20 - 200 Hz<br>4.0g rms @ 151 Hz | Horizontal | 20 hours |
| 2 | (same as the previous day) | Vertical | 20 hours |
| 3 | 0.8g rms 20 - 200 Hz<br>Swept Sine Set (see Table below) | Horizontal | 20 hours |
| 4 | (same as the previous day) | Vertical | 20 hours |
| 5 | 0.8g rms 20 - 200 Hz<br>Up to 3 sine dwells at critical frequencies selected based on Dresser #4's response to the horizontal broad band input. The amplitudes of the sine dwells are to be consistent with the Swept Sine Set (see Table below). | Horizontal | 20 hours |
| 6 | Same as previous day, except re-select the sine dwell frequencies based on Dresser #4s response to the vertical broad band. | Vertical | 20 hours |

**Swept Sine Set**

| From | To | Sweep Time | Amplitude |
|---|---|---|---|
| 20 Hz | 50 Hz | 5 min | 0.50 grms |
| 40 Hz | 80 Hz | 5 min | 1.44 grms |
| 60 Hz | 100 Hz | 5 min | 2.6 grms |
| 95 Hz | 125 Hz | 5 min | 4.0 grms |
| 120 Hz | 150 Hz | 5 min | 4.0 grms |
| 145 Hz | 175 Hz | 5 min | 4.0 grms |
| 170 Hz | 200 Hz | 5 min | 4.0 grms |

*2.6.4 Data Collection Requirements*

The form provided in Attachment B shall be used to document the data collection.

2.6.4.1 Vibration Data

For each 20 hour test, store the g rms time history for the input channel and all three response channels, for the entire 20 hours, in an Excel file. Note the name of the file in the data collection form.

For each 20 hour test, acquire and store the PSD for the input channel and all three response channels, as measured at a number of discrete times. At a minimum, the PSDs shall be acquired and stored near the beginning of the test and near the end of the test. Note the name of the file in the data collection form.

2.6.4.2 Inspections

Perform the visual, functional, and dimensional inspections as specified in Attachment B.

Note that Dresser #1A and Dresser #3A shall be dismantled as required to perform the specified daily inspections.

Dresser #4 shall have the cover removed in order to perform inspections, but shall *not* be dismantled for the final dimensional inspections until all testing has completed.

**2.7 Seismic Ruggedness Tests**

The seismic ruggedness tests are required only for Dresser #4. The other actuators may remain on the shake table while these tests are being performed.

The seismic ruggedness tests shall be performed after Day #4 and prior to Day #5 of the aging tests.

*2.7.1 Test Specimen Mounting*
(Same as aging tests)

*2.7.2 Vibration Instrumentation*
(Same as aging tests)

*2.7.3 Excitation*

***Prior to performing this test, the required seismic motion shall be provided by Exelon Design Engineering.***

*2.7.4 Data Collection Requirements*

The form provided in Attachment C shall be used to document the data collection.

2.7.4.1 Vibration Data

Record the time history of the table motion in the direction of excitation.

2.7.4.2 Inspections

Perform the visual and functional inspections as specified in Attachment C.

Dresser #4 shall have the cover removed in order to perform inspections, but shall *not* be dismantled in any other way.

## 2.8 Changes to the Test Plan

This test plan involves previously untested components and unusual testing requirements. As a result, it is expected that changes to the test plan may be required as the testing proceeds. Depending on the extent of these changes, a change may be reviewed, approved, and documented by either (a) revising this document per established procedures, or (b) using the Test Plan Change Notice included as Attachment A.

The responsible Exelon engineer shall decide which method is to be used.

The Test Plan Change Notice requires the following:

- The test plan number (06Q4568-DR-007).
- The test plan revision number current at the time of the change.
- A change notice number. Number sequentially starting with 1 (one).
- A description of the change.

- The basis for making the change.
- The responsible Exelon engineer shall designate a preparer and reviewer. The Exelon Corporate Design Engineering Director shall approve the change.

All Test Plan Change Notices shall be included with the test report.

### 2.9 Final Test Documentation Package

A final documentation package shall be assembled including as a minimum the following:

- A copy of the test procedure (this document)
- All test procedure changes that were issued & approved,
- A completed Attachment B documenting each day's testing, with all required signatures.
- All data on CDs labeled with applicable test data information.
- Copies of the calibration records for accelerometers and other instruments used.

## 3 REFERENCES

1. Stevenson & Associates Report No. 06Q4568-DR-001, "Quad Cities ERV Actuator Vibration Testing Requirements", Rev. 1, 2/5/06.

