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PILGRIM SAFETY ENHANCEMENT PROGRAM:
RESPONSE TO A REQUEST FOR ADDITIONAL INFORMATION (TAC #65356)

This letter provides Boston Edison Company's response to your request for additional information transmitted by your June 29, 1988 letter. The attached information supplements our February 22, 1988 response. This response pertains to the Backup Nitrogen Supply System and the Drywell Spray System, both of which are part of our Safety Enhancement Program (SEP).

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Attachment

PMK/amm/2343

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ATTACHMENT TO BECO LETTER NO. 88-131

REQUEST 1

Check valve 31-CK-167 has been identified as the containment isolation valve for the Backup Nitrogen Supply System. The use of a simple check valve is, in general, unacceptable for purposes of containment isolation. Identify any other valve(s) that could provide isolation capability for the system and details relating to the valve(s) identified including the associated piping.

RESPONSE 1

Valve AO-4356 is another valve which could provide containment isolation capability for the Backup Nitrogen Supply System.

AO-4356 is a spring loaded, fail open valve which can be closed by a remote manual control switch.

AO-4356 is powered from AC panel Y1. Panel Y1 is fed from MCC B10 which is supplied by swing bus B6. Bus B6 can be powered by either emergency diesel generator. AO-4356 is considered to have a reliable power supply.

This gate valve, check valve 31-CK-167 and the piping between these two valves are 3" stainless steel components qualified to Seismic Category I criteria. These components were replaced in 1984 as part of a valve betterment program. AO-4356 was purchased as an ASME III, Class 2 valve requiring N stamps, CMTRs, and NDE. This was a significant upgrade from the original plant design of a non-Q, bronze valve (AO-4356) and copper piping with no Seismic Category I analysis. As a part of the recent SEP Modifications, the operator for AO-4356 was replaced to provide a fail open feature. This operator is not qualified to Seismic Category I criteria.

Design Justification

The operation of the Automatic Depressurization System (ADS) valves during a design basis event (DBE), such as a LOCA, utilizes the ADS accumulators as the source of nitrogen. Check valve 31-CK-167 functions as the primary containment isolation valve during DBEs. AO-4356 is normally open and fails open. If needed, the operator can manually close AO-4356 from the remote manual control switch located in the control room.

The pneumatic supplies to AO-4356 are the normal cryogenic nitrogen tank and the backup gaseous nitrogen bottles installed as part of the SEP. If the existing nitrogen storage facility is depleted, a bank of nitrogen bottles will automatically supply drywell instrumentation. This mode of operation will continue until such time that the new liquid N_2/vaporizer trailer is available, i.e., connected to supply N_2 for torus/drywell makeup or drywell instruments. The N_2 cylinder supply is for a minimum of 12 hours which provides sufficient time to align the N_2 trailer. The N_2 trailer provides an increased onsite supply of nitrogen. Therefore, a reliable supply of nitrogen is available to AO-4356.

The Backup Nitrogen Supply System was installed as part of the SEP to provide a long term source of nitrogen since it is recognized that many of the beyond design basis events such as Station Blackout benefit from the long term availability of ADS. This requires continued dependence on external nitrogen sources. For this reason AO-4356 was designed with the fail open position to assure that an extended supply of nitrogen would be available to the ADS during a loss of AC power. The availability of a continued source of Nitrogen provides greater safety benefit than an additional automatic isolation valve.

SUMMARY

Valve AO-4356 provides additional isolation capability for the drywell instrument nitrogen containment penetration. BECo has upgraded the original design bases for Valve AO-4356 considering both design basis events and beyond design basis events consistent with the initiatives of the SEP.

Request 2

BECo reanalysis of a spectrum of MSLB accidents was performed to address the effect on the drywell response and in particular the thermal response of the drywell liner. BECo should confirm that the effect of spray nozzle modifications has similarly been considered for the relevant spectrum of accidents used for determining the equipment qualification environmental envelope. Summarize the analysis and results of the evaluation of the effects of reduced spray flow on equipment qualification.

Response 2

The drywell Main Steam Line Break equipment qualification environmental envelope was generated by analyses performed in compliance with the guidelines presented in NUREG-0588 Rev. 1. The report of this analysis (GE Report EAS-98-0887) was transmitted to the NRC by BECo in letter 88-051 dated March 15, 1988. This analysis provides temperature profiles inside the drywell for various sizes of steam line breaks (.01 ft^2 to 1.0 ft^2) suitable for equipment qualification purposes and included the effect of spray nozzle modifications. The temperature profiles were generated based on the following assumptions:

a) Loss-Of-Offsite-Power.

b) Steam line break assumed at the HPCI steam supply line resulting in a loss of HPCI.

c) Single failure assumed to be the loss of one (1) loop of RHR.

d) MSIV closure in 3 seconds after a one-half second delay.

e) 8% revaporization of heat sink condensate.

f) No steam bypass.

g) 30 minute delay for the initiation of drywell spray.

h) Drywell spray flow rate of 685 GPM.

i) Drywell spray droplet size of 1mm.

The equipment qualification temperature envelope initially reaches a peak temperature of 330°F which gradually decreases to 281°F in 30 minutes. At 30 minutes the drywell sprays are initiated, the drywell atmosphere superheat is removed and the temperature decreases to saturation at 255°F.

