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Subject: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Shutdown Cooling Line Thermal Stratification

Gentlemen:

Entergy Operations, Inc. is providing this voluntary information on the results of monitoring the ANO-2 shutdown cooling suction piping to detect if a thermal stratification phenomenon induced by direct RCS interface existed without valve leakage per NRC Bulletin 88-08. Valve-leakage induced thermal stresses in piping connected to Reactor Coolant Systems (RCS) was the subject of NRC Bulletin 88-08 and Supplements 1-3. The Bulletin and Supplements 1 and 2 addressed inleakage to RCS piping, while Supplement 3 introduced the concern of RCS outleakage through a valve's packing gland. Entergy Operations at ANO provided responses to the Bulletin and Supplements dated October 12, 1988, January 31, 1991, and October 14, 1991. The October 14, 1991 response restated that inleakage was not considered to be a concern for ANO-2. This response also stated that a Combustion Engineering Owner's Group (CEOG) study performed as an industry response to Supplement 3, revealed that only three (3) piping systems could possibly be subject to excessive stresses due to outleakage from the RCS. An internal evaluation determined that due to ANO-2's specific configuration and existing instrumentation, the three systems; safety injection, shutdown cooling, and hot leg injection would either not be subject to the outleakage type of stratification as described in Supplement 3 or there is sufficient instrumentation and precaution in place to detect outleakage. ANO therefore, concluded that no further action was required to address NRCB 88-08 and its Supplements .

As part of a separate industry effort to detect thermal stratification induced by direct interface to the RCS and not valve leakage per NRC Bulletin 88-08, ANO participated in a CEOG pilot study of thermal stratification in the three (3) referenced lines. Results from the study showed that thermal stratification occurred in the safety injection and the hot leg injection lines, even when leaking valves were not the cause. After reviewing the pilot plant results, ANO-2 instrumented the three lines due to the differences in the piping layouts from the pilot plant systems. This action was completed during the Unit 2 refueling outage 2R9 (Fall 1992) and the decision was made to monitor data from these

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three lines for at least one operating fuel cycle.

This submittal provides information on the results of monitoring the ANO-2 shutdown cooling suction piping as shown on Figure 1. Temperature measurements taken on the shutdown cooling (SDC) suction piping after start-up from 2R9 indicated that a top to bottom temperature differential existed in the first horizontal section of this line with a peak value of ~200°F measured during power ascension. A top to bottom temperature gradient of <100°F was measured once steady state operation had been achieved. During a temporary power reduction in November 1992 to support maintenance activities, a top to bottom temperature differential of ~300°F was observed. During power reduction in preparation for Unit 2 mid-cycle outage 2P-93-1 (May 1993), a maximum temperature differential of approximately ~350°F was measured in the first horizontal section of the SDC line.

Combustion Engineering (CE) was contacted to assess the potential stresses experienced by the SDC line and to evaluate these stresses against code allowable values. The results of the analysis indicated that this temperature differential resulted in significantly less stress for the shutdown cooling line than the analyzed stress on the pressurizer surge line which was previously evaluated for NRC Bulletin 88-11 (Pressurizer Surge Line Thermal Stratification). This is attributed to both the SDC piping's much shorter stratified horizontal run, and the fact that the piping is significantly more flexible than the pressurizer surge line (no rigid vertical supports between the hot leg and SDC MOV). Conservative estimates were made concerning the number of past stratification cycles and potential future cycles. These stresses induced by stratification were paired with the appropriate loadings out of the original stress report to ensure the maximum stress range was considered for the fatigue evaluation. This analysis indicated that even with a conservative number of thermal cycles over the 40 year life of the plant, a usage factor of significantly less than a code allowed 1.0 would not be exceeded. Therefore, the observed stratification does not represent a safety concern and a sufficient margin of safety exists.

These thermal stratification transients appear to be caused by variances in the turbulent penetration length driven by changes in hot leg temperature during reactor power reductions. These transients appear to be independent of reactor coolant flow since the observed transients occurred while all four RCS pumps were running. It is hypothesized that the increase in hot leg fluid density (that accompanies the reduction in reactor power and the decrease in hot leg temperature) slightly altered the hot leg flow characteristics. This in turn, changed the characteristics of the turbulent penetration by increasing the mass transport of RCS fluid into the branch line. This resulted in an increase in the turbulent penetration distance which, during the transient, extends into the first horizontal run of the SDC line causing a stratified fluid layer to develop.

In an attempt to confirm the cause of the phenomenon observed, outleakage past the SDC line motor-operated-valve (MOV) 2CV-5084-1, shown in Figure 1, was investigated to see if a leakage path existed that could be drawing the hot RCS fluid through the SDC piping and causing stratification similar to that discussed in NRC Bulletin 88-08,

Supplement 3. This isolation valve is more than thirty five pipe diameters from the hot leg. Thermocouple readings taken adjacent to valve 2CV-5084-1 indicated no leakage at this valve. Top and bottom temperatures remain virtually constant throughout each transient with a delta-T of less than 1°F. If outleakage past the SDC MOV was assumed to be the cause of these transients, hotter (possibly stratified) fluid temperatures would have appeared at this location during the transients. Additionally, if outleakage was occurring at this valve, increased valve leakage would have been present during transients and would have coincided with RCS pressure increases, not RCS temperature decreases. Therefore, it was concluded that valve leakage for 2CV-5084-1 could not have been the cause of the newly identified thermal stratification phenomenon at ANO.

Backleakage past the hot leg injection check valves, 2SI-27A/B and 2SI-28A/B, referenced on Figure 1, was also investigated. Upstream of these check valves are pressure indicators 2PI-5105 and 2PI-5106. If leakage past these check valves were assumed, RCS pressures would be observed at these pressure indicators. No pressure differentials were observed that would indicate backleakage through the check valves.

