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SUBJECT: Forwards response to NRC 930902 telcon RAI re NRC Bulletin 88-008, "Thermal Stresses in Piping Connected to RCS." Revs Calculation 13-MC-ZZ-643, "Auxiliary Spray Line Thermal Stratification" also encl.

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EXECUTIVE VICE PRESIDENT
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102-02680-WFC/RAB/ZJE
October 1, 1993

U. S. Nuclear Regulatory Commission
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Dear Sirs:

Subject: **Palo Verde Nuclear Generating Station (PVNGS)**
Units 1, 2, and 3
Docket Nos. STN 50-528/529/530
Response to Telephone Request for Additional Information Regarding NRC Bulletin 88-08
File: 93-005-419.05; 93-056-026

On September 2, 1993, a telephone discussion was conducted between Charles Trammell, NRC, and Richard Bernier, Arizona Public Service Company (APS). The NRC requested the following additional information regarding APS' actions and time schedule for implementing the requirements of NRC Bulletin 88-08 "Thermal Stresses in Piping Connected to RCS":

1) Diagram of the safety injection line connections to RCS, together with a description of the natural convection phenomenon that leads to thermal stratification in the horizontal section of the line,

2) APS' calculation of the bounding thermal stratification stresses in the auxiliary pressurizer spray line (APS Calculation # 13-MC-ZZ643), and

3) APS' schedule to implement the long term surveillance plan in Unit 3.

The enclosure to this letter contains the information in response to items 1 and 2. With regard to item 3, APS is committed to install thermocouples on the pressurizer auxiliary spray line and main spray line in Unit 3, no later than the fifth refueling outage currently scheduled for the fall of 1995. However, these thermocouples will likely be installed during the fourth refueling outage in Unit 3 currently scheduled for the spring of 1994, since the required engineering design for these thermocouples is underway.

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Should you have additional questions, please contact Richard A. Bernier at (602) 393-5882.

Sincerely

WFC/RAB/ZJE/rv
Enclosure

cc: B. H. Faulkenberry
C. M. Trammell
J. A. Sloan

ENCLOSURE

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

EVALUATION OF THE PVNGS SAFETY INJECTION LINE FOR NRC BULLETIN 88-08

An evaluation of the safety injection piping has been performed to address the concerns of NRC Bulletin 88-08. The bulletin is concerned with high cycle thermal fatigue of unisolable sections of RCS branch piping associated with branch system in-leakage or out-leakage. The PVNGS safety injection system piping is subject to the definition of susceptible piping as identified by the bulletin and NRC supplemental guidance. The evaluation concludes, however, that the safety injection piping is not at risk of high cycle thermal fatigue and the integrity of the unisolable piping sections is ensured for the design life of the units.

The safety injection lines at PVNGS provide a flow path to the RCS from the emergency core cooling system (ECCS) low pressure safety injection (LPSI) and high pressure safety injection (HPSI) pumps and from the safety injection tanks as shown in Figure 1. During normal power operation, the RCS pressure is sufficiently higher than the shut-off head of the HPSI pumps and injection is impossible in the event the pump(s) are in operation. Note also that the containment isolation motor operated valves isolate the ECCS pumps from the RCS. The piping segment between the isolation check valves is also connected to the chemical volume and control system (CVCS) via HPSI header 1. The charging system, along this flow path, is isolated from the safety injection line by a normally closed manual isolation valve and a normally closed containment isolation valve which, by procedure, is leak rate tested. Consequently, neither the ECCS pumps nor the charging pumps present the potential for in-leakage induced thermal stratification.

As a result of RCS isolation from the high pressure CVCS systems, conditions are more favorable for thermal stratification by RCS out-leakage (into the branch line). However, a torturous flow path precludes RCS out-leakage; there are 3 in-line check valves and 1 motor operated containment isolation valve that separate the ECCS injection headers and the RCS. Further, no flow path exists from the RCS to the corresponding safety injection tank as the system is closed. The segment of injection piping between the safety injection tank isolation check valve and the RCS isolation check valve is equipped with a 1.0" drain line and isolation valve. In the event of leakage past the RCS isolation check valve, the control room receives a high pressure alarm and the accumulated pressure is procedurally relieved through the 1.0" drain line. The occurrence of safety injection line high pressure alarm is extremely infrequent indicating the absence of RCS out-leakage.

In the absence of a flow path to support out-leakage of the relatively hotter RCS fluid into the stagnant injection piping, an initial evaluation concluded that the safety injection piping would not experience thermal loading beyond that defined in the original plant design. However, a mechanism does exist in which static loads develop linearly with increasing power level and corresponding RCS temperature. This mechanism has been identified as natural convective counter-currents that are established as a result of the high temperature difference between the ends of the stagnant body of water within the injection line between the RCS isolation check valve (V-217 typical) and the safety injection tank isolation check valve (V-215 typical).

Investigations of buoyancy driven counter-currents in horizontal pipes are documented. The references stated herein indicate that experimental data and the correlated results are applicable to the conditions of the safety injection line, characterized by the Rayleigh number (Ra). This research substantiates that the conditions favor the development of stratification by natural convection. Specifically, the temperature differences between the end conditions in the injection pipe produce Ra on the order of 10^{10} which is within that reported by researchers.

Indication of thermal stratification in the safety injection lines, in addition to the on-going efforts to resolve the concerns of NRC Bulletin 88-08, prompted the Combustion Engineering Owners Group (CEOG) to fund a task to develop a methodology to predict temperature distributions in the safety injection piping resulting from natural convective counter-currents. The program consisted of development of a computational fluid dynamics model, benchmarking the model to plant data, and development of an evaluation methodology. The resultant methodology for predicting pipe wall temperatures accounts for variations in line configuration and boundary conditions and is therefore applicable to all cases where natural convective currents are suspected of establishing stratified profiles in stagnant lines. These efforts will also be included in the Electric Power Research Institute (EPRI) program to address thermal stratification.

