AEOD TECHNICAL REVIEW REPORT

UNIT: Oconee, Catawba
DOCKET: Multiple
LICENSEE: Duke Power
NSSS/AE: Babcock and Wilcox, Westinghouse/Duke Power

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SUBJECT: ENHANCED SETPOINT TESTING PROCEDURES FOR PRESSURIZER SAFETY VALVES AT OCONEE AND CATAWBA

SUMMARY:

The Duke Power Company reported that as-found setpoint tests of pressurizer safety valves (PSVs) from Oconee and Catawba had revealed three valves whose setpoint exceeded the nominal ± 1 percent psig allowed by technical specification (TS).

Duke was aware that "setpoint drift," where the valve setpoint exceeded both the TS allowed ±1 percent and the ASME Code allowable ±3 percent for similar safety valves in non-nuclear applications, was a common problem with safety valves throughout the nuclear industry. Investigation into the cause of the setpoint deviation of the Oconee and Catawba valves developed nine possible contributing factors. The four more important factors are:

1. The valve leaked during setpoint testing, changing the seat area, causing it to lift at a lower setpoint.

2. The leakage control procedure, the jack and lap process, was not carefully controlled resulting in a different valve configuration and an indeterminate setpoint.

3. Setpoint trending control concentrated on producing results that fit a preconceived notion of what the pattern of the results should be rather than finding the accurate setpoint.

4. Ring adjustment after a setpoint test without retest could also change the valve configuration and make its setpoint indeterminate.

A variety of actions taken to resolve the problem are discussed in the report.

The PSVs prevent the overpressurization of the reactor coolant system (RCS) during transients and accidents which involve a mismatch between the primary heat source and the

secondary heat sink. The impact of an increased PSV setpoint for a pressurized water reactor would be a reduction of the margin between the peak transient RCS pressure and the pressure vessel safety limit.

The results of the Westinghouse Owners' Group actions discussed in T91-05 and in this report and Duke's actions discussed in this report are:

1. The industry efforts furnished an improved understanding of the role that testing plays in determining an accurate setpoint for spring-actuated safety valves.

2. An approach that narrowly focuses on a specific symptom can introduce errors into the testing process if the symptom, rather than the valve setpoint, becomes the prime objective of the test.

3. The individual efforts currently underway by the nuclear industry to resolve safety valve setpoint problems are demonstrated in these reports.

4. Adopting improved controlled testing procedures can result in more consistent setpoints.

Specifically, Duke has demonstrated that leakage can effectively change the seat area of a safety valve causing it to lift at a lower apparent setpoint. Attempts to correct leakage without retesting the valve can cause a different valve configuration which can result in a different setpoint. Carefully controlled testing procedures provided more precise setpoint determination.

DISCUSSION:

In AEOD T91-05, "Setpoint Testing of Pressurizer Safety Valves with Water-Filled Loop Seals," it was concluded that "carefully controlled standardized tests...do produce more accurate results than the commonly used general setpoint adjustment procedures." The Westinghouse owners' group actions described in T91-05 and the Duke actions described in this report are two examples of the individual approach that the nuclear industry is taking to resolve the "setpoint drift" problems with spring action safety valves. Duke Power Company reported that as-found setpoint testing of PSVs from Oconee and Catawba had identified three valves whose setpoint exceeded the nominal ± 1 percent psig allowed by TS. The valves were all Dresser spring-actuated pressurizer safety valves. The testing was done at Wyle Laboratories in Huntsville, Alabama. The Duke procedure emphasized the need to prevent seat leakage in safety valves. They developed a process called "jack and lap," approved by both Dresser and Wyle, to assure leaktightness.

Duke was aware that "setpoint drift," where the valve setpoint exceeded both the TS allowed ±1 percent and the ASME Code allowable ±3 percent for similar safety valves in non-nuclear applications, was a common problem with safety valves throughout the nuclear industry. Investigation into the cause of the setpoint deviation of the Oconee and Catawba valves developed nine possible root causes, four of which were thought to be more likely than the remaining five. These causes [1] are :

1. Leaking valve during setpoint test

   If valves are leaking during the steam setpoint verification test, the valves' huddle chamber (See Figure 1) could become pressurized, effectively increasing the valve seat area. [With this larger area, a lower pressure could then produce sufficient force to lift the disc.] This would cause a lower apparent setpoint and the compression screw would be adjusted to further compress the spring. This would give an artificially high setpoint on the valve if the leak was later repaired as was done with the jack and lap process. If testing on steam is not performed [after the valve is repaired to correct leakage] then the repaired valve will have a higher setpoint than desired.