2. Stevenson & Associates Report No. 06Q4568-DR-005, "Quad Cities ERV Pilot Valve Actuator Vibration Test Report", Rev. 0, 3/8/06.

| TEST PLAN CHANGE NOTICE | |
|---|---|
| Test Plan No: | 06Q4568-DR-007 |
| Revision No: | |
| Change No: | |
| Description Of Change: | |
| Basis For Change: | |

| | | | |
|---|---|---|---|
| Prepared by: | Name | Signature | Date |
| Reviewed by: | Name | Signature | Date |
| Exelon Corporate Design Engineering Director | Name | Signature | Date |

| Aging Test No: | | Date: | |
|---|---|---|---|
| Horizontal Test | | Vertical Test | |
| Start Time | Stop Time | Start Time | Stop Time |
| | | | |
| | | | |
| Total Time: | | Total Time: | |

Comments:

| Prepared by: | Name | Signature | Date |
|---|---|---|---|
| Reviewed by: | Name | Signature | Date |
| Exelon Corporate Design Engineering Director | Name | Signature | Date |

## 1. PREREQUISITES

*This section shall be completed prior to the first test, using the report for the first test. It is not required for the subsequent tests. No testing shall be performed until this section has been completed.*

**Instrument Information Sheet**

| Instrument Description | ID Number | Instrument Range | Instrument Accuracy | Units | Recorded by |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**Instrument Calibration Sheet**

| Instrument Description | ID Number | Calibration Due Date | Recorded by |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

## Personnel Sign-off Sheet

By signing this form, all test personnel listed below indicate that they have read this Test Plan and understand their responsibilities as contained herein.

| Name (Print) | Signature | Initials | Date |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

**QA HOLD POINT – TEST WITNESS**

An MPR Inspector shall verify completion of prerequisites and witness the testing. No testing shall commence unless the MPR witness is present.

_____ _____

Inspector Date

## 2. DATA CHANNEL LIST

| Channel # | Instrument ID | Location | Direction |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |

X = Horizontal, parallel to horizontal table motion
Y = Horizontal, normal to horizontal table motion
Z = Vertical

## 3. EXCITATION INPUT

| Description |
|---|
| |

## 4. DATA FILE LIST

| File Name | Description of Contents |
|---|---|
| | |
| | |
| | |
| | |
| | |

## 5. PRE-TEST CHECKS

*This section shall be completed prior to the first aging test, using the report for the first aging test. It is not required for the subsequent tests.*

| | Dresser #1A | Dresser #3A | Dresser #4 |
|---|---|---|---|
| **Visual Inspection** | | | |
| Cover Box | | | |
| Guide Posts | | | |
| Springs | | | |
| Limit Switches | | | |
| Solenoid / Solenoid Frame | | | |
| Pivot Plate | | | |
| Plunger | | | |
| Roller | | | |
| Other (Describe) | | | |
| | | | |
| | | | |

| | Dresser #1A | Dresser #3A | Dresser #4 |
|---|---|---|---|
| **Functional Checks** | | | |
| Limit Switch continuity check (S1 / S2) | | | |
| Electrical Actuation (3 times) | | | |
| Plunger depresses pivot plate fully | | | |
| Plunger retracts fully | | | |
| Contact switch lifts | | | |
| Plunger moves smoothly by hand | | | |
| Pivot plate spring in tension | | | |
| Hand actuation of pivot plate lifts contacts | | | |
| Other (Describe) | | | |
| | | | |

| | Dresser #1A | Dresser #3A | Dresser #4 |
|---|---|---|---|
| **Dimensional Checks** | | | |
| Actuator Weight (with cover, lbs) | | | |
| Guidepost O.D. (S1 / S2, mils) | | | |
| Upper Bushing I.D. (S1 / S2, mils) | | | |
| Lower Bushing I. D. (S1 / S2, mils) | | | |
| Upper Bushing O.D. (S1 / S2, mils) | | | |
| Upper Bushing Mate Hole I. D. (S1 / S2, mils) | | | |
| Spring Wire Diameter (S1 / S2, mils) | | | |
| Spring Free Lengths (S1 / S2, inches) | | | |
| Pivot Pin O. D. | | | |
| Pivot Pin Bushing I. D. | | | |
| Cut-off switch lift on manual actuation (mils) | | | |
| Plunger leg wear depth (mils) | | | |
| Other (Describe) | | | |
| | | | |