As noted, the existence of the natural convective counter-currents is supported by plant data. The data demonstrates steady state temperature profiles at normal operation with maximum top to bottom temperature differences of 140°F. The existence of this stratified temperature distribution has been verified at PVNGS by local measurements while at normal operating temperature and pressure. The maximum top to bottom temperature differences recorded were approximately 100°F at the RCS isolation check valve (Point A) and decreased somewhat linearly to a uniform pipe wall temperature at the safety injection tank motor operated isolation valve (Point B). The model developed to predict these distributions bounds the maximum stratified profiles, in particular those recorded at PVNGS.

Application of the preliminary evaluation methodology developed for the CEOG indicates that the PVNGS safety injection lines are not subject to high cycle thermal fatigue. Natural convective counter-currents are established as the units ascend in power due to the increased temperature difference between the boundary conditions of the stagnant water in the injection piping. The thermal loads are steady and no cyclic behavior is expected based on theory, models, and plant evidence. The resulting static loads are small and do not impact the structural evaluations.

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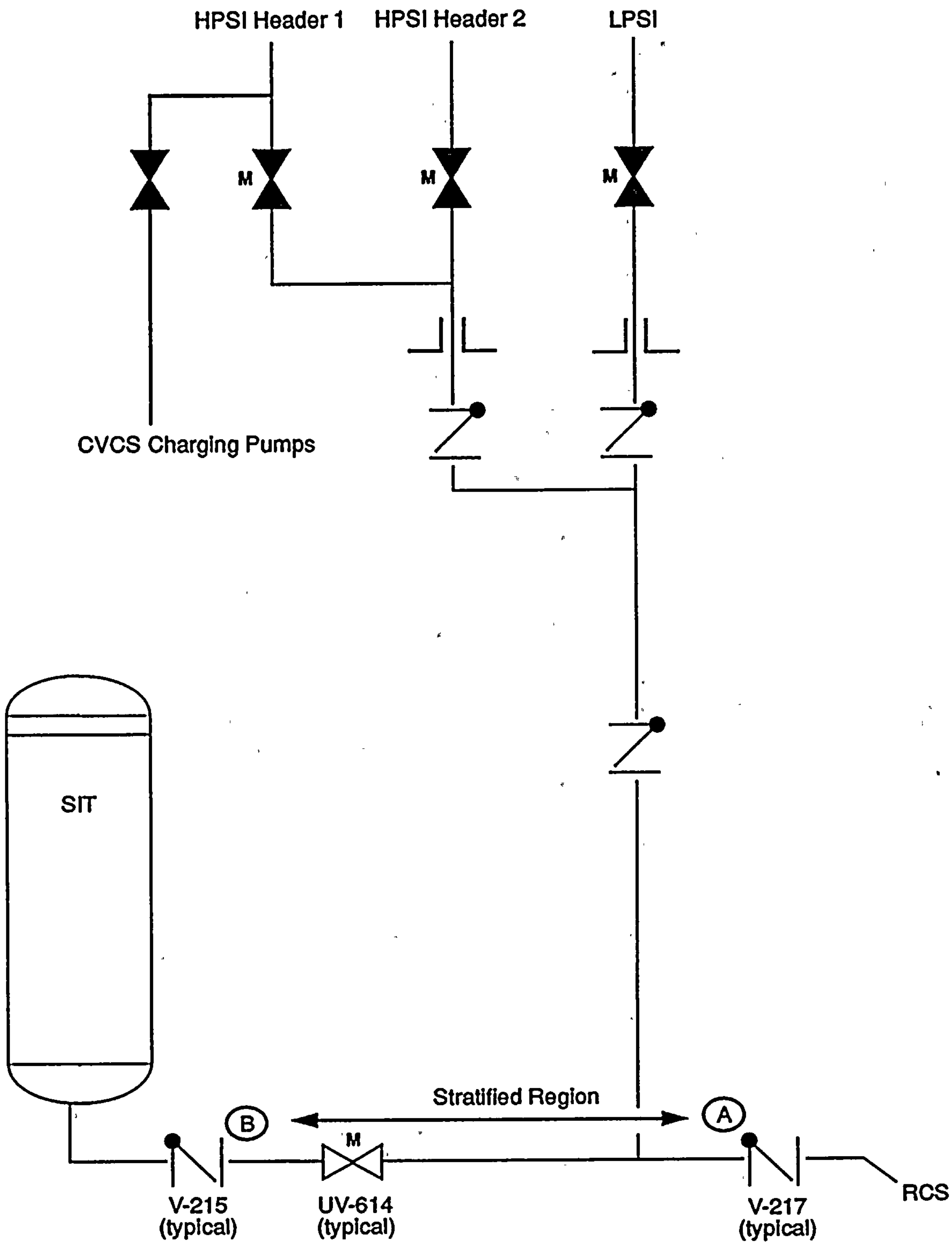
FIGURE 1

PVNGS SAFETY INJECTION SYSTEM PIPING (TYPICAL)



Upon review of the calculation, it was determined that a revision per the following sheets should be done for clarity. The existing calculation calculates the change in stress ranges caused by stratified flow. The stress ranges from the existing design calculations are then increased by these changes and compared to code allowables. It was determined upon further review that this was not clearly shown in the existing calculation. Therefore, the revision will recalculate the stress ranges and usage factors based on the revised stresses and compare to code allowables. Existing sheets 6, 7, 23, 24, 25, 32 & 33 will be revised per attached. Existing sheets 9 through 15 will be replaced with attached sheets 9 through 15B.