2. The jack and lap process

   The jack and lap process is a partial disassembly of the valve while maintaining spring compression. This process is used to polish the valve seats, often in preparation for a final gaseous nitrogen leakage test. This disassembly process obviously can introduce some small error into the as-tested setpoint since it is very difficult to reassemble the valve exactly as it was found.

3. Setpoint trending control

   While performing setpoint verification testing, particularly after a valve rebuild, performance stabilization is necessary to validate a true setpoint. If setpoints [test pressure at which the valve lifts] are trending in one direction some stabilization or "turn around" is desired before a test is considered valid. Test controls should be tight enough to insure that trending will not continue and that the valve's true setpoint has been achieved.

4. Ring adjustment after a setpoint test

   If a valve undergoes ring adjustments, particularly on the lower ring [nozzle ring], its transition from simmer to pop is changed and its performance under leaking conditions is also changed.

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1 Duke Power company handout, Meeting of July 2, 1991, at Duke Power Company's Charlotte, N.C. offices.

Duke Power also considered temperature effects [See also AEOD/T91-05], spring performance, seat adhesion effects, transportation/handling effects, and test process effects to be less credible contributors.

Actions taken to stop valve leakage that occurred during setpoint testing involved changes to the setpoint testing procedure. Valves which leaked during or after a setpoint test were required to be repaired and retested on steam. Acceptance criteria for leakage allowed no leakage, not even fogging, at 93 percent of the set pressure.

To improve the jack and lap process, the procedure was changed to require reestablishment of the body-to-bonnet gap (see Figure 1) as well as a subsequent steam setpoint verification test. To control setpoint trending, the test procedure was changed to require three consecutive setpoint verification pops be within 10 psi if trending occurs with no turn around. Ring adjustments after setpoint tests were prohibited; that is, if ring adjustments were made, steam setpoint verification tests would be conducted subsequent to ring adjustments.

Although the remaining possible root causes were thought to be less credible, some corrective actions were instituted to address them. Temperature measurements of three body and bonnet locations were to be done by using two thermocouples on the upper bonnet flange, two thermocouples on the lower bonnet flange, and two thermocouples on the inlet flange. One thermocouple of each pair would be located 120° from the other. Test process affects were addressed by two procedure changes which instituted a torquing guideline to ensure even loading and alignment when the valve was installed for the test and a standardized pressurization rate to eliminate the possible effects of the pressure ramp on the setpoint determination.

On August 12, 1991, about two months after the valve setpoint was determined satisfactorily using the improved procedures, Duke requested that Wyle Laboratories again test PSV BSO 2871 from Catawba. Wyle used test procedure number 41787, dated August 1, 1991, entitled "Testing of Dresser Model 31700 Safety Valves at Elevated Temperature."

The test sequence called for an "as-received" set pressure test followed by a steam seat leakage test. Next came disassembly, verification of ring positions, lubrication, reassembly, and ring reset. The next steps were a set pressure verification test and a steam seat leakage test followed by packing and shipping if the tests were successful. A valve which failed the steam seat leakage test was repaired by the jack and lap process and was again subjected to the set pressure verification test followed by a steam seat leakage test until it was both set properly and did not leak.

Since the subject valve had previously been properly setpoint tested and successfully leak tested, it was mounted on the steam header for a setpoint verification test. After mounting the valve and attaching the required instruments per procedure (see Figure 2), saturated steam at 90 percent of the nameplate rating was applied to the valve inlet until the temperatures were stabilized prior to starting the testing.

The steam pressure was then increased until the valve actuated. The setpoint was determined from the pressure vs. time trace. Following the actuation, the pressure was re-established at 90 percent of set pressure and maintained at that level for at least 10 minutes before the next actuation.