| Comments |
|---|
| |

## 6. POST-TEST CHECKS

*This section shall be completed after each day of testing.*

| | Dresser #1A | Dresser #3A | Dresser #4 |
|---|---|---|---|
| **Visual Inspection** | | | |
| Cover Box | | | |
| Guide Posts | | | |
| Springs | | | |
| Limit Switches | | | |
| Solenoid / Solenoid Frame | | | |
| Pivot Plate | | | |
| Plunger | | | |
| Roller | | | |
| Other (Describe) | | | |
| | | | |
| | | | |

| | Dresser #1A | Dresser #3A | Dresser #4 |
|---|---|---|---|
| **Functional Checks** | | | |
| Limit Switch continuity check (S1 / S2) | | | |
| Electrical Actuation (3 times) | | | |
| Plunger depresses pivot plate fully | | | |
| Plunger retracts fully | | | |
| Contact switch lifts | | | |
| Plunger moves smoothly by hand | | | |
| Pivot plate spring in tension | | | |
| Hand actuation of pivot plate lifts contacts | | | |
| Other (Describe) | | | |
| | | | |

| | Dresser #1A | Dresser #3A | Dresser #4 |
|---|---|---|---|
| **Dimensional Checks** | | | |
| Guidepost O.D. (S1 / S2, mils) | | | |
| Upper Bushing I.D. (S1 / S2, mils) | | | |
| Lower Bushing I. D. (S1 / S2, mils) | | | |
| Upper Bushing O.D. (S1 / S2, mils) | | | |
| Upper Bushing Mate Hole I. D. (S1 / S2, mils) | | | |
| Spring Wire Diameter (S1 / S2, mils) | | | |
| Spring Free Lengths (S1 / S2, inches) | | | |
| Pivot Pin O. D. | | | |
| Pivot Pin Bushing I. D. | | | |
| Cut-off switch lift on manual actuation (mils) | | | |
| Plunger leg wear depth (mils) | | | |
| Other (Describe) | | | |
| | | | |
| | | | |

| Comments |
|---|
| |

## 7. FINAL CHECKS

*This section shall be completed after all testing has been completed. It shall be including with the report for the last day of testing. It is not required for any of the other tests.*

| | **Dresser #4** |
|---|---|
| Upper Bushing I.D. (S1 / S2, mils) | |
| Lower Bushing I. D. (S1 / S2, mils) | |
| Upper Bushing O.D. (S1 / S2, mils) | |
| Upper Bushing Mate Hole I. D. (S1 / S2, mils) | |
| Spring Wire Diameter (S1 / S2, mils) | |
| Spring Free Lengths (S1 / S2, inches) | |
| Pivot Pin O. D. | |
| Pivot Pin Bushing I. D. | |
| Other (Describe) | |
| | |
| | |
| | |

| **Seismic Ruggedness Test for Dresser #4** | | Date: | |
|---|---|---|---|
| Horizontal Test | | Vertical Test | |
| Start Time | Stop Time | Start Time | Stop Time |
| | | | |
| | | | |
| Total Time: | | Total Time: | |

Comments:

| | | | |
|---|---|---|---|
| Prepared by: | Name | Signature | Date |
| Reviewed by: | Name | Signature | Date |
| Exelon Corporate Design Engineering Director | Name | Signature | Date |

**1. Data Channel List**

| Channel # | Location | Direction |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |

X = Horizontal, parallel to horizontal table motion
Y = Horizontal, normal to horizontal table motion
Z = Vertical

**8. EXCITATION INPUT**

| Description |
|---|
| |

**9. DATA FILE LIST**

| File Name | Description of Contents |
|---|---|
| | |
| | |
| | |
| | |
| | |

## 10. POST-TEST CHECKS

*This section shall be completed after all seismic ruggedness tests have been completed*

| | Dresser #4 |
|---|---|
| **Visual Inspection** | |
| Cover Box | |
| Guide Posts | |
| Springs | |
| Limit Switches | |
| Solenoid / Solenoid Frame | |
| Pivot Plate | |
| Plunger | |
| Roller | |
| Other (Describe) | |
| | |
| | |

| | Dresser #4 |
|---|---|
| **Functional Checks** | |
| Limit Switch continuity check (S1 / S2) | |
| Electrical Actuation (3 times) | |
| Plunger depresses pivot plate fully | |
| Plunger retracts fully | |
| Contact switch lifts | |
| Plunger moves smoothly by hand | |
| Pivot plate spring in tension | |
| Hand actuation of pivot plate lifts contacts | |
| Other (Describe) | |
| | |

| Comments |
| --- |
| |