RECLAMATION

Managing Water in the West

TR-2016-01

Travel to Upper Molina Powerplant

To perform cavitation detection testing for research project 2944.

Date(s) of Travel: January 6 – 7 and January 27 – 28, 2016

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Hydraulic Investigations and Laboratory Services Group
Denver, Colorado

BUREAU OF RECLAMATION
Technical Service Center
Denver, Colorado

TRAVEL REPORT

Code: 86-86560 Date: March 11, 2016

To: Manager, Hydraulic Investigations and Laboratory Services Group
From: Josh Mortensen, Hydraulic Engineer
Kit Shupe, Hydraulic Engineer

Subject: Travel to Upper Molina Powerplant to perform cavitation detection testing for research project 2944.

1. Travel period: 6 – 7 January and 27 – 28 January 2016

2. Places or offices visited: Upper and Lower Molina Powerplants

3. Purpose of trip: Perform testing to obtain data for the cavitation-damaged Pelton turbine at the Upper Molina Powerplant before and after repair of a single bucket with cavitation damage. Upper Molina presents a unique testing opportunity as a single known bucket was found to have severe cavitation erosion damage. A comparison of test results before and after the bucket repair will help assess and hopefully improve methods of cavitation monitoring and detection measurements for powerplants as part of a current research project to develop an effective cavitation detection and monitoring system.

4. Synopsis of trip:

Test Equipment Installation (Wednesday January 6, 2016): Josh and Kit arrived at the Lower Molina Powerplant on Wednesday afternoon to discuss the test plan with George Hoard and other plant personnel. After reviewing the JHA, installation of test equipment at the Upper Molina Powerplant commenced. Acoustic emission (AE) sensors and accelerometers were installed on the turbine shaft bearing case, bonnet shaft collar, and lower bonnet at a location near the internal needle valve (Figures 1-3). Wiring was also run from the plant's drivers for the turbine shaft horizontal and vertical proximity probes and key phasor. The sensors and data acquisition system were tested to verify that they were functioning properly for test conditions. This process was repeated for the post-repair trip on Wednesday January 27th. The only exception was that a different model accelerometer without a machined mounting stud was used on the shaft bearing case as the one from the first test had been damaged. For both trips Josh and Kit traveled to Grand Junction to spend the night.

Cavitation detection testing (**Thursday January 7, 2016)**: Cavitation detection testing was performed for a stepped progression of power outputs which included 0 (motoring), 1, 2, 4, 6 and 8 MW. At each step, measurements were recorded for the AE sensors (sample rate of 0.5 MHz for 10 seconds), accelerometers (sample rate of 0.25 MHz for 10 seconds), and turbine shaft proximity probes (sample rate of 3 kHz for 30 seconds). Key phasor data were recorded simultaneously with every sensor to identify the location of cavitation damaged bucket (#16) relative to the sensor locations at each revolution. The same test procedure was repeated on Thursday January 28th. For both trips, Josh and Kit drove back to Denver following testing.

5. Conclusions: While an initial data analysis is shown in this report, a more thorough analysis will be included in a final R&D report at the end of FY2016. The shaft bearing case and lower bonnet test locations seemed to be the most sensitive to changes in unit power output (see Figures 4-9). The root-mean-square (RMS) of each signal was quantified to show any change in overall signal amplitude. Figure 4 shows that the RMS of the AE signal on the bearing case is almost identical before and after the repair. In contrast, lower bonnet accelerometer data show the post-repair signal is significantly less than the pre-repair signal (Figure 5).

Figures 6 and 7 show results from a frequency analysis using demodulation to identify the magnitude of high frequency activity (such as cavitation erosion) at a low frequency occurrence (single bucket passing frequency – 600 rpm or 10 Hz). These initial results (shown in raw voltages that are not scaled to engineering units) show that the amplitudes of the post repair signal are slightly lower in general compared to those measured before the repair. However, the trends of both signals which increase with power output are very similar. Also, time series (Figure 8) and frequency domain (Figure 9) comparisons of the pre-repair and post-repair shaft bearing AE signals show very little difference.

A full analysis will be performed to determine whether the cavitation erosion was detected from the pre- and post-repair test data. Results and conclusions will be included in an R&D report.

