PCWA-L-114

Placer County Water Agency

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November 5, 2004

Mr. Takeshi Yamashita, Regional Engineer
FEDERAL ENERGY REGULATORY COMMISSION
901 Market Street, Suite 350
San Francisco, CA 94103

Re: FERC Project No. 2079-CA; NATDAM No. CA00856
Ralston Afterbay Dam, State of California No. 1030-4, Placer County

Dear Mr. Yamashita:

The purpose of this letter is to report the results of tests performed at Ralston Afterbay Dam on October 11-12, 2004 to try to learn what caused the gate opening incident that occurred on August 5, 2004. In preparation for these tests, a portable, multi-channel, strip chart recorder was connected to measure 12 parameters associated with the two Float Controllers. Copies of four charts produced by these recorders on October 11, 2004, are attached as Figures 1 – 4.

As mentioned in previous correspondence and reports, the purpose of the Float Controllers is to monitor the reservoir water level and automatically control four gates to maintain the water level at a pre-determined set point. One Float Controller is connected to control gates 2 and 3, and it will begin opening one gate if the reservoir water level rises above the setpoint value of 1177.11 feet plus a deadband of 0.15 feet, which equals 1177.26 feet. The other Float Controller is connected to control gates 1 and 4, and it will begin opening one gate if the reservoir water level rises above the setpoint value of 1177.61 feet plus a deadband of 0.15 feet, which equals 1177.76 feet. Under past normal operation, with the Float Controllers in service, the reservoir elevation must rise to a level above the set point plus deadband value for each controller before the controller will begin opening one of the two gates that it is capable of opening or closing. The actual reservoir elevation at 2:22 p.m. on the day of these tests was 1176.71 feet.

A frequency-shift-keyed (FSK), 2125 Hertz (Hz) tone is sent to each Float Controller from a Water Level Transducer located adjacent to the float well on the dam. Each controller has its own Water Level Transducer and both Water Level Transducers receive the water level elevation from the same tape from the same float and float well. A stainless steel tape is physically connected to the float in the float well. The tape extends vertically up out of the well and over the wheel of one of the Water Level Transducers. A stainless steel counterweight provides a constant tension on the tape. The wheel the tape passes over rotates a shaft connected to a precision potentiometer. The shafts of both Water Level Transducers are ganged together with two sprockets and a chain so that they operate together. The potentiometers are precision linear devices that have a resistance change proportional to the input shaft rotation. The potentiometers have positive stops at the top and bottom of their range, and a slip clutch is provided to prevent damage to the potentiometer if they are over rotated.

Each Water Level Transducer contains electronic circuitry that converts the analog signal from the potentiometer into a binary-coded-decimal (BCD) digital signal. Then the BCD signal is converted to a FSK 2125 Hz tone which is sent over a pair of wires to the Float Controllers.

The actual position of each gate is provided as a 4 to 20 milliampere signal to the respective Float Controller from a gate position transducer that is mounted on each of the four radial gates.

After receiving the 2125 Hertz tone, the Float Controller decodes the tone. A digital-to-analog converter converts the decoded tone into a zero to 10 volt analog output. It is this output that was monitored on the day of the tests in order to record what each Float Controller "thought" the reservoir elevation was.

The Float Controllers were tested under various abnormal conditions in an attempt to identify one or more conditions that might have been responsible for the gate opening incident. In addition, since the controllers are powered from a 120 volt, single phase alternating current supply, and since, as reported in the incident report submitted to you by letter dated August 19, 2004, it was hypothesized that a fluctuating supply voltage or a supply voltage with severe voltage transients may have caused the Float Controller for gates 1 and 4 to erroneously open the gates, attempts were made to duplicate these conditions while monitoring the controllers.