A conference call was held on May 12, 1993, with members of NRR and NRC Region IV staff to discuss these preliminary findings concerning thermal stratification in the ANO-2 shutdown cooling line. As discussed during the call, the affected piping will continue to be monitored for an additional fuel cycle and an evaluation will be made of the need for additional instrumentation to be installed during refueling outage 2R10 currently scheduled for March 1994. The NRC staff also requested that they be provided a copy of the final CE analysis of the shutdown cooling line thermal stratification, the mass flow velocity of the Reactor Coolant System (RCS) fluid prior to and during shutdown, and any additional information that we may know on the new phenomenon experienced.

In response to the Staff's request, a copy of the final CE analysis for the shutdown cooling line is attached. Note that this calculation is considered an operability evaluation used to demonstrate that there is no safety concern regarding thermal stratification in this line for this newly identified phenomenon. As previously noted, the affected piping will continue to be monitored during the current fuel cycle in order to better quantify potential causes for these transients. Once these stratification transients are better defined, this information will be used in a formal revision to the stress report for the SDC line.

In regards to RCS flow velocity during observed thermal stratification events, the RCS total coolant flow rate remains constant during power operation and during power reduction at ~322,000 GPM until a reactor coolant pump is taken off line. The pressure also remains constant at ~2210 psi. However, the hot leg temperature varies from ~600° F at 100% power to ~545°F at 0% power.

The above discussion provides the relevant information that ANO has on the newly identified thermal stratification phenomenon. In addition, this submittal addresses the comments provided in NRC Inspection Report 93-05, dated July 2, 1993, Section 2.4.

Should you have any questions concerning the information provided, please contact me.

Very truly yours,

for James J. Fisicaro
Director, Licensing

JJF/jrh

Attachments

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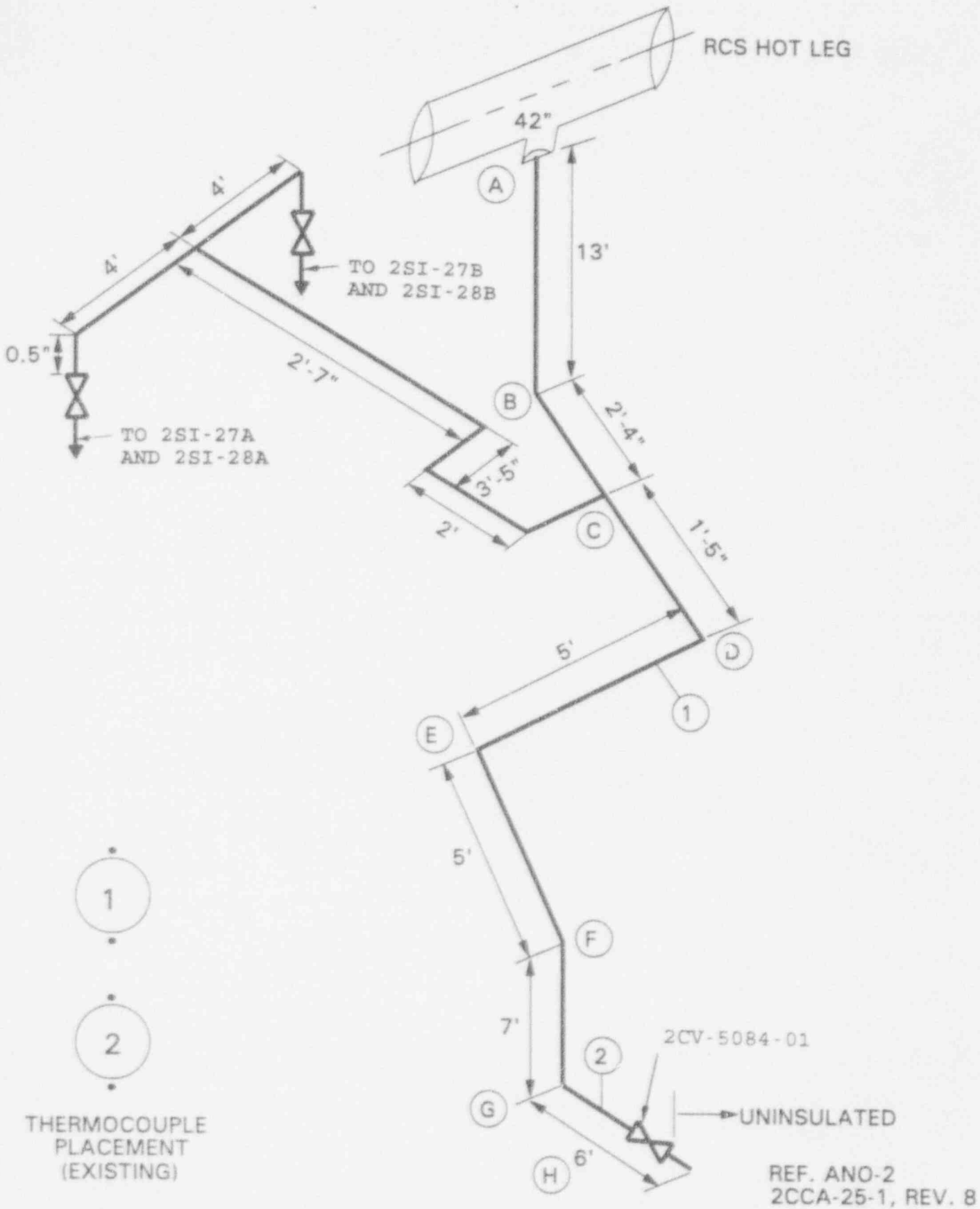
FIGURE 1



SDC LINE MEASUREMENT LOCATIONS - ANO-2