6. Action correspondence initiated or required: Data from the turbine shaft proximity probes will be sent to the Mechanical Equipment Group (86-8410) for vibration analysis.

7. Client feedback received: N/A

cc:
John Germann (86-8410)
Seth Gregg (sgregg@mymail.mines.edu)
Erin Foraker (08-10000)
George Hoard (CCI-440 Molina)

<u>**SIGNATURES AND SURNAMES FOR:**</u>

Travel to: Upper Molina Powerplant, Western Colorado Area Office, Grand Junction, CO

Dates of Travel: 6 – 7 January and 27 – 28 January 2016

Names and Codes of Travelers: Josh Mortensen, 86-8560, Kit Shupe, 86-8560

<u>**Traveler:**</u>

JOSHUA MORTENSEN

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Date: 2016.03.08 10:56:32 -07'00'

Josh Mortensen, P.E. Date
Hydraulic Investigations and Laboratory Services Group

CHRISTOPHER SHUPE

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Date: 2016.03.08 17:05:38 -07'00'

Christopher (Kit) Shupe, EIT Date
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<u>**Reviewed:**</u>

JOSEPH KUBITSCHEK

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Joe Kubitschek, P.E., PhD Date
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<u>**Noted and Dated by:**</u>

ROBERT EINHELLIG

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Robert F. Einhellig, P.E., Manager Date
Hydraulic Investigations and Laboratory Services Group

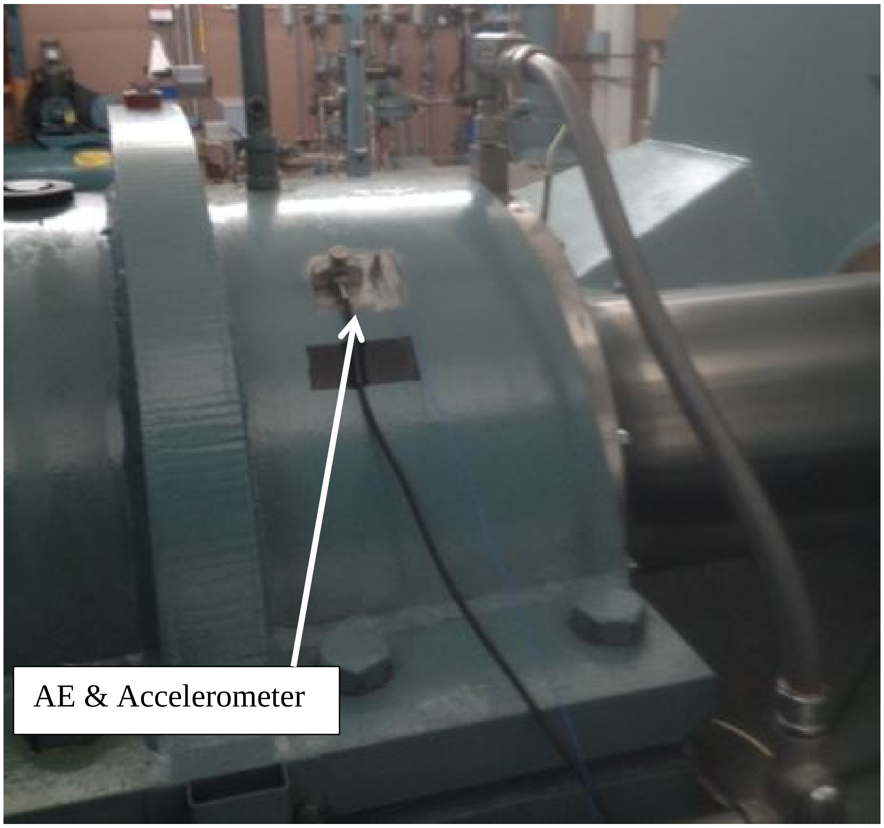

Figure 1. AE sensor and accelerometer mounted on the turbine shaft bearing case.