The tests were performed by Frank Nann, our Communications Technician, and John Nypl, our Electrical Technician. For the tests made on October 11, the circuit breakers that supply power to the radial gate hoist motor controls were closed and the normal 120 volts alternating current supply voltage was supplied to the Water Level Transducers located at the reservoir float wells out on the dam, the Float Controllers, which are located in a three-room building at the north end of the dam, the interposing relays that the Float Controllers energize to raise or lower the gates, and the gate hoist motor contactors. In addition, the leads to the gate hoist motors were lifted so there would be no possibility of the Float Controllers causing one of the radial gates to open.

On Figures 1 – 4 are displayed twelve parameters connected with the controllers. These parameters are as follows:

1. The eight Float Controller raise and lower relay outputs for gates 1 – 4.

2. The water level analog output signal from each controller. This output normally follows the 2125 Hertz, binary coded decimal (BCD) tone received by the Float Controllers from the Water Level Transducers. The analog output of the Float Controller for gates 2 and 3 is used as an input to a chart recorder that records the reservoir elevation, and the analog output of the gates 1 and 4 Float Controller is not used in normal service.

3. The power supply voltages to the controllers.

Figure 1 documents the results of the controllers being subjected to switching from no power to power suddenly on, then the engine-generator being shutoff with the result that the supply voltage to the controllers ramps down to zero as the engine-generator comes to a stop. Following that, a test was done starting the engine-generator and letting it come up to speed with the power from the engine-generator being continuously tied to the controllers during the acceleration and stabilizing of the voltage output of the engine-generator, which subjected the controllers to rapid variations in the input voltage. It can be seen from Figure 1 that during the application of power from the engine-generator to the controllers at both about the 37 second point and the 46 second point of the trace time line, the reservoir elevation analog output signals of both controllers went falsely high to about 1180 feet for about 1.5 seconds before dropping to an elevation of about 1177 feet. As mentioned above, the actual reservoir elevation at 2:22 p.m. on the day of these tests was 1176.71 feet.

At about the 1 minute, 39 second point on the time line, power to the controller was switched back and forth between the engine-generator and the normal source of power which is from Oxbow Powerhouse. *It can be seen that the normal source voltage is slightly higher than the* engine-generator source voltage. Switching from one power source to the other power source, with the supply voltage spiking to zero during the switching, had no documented undesirable effects on the controllers. Finally, at about the 2 minute, 35 second point, the engine-generator voltage was rapidly varied up and down about plus or minus 10 percent many times, which also had no undesirable effects on the controllers.

Figure 2, which documents testing which occurred around 12:55 p.m. on October 11, 2004, shows the results of more tests of the controllers for any undesirable responses to supply voltage switching and perturbations. Whereas the Figure 1 time line has a scale of 5 seconds/division, the Figure 2 time line scale has a scale of 2 seconds/division. Once again, when supply voltage is applied to the controllers at about the 39 second and the 49 second points on the time line, the controllers' reservoir elevation analog output goes abnormally high for about 1 second, corresponding to a reservoir elevation of about 1180 feet, before dropping to about 1177 feet, which correctly represents the true reservoir elevation at the time of the test. Supply voltage noise caused by the start-up of the engine-generator did not cause either controller to issue any "raise" commands to the gates.

Figure 3 shows the results of more tests run about 2:19 p.m. on October 11, 2004. The reservoir elevation input signal was disconnected from the gates 1 and 4 controller for these tests. At about the 9 second point on the time line, the normal source power was switched on. As we have already seen in the tests documented in the previous figures, the signal that indicates reservoir elevation went abnormally high. However, while the gates 2 and 3 controller reservoir elevation signal dropped back to the actual reservoir elevation in less than one second, the gates 1 and 4 controller reservoir elevation signal stayed high for about 31 seconds, until the reservoir elevation input signal was re-connected. A "raise" command of a little over one second in duration to gate #1 was given about 20 seconds after the gates 1 and 4 controller reservoir elevation signal had returned to normal. At this time, we do not know with absolute certainty why the controller issued the "raise" command, although we do know that the controller issued the raise command after having the Water Level Transducer input signal disconnected for about

31 seconds. It does appear that if a Float Controller is powered up while the reservoir input signal is disconnected, the Float Controller will respond as if it was receiving a full scale reservoir elevation signal, which is about 1180 feet, for as long as the reservoir input signal is disconnected.

