UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION REGARDING A POSTULATED FIRE
IN THE CHARGING PUMP ROOM OR CORRIDOR
CONSUMERS POWER
PALISADES PLANT
DOCKET NO. 50-255

1.0 INTRODUCTION

A fire in the charging pump room or 590 corridor at Palisades could result in the loss of all three charging pumps. In this situation, the High Pressure Safety Injection (HPSI) pumps would be available to pump water into the reactor coolant system (RCS). However, the shutoff head of the HPSI pumps, which is about 1213 psia, is much less than the normal operating pressure. The staff expressed concern that the pressurizer could be emptied, prior to the reactor coolant system being depressurized below the shutoff head of the HPSI pumps.

In Reference 1, the licensee committed to make modifications and procedural changes to allow the alignment of the suction side of an HPSI pump to the discharge side of a containment spray pump (CSP) in the event of such a fire. The licensee also provided analyses which demonstrated that the RCS could be depressurized below the shutoff head for this tandem pumping arrangement without interrupting natural circulation.

Appendix R of 10 CFR 50 requires one train of the systems necessary to achieve and maintain hot shutdown conditions to be protected against fire damage or an alternative safe, shutdown capability be provided. To meet this requirement, the licensee proposes that the discharge side of CSP P-54B be aligned to the suction side of HPSI pump P-66B to provide make-up to the RCS if all three charging pumps are lost to a fire. The P. & I. D. diagrams in the FSAR show that this can be done through a 4-inch line by opening the normally-closed valve CV-3070. The modifications and procedures for doing this shall be in accordance with 10 CFR 50 Appendix R or an exemption must be requested.

2.0 EVALUATION

The pump performance curves show that by aligning the HPSI pump in tandem with the CSP pump, the HPSI pump can provide water to the reactor coolant system when the RCS pressure is 1463 psia or less. Since the normal RCS operating pressure is 2100 psia, the first aspect of a safe cooldown is to remove the decay heat from the core while the RCS pressure is being reduced to 1463 psia. For the purpose of this evaluation, the discussion of the initial cooldown is divided into two phases, i.e., the removal of decay heat prior to cooling down, and the cooldown to safety injection at 1463 psia. This is followed by an evaluation of the cooldown to Shutdown Cooling System temperature and then the shutdown cooling.

2.1 Removal of Decay Heat

In the event of a fire in the charging pump room or corridor, the reactor will be tripped and the steam flow to be turbine will be automatically stopped. The bypass and Atmospheric Dump Valves may not be immediately available since the operating procedures instruct the operators not to commence cooldown until make-up capability and pressurizer level control are available. As a result, the pressure in the secondary side of the steam generators could increase to the average safety valve set point.

Palisades Technical Specification 3.1.7 states that whenever the reactor is in power operation, a minimum of 23 secondary system safety valves shall be operable with their lift settings between 985 psig (±10 psig) and 1025 (±1 percent) psig. Taking the average of the high limit settings, the steam generator pressure could be as high as 1030 psia. The saturation temperature of the water in the steam generator at this pressure is 548°F. With natural circulation flow, the temperature of the cold leg water exiting the steam generator will also be about 548°F.

Based upon natural circulation cooldown calculations for Palisades and other plants, the licensee has estimated an upper limit for the core delta T as 33.8°F, resulting in a hot leg temperature of 582°F. This estimate is consistent with values that the staff expects during natural circulation. Based upon staff knowledge of natural circulation calculations, the staff concludes that it is unlikely that more than a 40°F core delta T would occur during natural circulation. At a pressure of 1463 psia the saturation temperature of water is 593°F. Thus, even using the staff's conservative assessment of core delta T, there would still be about 5°F of subcooling at the core outlet when the RCS is depressurized to the shutoff head of the tandem pump arrangement.

Therefore, the staff finds that as long as the pressure in the reactor coolant system is at or above 1463 psia and the pressurized water level is maintained within the pressurizer during the depressurization, all of the decay heat will be removed by single-phase, natural-circulation flow. The next section evaluates whether or not the pressurizer inventory can be maintained within the pressurizer while the pressurizer is cooled down to the injection point of the combined CSP and HPSI pumps.

2.2 Cooldown to Safety Injection

When Palisades is operating at power, the RCS pressure is 2100 psia. The saturation temperature of water at this pressure is 643°F. To reduce the RCS pressure down to 1463 psia, the pressure at which a combined CSP and HPSI pump could inject water into the RCS, the pressurizer has to be cooled down to about 593°F.

When the water in the RCS is cooled down, its volume decreases; thus, the water level in the pressurizer drops. Also, the Palisades Technical Specifications allow up to 10 gpm leakage from the RCS. This leakage would also decrease the pressurizer water level. If the pressurizer was to empty, the pressurizer would no longer regulate RCS pressure and the primary loop pressure would be maintained at the saturation temperature of the hottest water in the primary. Additionally, bubbles could be created in the RCS which could, if they became large enough, interrupt single-phase, natural-circulation flow.

According to the licensee's submittal (Reference 1), there is about 202,000 pounds of steel in the Palisades pressurizer. There is also about 29,000 pounds of water in it when the water is at its normal operating level. The rate at which the pressurizer cools down depends on the heat capacities of these two materials and how the heat is removed from them.