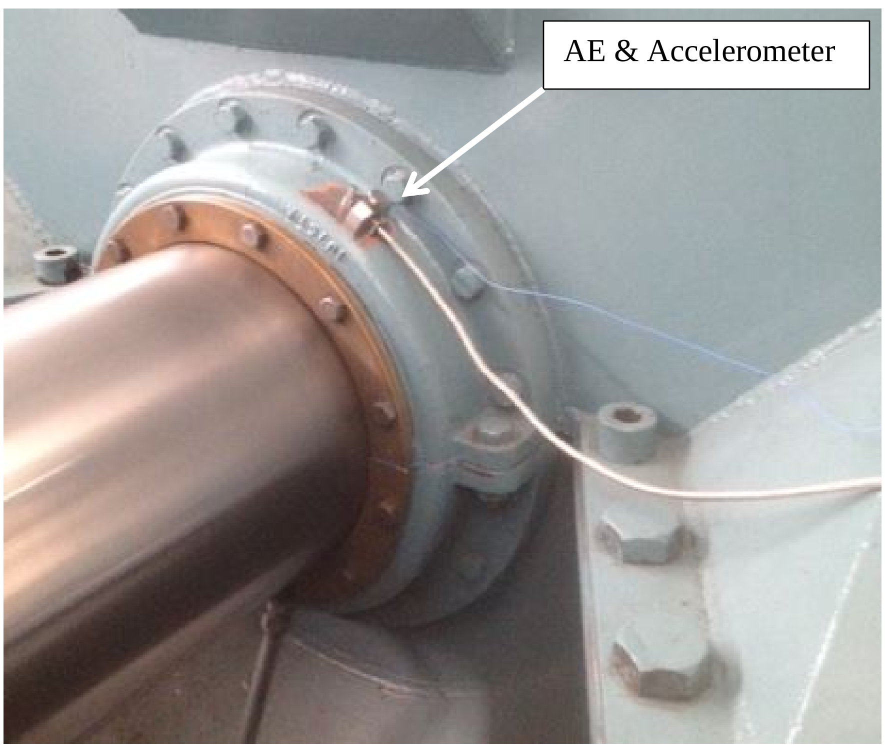

Figure 2. AE sensor and accelerometer mounted on the bonnet shaft collar.

Figure 3. AE sensor and accelerometer mounted on the lower bonnet near the location of the internal needle valve.