Figure 4 shows the results of more tests run about 2:23 on October 11, 2004. During these tests, the power to the controllers was switched "on" and "off" several times, with the results of two such cycles being shown in Figure 4. The reservoir elevation signals to the controllers were also connected. What is of interest is the sudden application of supply voltage at about the 44 second point on the time line. The gates 2 and 3 controller reservoir elevation signal went abnormally high for four seconds, and the gates 1 and 4 controller reservoir elevation signal went high for about 4.2 seconds. However, simultaneous one second gate raise commands were issued to both gates 1 and 4, and one-half second later it appears that the controller was also trying to send a lower command to gate 4.

On the following day, October 12, 2004, I was present for some additional tests performed at the dam. In addition to Mr. Nann and Mr. Nypl, we were joined by one of our Operators, Don Fleming, and by a PG&E Communication Technician, Ron Desilva. Mr. Desilva brought a Sierra Controls Test Receiver for monitoring the 2125 Hz, FSK signal from the Water Level Transducers. This equipment indicated that the Water Level Transducers sends a momentary false high reservoir indication when first powered up. After this momentary (not over 1 second in duration) false high reservoir elevation indication, the signal drops to a level that accurately represents the actual reservoir elevation. The circuit breakers that supply power to the gate hoist motor circuits were closed and the Float Controllers were placed into service. The Float Controllers performed satisfactorily under tests that were limited to small and short duration opening and then closing of the gates. In addition, a large coil was used to induce voltage spikes into the supply voltage to the Float Controllers. The Float Controllers did not issue any gate raise or lower commands as a result of these voltage spikes. At no time during the tests performed on October 12, 2004, did either Float Controller issue any erroneous gate raise or lower commands.

Although we did not duplicate the exact conditions that caused gates 1 and 4 to go open on August 5, 2004, the tests did indicate the importance of supplying power to the Water Level Transducers and the Float Controllers from as clean and as uninterruptible a source of electrical power as is reasonably possible. That could be accomplished by either supplying power from an Uninterruptible Power Supply (UPS) or from the 48 volt station battery. Actually, if the power to the Water Level Transducers and the Float Controllers had never been cycled on and off, there would have been no test, and we expect that there would have been no false reservoir elevation signals or gate raise or gate lower signals. We would expect the Float Controllers to operate flawlessly, as they did for about 10 years, until the morning of August 5, 2004.

We have also reviewed the level of potential exposure of the float control system to disruption or damage from lightning. The primary existing exposure is through the alternating current power source. However, if the power source were changed to the 48 vdc indoor battery bank, the level of exposure becomes much less because the Float Controllers and Water Level Transducers are located in protective structures, and the wiring is in conduit. With this change in power source, the primary potential exposure would most likely be the Gate Position Transducers, which are located in small enclosures located in each radial gate bay. However, they are small and they are located under the steel bridge that spans all the radial gates and that would probably serve as a lightning rod.

Based on what we learned from this test, it appears to us that implementing the following recommendations may be sufficient to allow the Float Controllers to be put back into service and protect against another inadvertent sudden opening of one or more radial gates as occurred on the morning of August 5, 2004:

1. The Sierra Controls Float Controller manual recommends that water level signals be carried over shielded wires, that the cable runs be kept short, and that, if possible, they be routed away from high voltage lines. There are no high voltage lines in the immediate area, however, water level signals are sent over un-shielded wires that are several hundred feet in length and that are packed into large conduit with many other wires. We recommend that the water level signals be carried over shielded wires in their own conduit. We have contacted the equipment manufacturer who stated that the FSK tone signal can be satisfactorily sent over several thousand feet of cable without losing its integrity.

