Problem Statement

It is postulated that a fire could have occurred in the service water pump room during a 21 day period when Division I gland water was manually aligned to provide flow to all four service water pumps. The incremental core damage probability due to a fire during this period is determined. A sensitivity study examines the importance of operator action to restore GW value alignment for applicable scenarios.

Assumptions

1. The initiating frequency of a fire in the service water pump room is 6.55E-03/yr, Ref. 1.
2. The probability of failure of the Halon suppression function is 5.0E-02/demand, Ref. 1.
3. The probability of an unrelated loss-of-offsite power (independent event) over a 24-hour period is estimated as 2.2E-04, similarly a 12-hour period is as 1.1E-04, Ref. 2.
4. Conditional core damage probability for loss of one, three and four SW pump motors is taken from Reference 1, as follows:
    a. Loss of one SW pump, CCDP = 2.29E-05
    b. Loss of two SW pumps, CCDP = 8.76E-04 (three pump case)
    c. Loss of three SW pumps, CCDP = 8.76E-04
    d. Loss of four SW pumps, CCDP = 9.83E-02
5. The dependency of service water pump operation on gland water flow is as follows, Ref. 4, 5:
    a. The SW function becomes inoperable with loss of GW flow (< 2 gpm) for longer than 30 minutes duration (may require LCO entry depending on extent-of-condition.)
    b. For an idle SW pump, one dry-start is allowed (un-wetted condition, no GW flow.)
    c. For a running SW pump, a loss of GW flow (< 2 gpm) does not cause pump failure.

The GW flow provides cooling and lubrication to the rubber bushings which primarily provide shaft alignment during pump start. Without GW the rubber bushings become damaged due to dry-out and shaft failure during pump restart dominates the pump failure modes. Without radial loading on the shaft, any running SW pump will continue operate during the mission time (> 24 hours) with sufficient capability to remove post-trip decay heat loads. Radial loading is limited to impeller balancing issues, since large axial down forces on the shaft act to limit shaft radial loads for a running pump. Since the rubber bushings begin to degrade after 30 minutes, the pump failure-to-start probability begins to increase with bushing wear. For example, standby pump restart would most likely fail for any LOSP events that occur after sufficient bushing damage takes place. In addition, degraded bushings would lead to higher failure rates for running pump(s) during upset conditions, such as seismic event or large submerged debris impacting the pump impeller. In no case is bearing failure expected to cause immediate pump failure for an already running pump. The overall impact of bearing (pump) degradation on the reliability of the SW function is negligible, since the effects are limited to concurrent LOSP events (combined with failure to restore) and the limited impact on running pumps (combined with the short 24-hour mission time of the SW mitigation model.)

Evaluation

The risk significance of postulated fires in the service water pump room (FHA zone 20A) is determined using the IPEEE Fire analysis as a basis [Ref. 1]. The SW room configuration includes an automatic fire detection and suppression system. Fire mitigation features include flame, smoke and heat, detection devices (with alarm in the control room) and automatic actuation of the "total flooding" Halon 1301 system. The effectiveness of the installed Halon system ensures that fire events are limited to single train of SW [Ref. 6.] There are five sequences ending in core damage following a fire in the service water pump room, refer to Attachment 1. The overall plant impact from loss of SW capability due to fire, is 8.7E-07/yr. This represents the baseline CDF for fire risk in Zone 20A. The BOP systems needed to support the main condenser are located in an adjacent compartment (FHA Zone 20B) and are not effected by the postulated fire. Therefore, both the PCS and the hard pipe vent are initially available to support decay heat removal requirements.

To evaluate the risk increase associated with Division I gland water supplying all 4 pumps, a human action to realign the gland water supply is added to the event scenario. The action is only applicable to scenarios where access is gained within the expected pump run-time without GW flow. A screening value of 0.1 is used to estimate a bounding increase to plant risk. To accurately reflect the GW dependency, all fires that previously rendered one SW loop unavailable are assumed to render both loops unavailable given no recovery. In addition, manual action credit is given only for scenarios where fire duration less than 3 minutes or fire suppression is successful. The new contribution to CDF is represented by sequences 4 and 6 of Attachment 2. The sum of these sequences is 8.1E-07/yr, which due to failure to recovery divisional GW supply to the SW pumps.

The bounding change in CDF due to increased consequences for fires originating with Division II service water is:

ΔCDF = 8.1E-07/yr

Since the condition existed for a period no longer than 21 days, the incremental core damage probability incurred due to the GW supply valve mis-alignment is:

ICDP = 8.1E-07 /yr (21 d/365d/yr) = 4.66E-07

This well below the risk significant limit of 1E-06 for temporarily degraded plant conditions.

Conclusion

The risk contribution due to gland water mis-alignment for fire events during a 21-day period was determined to be negligible.

References

1. CNS Individual Plant Examination for External Events, October 30, 1996.
2. PSA-ES045, Rev. 0, Evaluation of Compound Design Basis Events.
3. EPRI TR-1003467, NP-7413, Vertical Pump Maintenance Guide.
4. Comments Regarding Loss of GW Flow, R. Noon
5. CNS IPEEE TIER II Documentation, Fire Compartment Close-out Strategy, Scenario 20A.