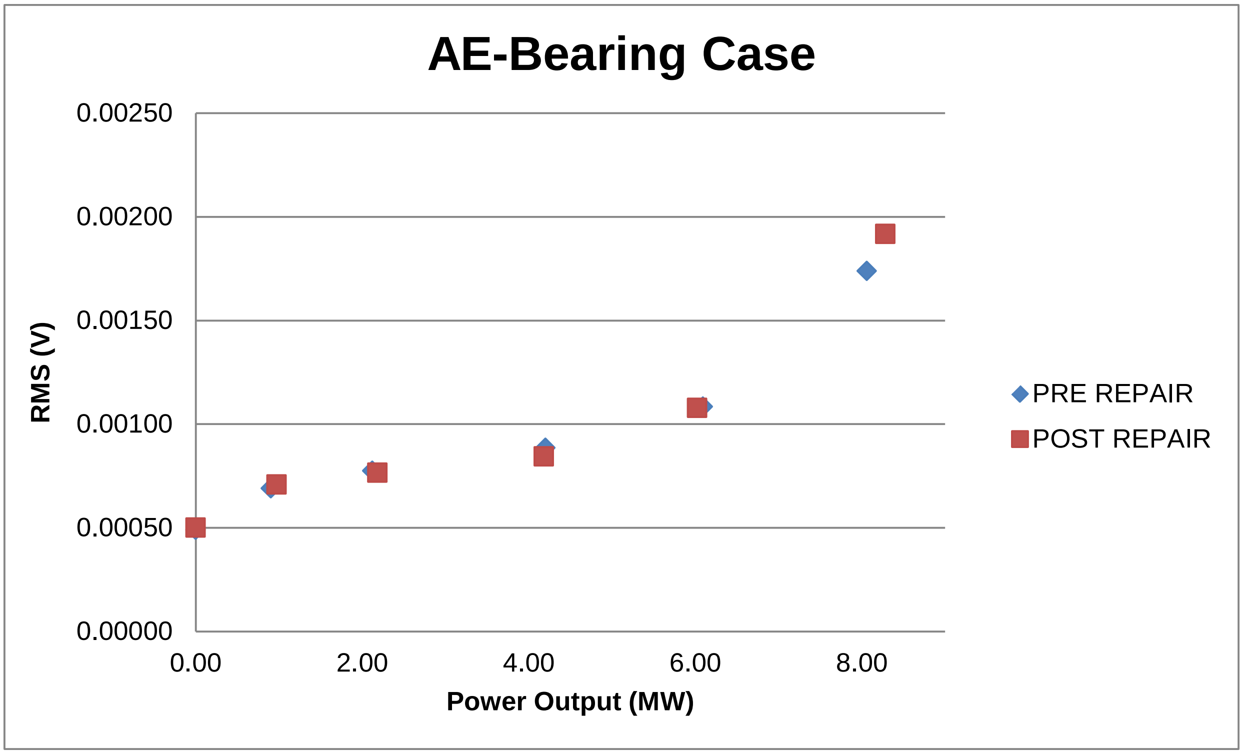

Figure 4. Comparison of cumulative RMS signals from the AE sensor on the shaft bearing case.

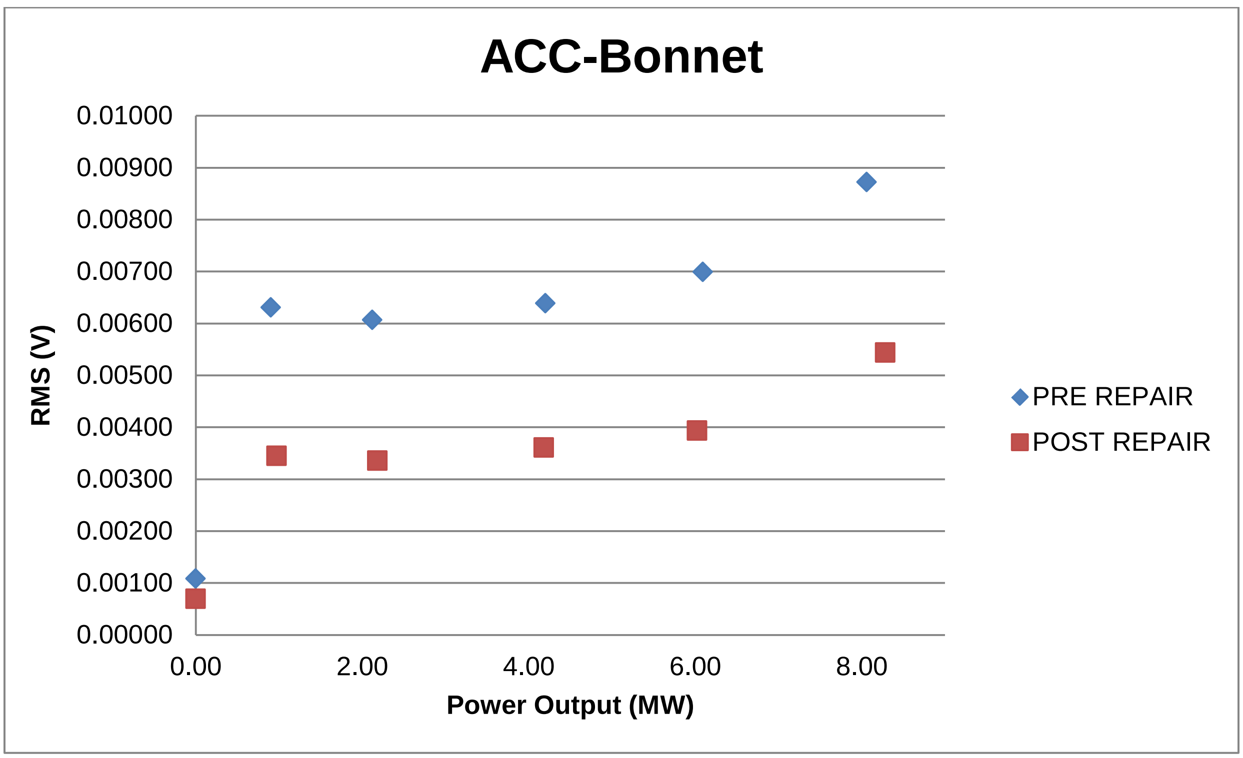

Figure 5. Comparison of cumulative RMS signals from the accelerometer on the lower bonnet.