The results of the tests were 0 leakage at 90 percent set pressure; 2494 psig setpoint for the first actuation at a 152 psig/sec ramp. The second actuation was at 2511 psig at a 152 psig/sec ramp, more than 10 psig above the previous lift. The third lift was at 2504 psig with a 144 psig/sec ramp. The fourth actuation was at 2502 psig at a 160 psig/sec ramp. The fifth actuation occurred at 2498 psig with a 148 psig/sec ramp, satisfying the requirement for three consecutive lifts within 10 psig of each other. Each of the five lifts were within one percent of the as-left setpoint. For repeatability of setpoints, this test was successful in that the ± 1 percent was attainted. The subsequent seat leak test at 93 percent set pressure was unsuccessful; the inspection mirror was fogged. The valve was scheduled for refurbishing and retesting on steam.

ANALYSIS:

LERs, NPRDS reports, information notices, and AEOD reports document the problem called "setpoint drift." The setpoint of a pressurizer safety valve is usually 2485 ±1 percent psig. The RCS design pressure is also 2485 psig. The positive tolerance, therefore, is a part of the 10 percent pressure band between design pressure and the 2735 psig safety limit.[2] The setpoint is the pressure at which the valve begins to lift. The pressure at which the valve achieves full lift includes the setpoint plus or minus the tolerance (± 1 percent) plus the accumulation[3]. This would give an RCS pressure of up to 4 percent over the nominal setpoint as permitted by current Technical Specifications.

The PSVs prevent overpressurization of the RCS during transients and accidents which involve a mismatch between the primary heat source and the secondary heat sink. For Catawba, a Westinghouse designed plant, the limiting transients are uncontrolled rod withdrawal, turbine trip, and rod ejection. For Oconee, a Babcock and Wilcox designed plant, these transients and accidents include uncontrolled rod withdrawal, loss of main feedwater, and rod ejection.

The impact of an increased PSV setpoint for either type plant would be the reduction of the margin between the peak transient RCS pressure and the safety limit.

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2 NUREG-0452: "Standard Technical Specifications for Westinghouse Pressurized Water Reactors," Section 2.1.2: "The reactor coolant system pressure shall not exceed 2735 psig."

3 Accumulation is defined as the difference in pressure between the setpoint and the pressure at which the disc reaches full travel expressed in a percent of the setpoint. Requirement for accumulation is generally 3-4 percent.

FINDINGS AND CONCLUSIONS:

The results of the Westinghouse Owners' Group actions discussed in T91-05 and Duke's actions discussed in this report illustrate the following:

1. The industry efforts furnished an improved understanding of the role that testing plays in determining an accurate setpoint for spring-actuated safety valves.

2. An approach that narrowly focuses on a specific symptom can introduce errors into the testing process if the symptom, rather than the valve setpoint, becomes the prime objective of the test.

3. The individual efforts currently underway by the nuclear industry to resolve safety valve setpoint problems are demonstrated in these reports.

4. Adopting improved controlled testing procedures can result in more consistent setpoints.

Specifically, Duke has demonstrated that leakage can effectively change the seat area of a safety valve causing it to lift at a setpoint which is lower than that at which it was set to lift.

Further, Duke has shown that actions taken to resolve a problem must be carefully controlled so that they do not introduce new errors into the testing process. The jack and lap process cured leakage, but a failure to restore the original body-to-bonnet gap created a different valve configuration and an uncertain setpoint. Duke also found that ring adjustments changed the valve configuration, making the setpoint uncertain.

From Duke's experience, as well as the earlier Westinghouse Owners' Group experience, it can be concluded that well designed, carefully controlled procedures for setpoint testing of spring action safety valves produce more accurate setpoints.

From the sum of Duke's and the Westinghouse Owners' Groups experience, it can also be concluded that a concerted effort on the part of the nuclear industry would be more efficient in the resolution of these common problems, than the individual efforts currently underway.