2. We recommend that each of the Water Level Transducers be operated from separate float wells rather than being ganged together and operated from the same float well. In addition, the Float Controllers have the ability to receive two, separate water level input signals from two, separate Water Level Transducers, and compare the water level signals from each transducer. If the difference in level exceeds 0.1 foot, the Float Controller issues an alarm and is inhibited from operating. We recommend that the two Water Level Transducers be input to both Float Controllers which will implement this redundant feature and allow the Float Controllers to detect a failure or problem with one of the Water Level Transducers or float wells.

3. During testing, it was noticed that the 38 year old interposing relays chattered and were excessively noisy. These relays are operated by the smaller gate-raise and gate-lower relays within the Float Controllers, and the interposing relays operate the radial gate motor contactors. We recommend that the interposing relays be replaced.

4. As a result of investigations and tests to date, mis-operation of either or both the gates 1 and 4 Float Controller and its Water Level Transducer appears to be the most likely cause of the sudden opening of gates 1 and 4 on August 5. Supply voltages were probably fluctuating widely as a result of the failure of the transfer switch. These disturbances may have caused the gates 1 and 4 Float Controller to lock up. As reported in our August 19, 2004 letter report to you, after reviewing the incident, visiting the site and performing tests on the equipment, the manufacturer's representative recommended that the Float Controllers be powered from either a UPS or directly from the 48 vdc battery bank that is located in the same room the Float Controllers are presently in. Our recommendation is that the Float Controllers, the Water Level Transducers and the Gate Position Transducers be either powered

through an inverter from the 48 vdc battery bank or be sent back to the manufacturer to be retrofitted with 48 vdc power supplies. Either of these changes would isolate the float control equipment from supply voltage fluctuations and transfers. We also recommend that controls be added that would require an operator or technician to restore power to them if it is ever interrupted.

5. When operating normally, the Float Controllers will not issue simultaneous raise commands to both gates that it controls. We propose to add controls that would detect any attempt of a Float Controller to issue simultaneous raises, would prevent simultaneous raises and would lock-out the Float Controller if it tried to issue simultaneous raises.

6. The operation of the Float Controllers is based on proportional, integral and differential control of the gates. Based on information received from the manufacturer, it is our understanding that when a gate raise command is called for, the length of the gate raise command that is issued is proportional to the elevation the reservoir water level is above the setpoint plus deadband value. The length of gate raise command is also affected by the rate-of-rise of the reservoir elevation (the differential component), and it is affected by a longer term average of samples of reservoir elevation (the integral component). The maximum possible gate raise command in seconds is easily adjustable and it is presently set at 30 seconds. After a gate raise command occurs, the Float Controller will wait a minimum of 10 minutes before issuing the next gate raise command. This "wait" time is also adjustable. All the various adjustments taken together allow the Float Controller to be adjusted for the unique hydraulic characteristics of the river/reservoir/dam system, so that as river flows rise due to heavy rains and/or snow melt, the reservoir level does not overtop the gates, and the gates do not open any more than is necessary to regulate the reservoir around the setpoint plus deadband elevation. We propose to install controls that will interrupt and lock out the Float Controller if it ever attempts to send a raise command longer than the maximum allowable raise time that is already dialed into the controller.

7. Inspection of the control cabinets for each gate that are located near each gate hoist motor revealed that some door seals need to be replaced and some cabinet heaters are not functional. We propose to thoroughly test the power transformer and controls in each cabinet, install cabinet heaters, thermostats and door seals where needed, and refurbish or replace any components requiring this level of attention.

We will be requesting proposals from qualified independent licensed professional electrical engineers to evaluate the above described test results and recommendations, and to perform all the other tasks requested in your letters dated September 1, 2004, and October 29, 2004.

If you have any questions, please call me at (530) 885-6917.

Sincerely,

PLACER COUNTY WATER AGENCY

Stephen J. Jones
Power System Manager

Enclosure

cc: David Breninger
Jerry Kelley
Edward Tiedemann
Kevin Goishi, PG&E
David A. Gutierrez

LARGE-FORMAT IMAGES

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