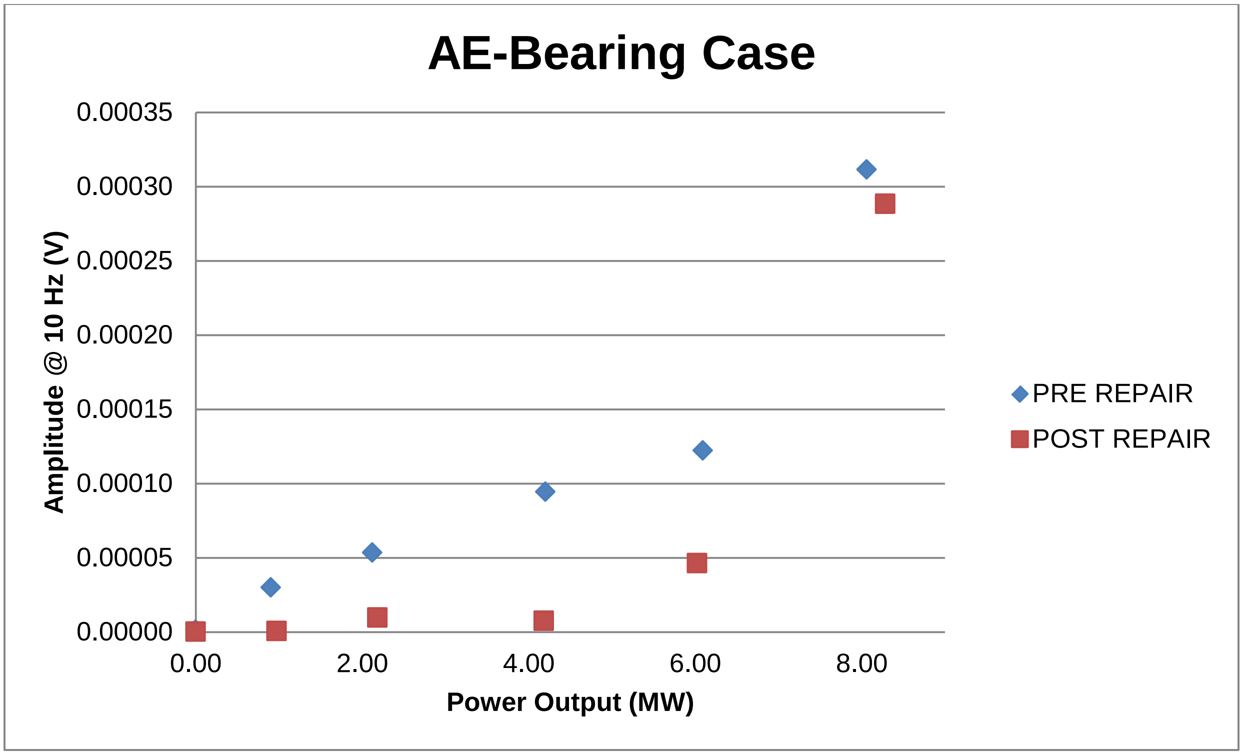

Figure 6. Comparison of amplitudes for the demodulated AE signals at 10Hz on the shaft bearing case.