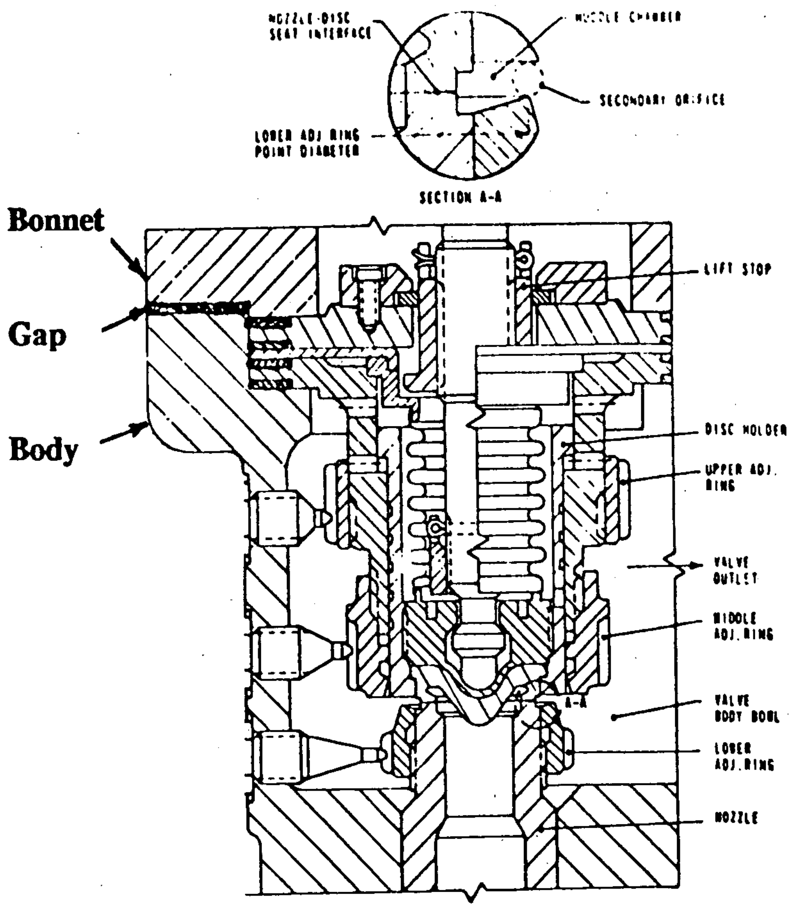

Figure 1: PSV Internals

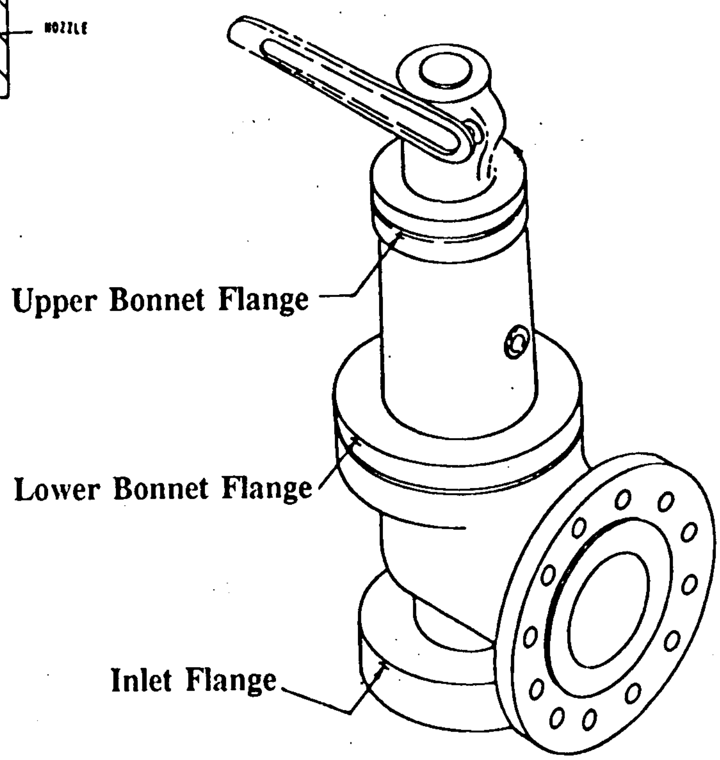

Figure 2: Location of Thermocouples