The heat in the steel is primarily taken away by radiation to the surroundings in the containment. The specific heat of steel is about 0.11 BTU/pound-°F; so to cool the pressurizer down from 643°F to 593°F, about 202,000 pound x 0.11 BTU/pound-°F x 50°F = 1,111,000 BTU's have to be removed.

The heat in the water can be taken away by removing the water from the pressurizer. Since the enthalpy of the water in the pressurizer under normal operating conditions is greater than 600 BTU/pound, more than 600 BTU/pound x 29,000 pounds = 17,400,000 BTU's can be taken away by removing the water from the pressurizer.

Thus, in the initial cooldown, much more heat can be taken away from the pressurizer by removing water than can be taken away be radiating heat to the containment. For the cooldown scenario being examined herein, when water is leaked from the RCS, the same amount is removed from the pressurizer. Thus, the cooldown rate of the pressurizer is a direct function of the RCS water leak rate; the higher the RCS water leak rate, the faster the pressurizer will initially cool down.

To perform the cooldown evaluation, the licensee wrote a computer program to calculate the pressurizer pressure versus water level. From Palisades test data, the licensee determined that the radiative heat loss rate from the pressurizer is initially 150 kw and then decreases linearly with temperature down to 100°F. In the licensee's analysis, the 150 kw heat loss rate was assumed to be not only that due to radiation but also that due to an RCS leakage rate of 10 gpm and the contraction of water in the RCS, caused by a drop of 4°F in the average water temperature. Using these assumptions, the licensee calculated that the RCS would naturally cool to 1463 psia pressure in about five hours and the water level in the pressurizer would be about 6 percent. A more conservative calculation that assumed a 125 kw initial pressurizer heat loss rate showed a longer cooldown time which resulted in a lower pressurizer water level, but the water level was still maintained on scale.

Since the initial cooldown rate of the pressurizer is primarily due to the RCS water leak rate and since the Palisades test was obtained with essentially no leak rate, the staff has concluded that the licensee's calculated cooldown time is conservatively long. Thus, the staff agrees with the licensee's conclusion that the pressurizer inventory will be maintained on scale while the RCS depressurizes to the shutoff head of the tandem pump arrangement. Therefore, natural circulation will be maintained during the initial cooldown.

From St. Lucie cooldown data and a simple hand calculation, the licensee concluded that during the first five hours after the event, the reactor vessel head will not be hotter than the pressurizer; so it will not control the RCS pressure. The staff agrees that during this time the reactor vessel head temperature will be less than the pressurizer temperature. Specifically, the staff finds that the reactor vessel head temperature will be less than 593°F at five hours after the event. Since the saturation pressure at this temperature is 1463 psia and since the combined CSP and HPSI pumps can inject water into this pressure, the staff concludes that the flashing of the upper head will not occur prior to safety injection.

2.3 Cooldown to Shutdown Cooling System Temperature

After the RCS pressure has been reduced to 1463 psia, the combined CSP and HPSI pumps will begin injecting water into the RCS and will refill the pressurizer to its normal level with relatively cool water. At this time, two Atmospheric Dump Valves (ADVs) would be operated to vent steam to cool down the reactor. Steam would also be going to the Auxiliary Feedwater (AFW) turbine to drive the pump and to the Hogging Air Ejector. The licensee's calculations show that two ADVs have sufficient steam flow rate capacity, even at low steam generator pressures, to provide a sufficient energy removal rate to cool the RCS hot leg temperature below 300°F within 62 hours of the reactor trip. The staff finds this acceptable.

2.4 Shutdown cooling

The licensee's analyses show that, when the RCS temperature is below 300°F, the Shutdown Cooling (SDC) system can reduce this temperature at the rate of 40°F/hour, which because of thermal stresses, is the maximum allowable cooling rate. At this rate the SDC system could cool the RCS temperature down to the cold shutdown condition (210°F) in 2.5 hours. However, the licensee has conservatively allowed ten hours for shutdown cooling. Thus, the staff finds that the plant can be cooled to the cold shutdown condition in less than 72 hours.

3.0 CONCLUSIONS

The staff finds that in order to provide adequate core cooling after a fire in the charging pump room or in the 590 corridor at the Palisades plant, a modification and new emergency procedures are required. The modification is to isolate from the fire area the control of the valves that are necessary to align the suction side of a HPSI pump to the discharge side of a CSP. This modification is required to prevent losing control of these valves during such a fire. New emergency procedures are required to get the discharge side of CSP P-54B aligned to the suction side of HPSI pump P-66B in this event.

The staff finds that the core can be adequately cooled by natural-circulation cooling during the extended, hot shutdown period while the RCS pressure is dropping to 1463 psia. The staff also finds that, after the above changes are completed, the core can be adequately cooled during the cooldown phase while water is being injected into the primary coolant system by the combined containment spray pump and high pressure injection pump.

With the above required modifications and procedures implemented, the staff agrees with the licensee's conclusion that the Palisades plant can be safely cooled to the cold shutdown condition in less than 72 hours after a fire in the charging pump room or in the 590 corridor.

4.0 REFERENCE

1. Letter to Director, NRR, USNRC, from K. W. Berry, Consumers Power, dated December 23, 1986