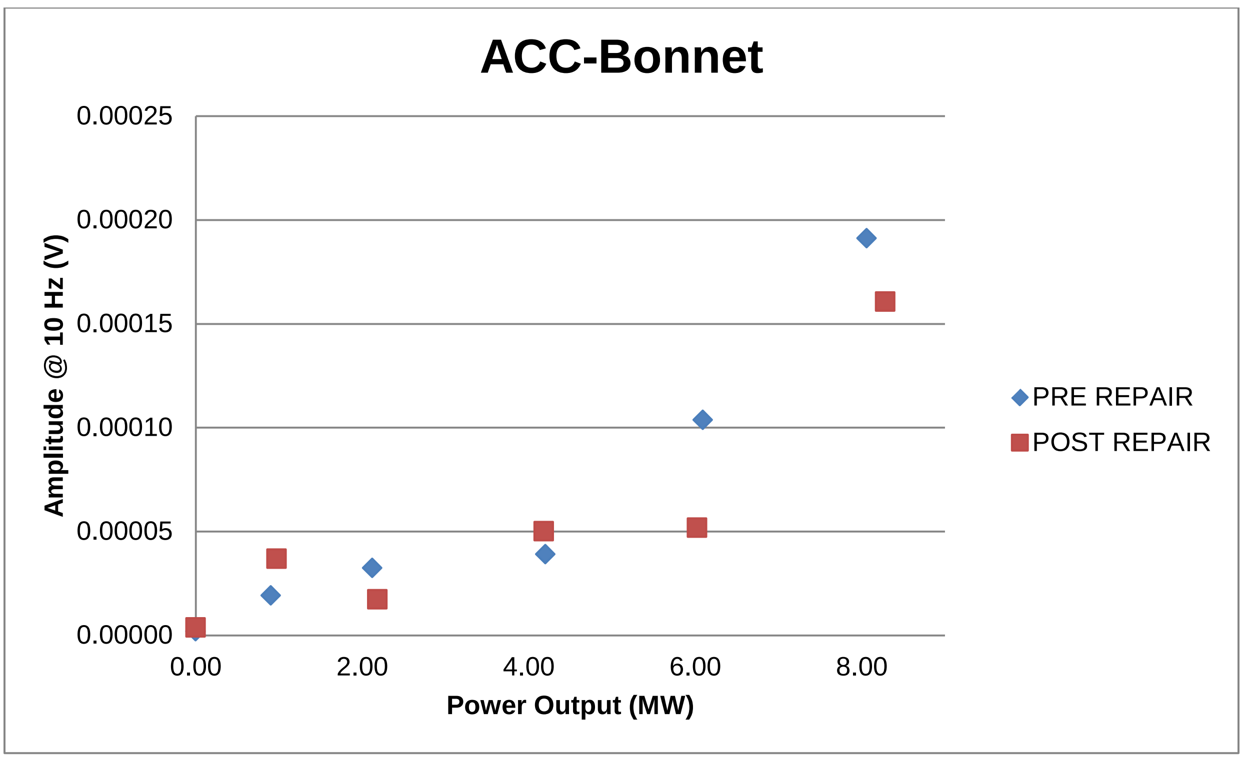

Figure 7. Comparison of amplitudes for the demodulated accelerometer signals at 10Hz on the lower bonnet.

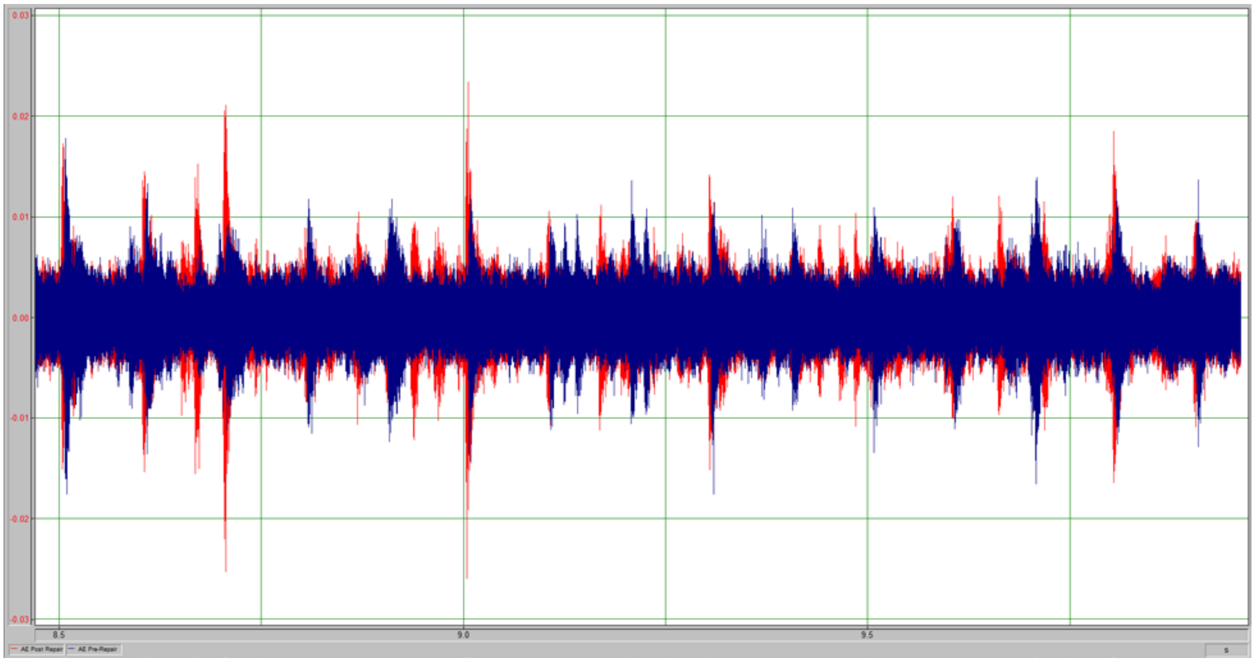

Figure 8. Time series signal of the AE sensor at the bearing case before the bucket repair (blue) and after the repair (red) at 8 MW. Green grid lines are spaces at 0.25 sec on x-axis.

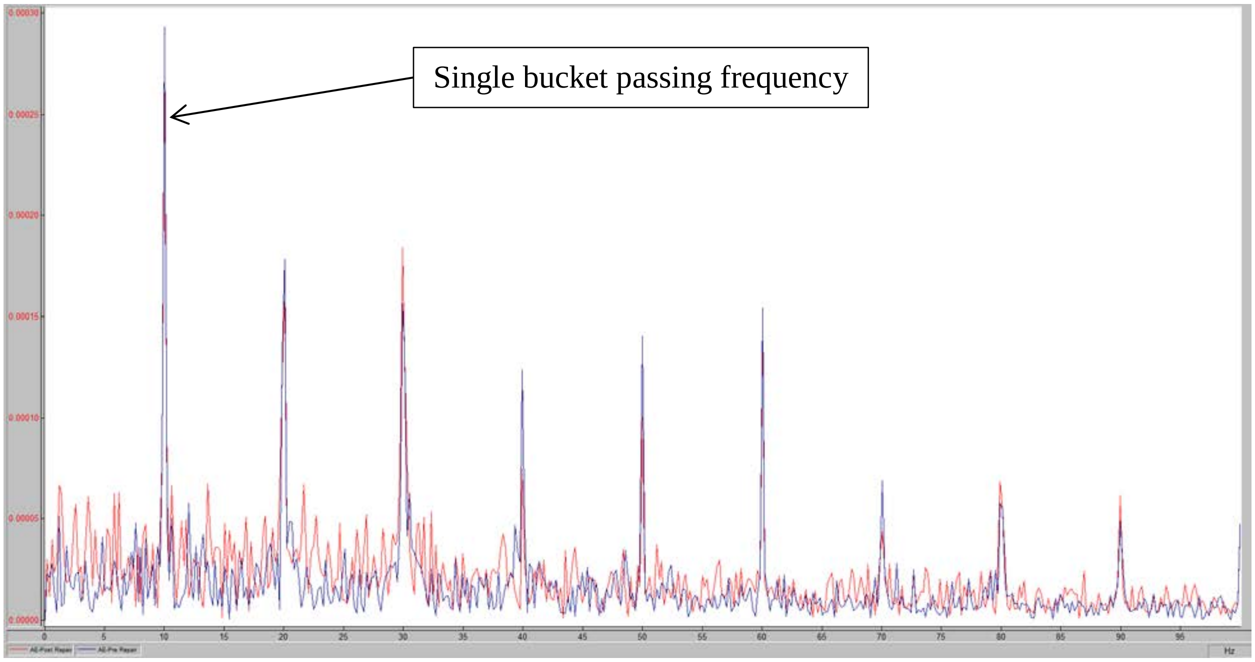

Figure 9. Demodulated signals in the frequency domain of the AE sensor at the bearing case before the bucket repair (blue) and after the repair (red) at 8MW.