The GE analysis used a drywell spray flow rate of 685 GPM. The actual drywell spray flow rate is 720 GPM and is based on one loop of RHR with the containment spray modification, throttling of the suppression pool return valve, and torus sprays in operation. This is a conservative flow rate because closure of either the suppression pool return valve or the torus spray header valve will result in an increase of the drywell spray flow rate.

The analysis assumed a spray droplet size of 1mm. The actual spray droplet size is approximately 2mm. The effect of the change in droplet size on the EQ temperature profile is negligible as can be seen in response #3.

REQUEST 3

In the reanalysis of the drywell response to MSLB accidents, the revised calculation (described briefly in BECo Safety Evaluation 2133) assumed a spray droplet size of 1 mm. Discuss the basis for this assumption and describe how water impingement on drywell walls and other surfaces is accounted for in the calculation of the drywell atmosphere temperature. Discuss any differences between the revised calculation and that analysis which served as the licensing basis for Pilgrim.

Response 3

Droplet Size

General Electric generated two analyses on the drywell response to MSLB accidents. The first analysis GE Report EAS-52-0587, which formed the basis for Safety Evaluation 2133, assessed the impact of the containment spray modification on the original licensing basis (FSAR) for Pilgrim's containment spray. The purpose of the FSAR analysis was to show that containment design parameters were not exceeded. The containment spray was credited with stopping any temperature and pressure rise before limits were reached. The analysis used assumptions (e.g. no steam bypass to torus) that maximized containment parameters for drywell liner temperature. (Detailed calculation of these parameters after the spray initiation is not available for the original FSAR analysis). GE also generated report EAS-98-0387 to provide temperature profiles suitable for equipment qualification purposes that also reflected the containment spray modification. This analysis was performed in compliance with the guidelines presented in NUREG-0588 Rev. 1. Both analyses were performed with a 1 mm spray droplet size. This value was based on the manufacturer's data for operation at the maximum possible pressure drop across the nozzles. In some modes of operation, this pressure drop will be lower and the droplet size could be as great as 2 mm.

The increase in spray droplet size from 1 mm to 2 mm will not cause the maximum drywell temperature reported in the GE analyses to be exceeded. In general, droplet size can influence the spray droplet heat and mass transfer in a post-accident steam environment; larger droplet size results in faster fall velocity and shorter droplet residence time for heat removal in the drywell; larger size also reduces the total aggregate droplet surface area available for heat transfer for a fixed spray flow rate. Since the water droplet/steam interface heat transfer coefficient is only a small function of droplet diameter and fall velocity for droplet diameters in the order of 1 mm, increasing the droplet diameter would only slightly lower the heat transfer coefficient. The effect of increasing spray droplet size is a reduction in the net spray cooling rate of the drywell, and results in a longer time to quench the drywell superheat.

The impact of increasing the drywell spray droplet diameter from 1 mm to 2 mm on PNPS's containment thermal response was determined by applying a mechanistic spray heat transfer model to the spectrum of steamline break accidents reported in the PNPS FSAR. Break sizes considered ranged from 0.02 ft^2 to 0.50 ft^2. Results indicate that the 2 mm droplet size spray flow will increase the time required to remove the initial drywell superheat by less than 40 seconds (less than a 50 percent increase).

This time period is small compared to the time span of interest. Both drywell atmosphere and liner temperatures will immediately begin to drop upon activation of drywell spray for both 1 mm and 2 mm droplet sizes. Therefore, the maximum drywell temperature reported in the GE analyses will not be exceeded with 2 mm droplets.

Water Impingement

The drywell temperature analyses (both the EQ and FSAR analyses) do not explicitly account for water impingement of the drywell spray droplets on the drywell walls/internals. However, the effects of water impingement would not change the results of these analyses for peak or long-term containment temperatures, as demonstrated below.

The structures within the drywell (including containment liner, pedestal, shield wall, and other internal structures) serve as heat sinks for events that release energy to the containment. These heat sinks moderate the drywell temperature response, by absorbing some of the energy during the early part of the event (during heatup) and releasing the energy to the airspace (gas) later in the event. The effect of spray impingement on the drywell walls/internals is to change the rate at which the energy, absorbed by the structures before spray initiation, is released to the drywell airspace after spray initiation.

The initial drop in drywell gas temperature (de-superheating) with spray initiation would occur with or without droplet impingement, based on the heat removal capability of the spray as demonstrated by the FSAR analysis. The FSAR analysis uses a spray flowrate of 300 gpm compared to the actual spray flowrate which is 720 gpm. For all cases in the FSAR analysis, the drywell temperature is reduced to the saturation temperature immediately upon spray initiation (within 2 minutes). This shows that less than half of the available drywell spray flowrate is capable of reducing the drywell gas temperature. Therefore, the peak gas temperatures are unaffected by even large amounts of impingement and since peak gas temperatures to maximize drywell liner temperature was the key purpose of this analysis, there is no effect to neglecting spray impingement on the "FSAR" results.

The EQ analysis was used to develop an envelope of maximum drywell airspace temperatures throughout the transient for a range of break sizes. As was shown above for the FSAR analysis, impingement will not prevent the drywell atmosphere temperature from attaining saturation after spray initiation. It is possible, however, that extreme assumptions regarding spray flow impingement on the drywell walls/internals, such as 1) the majority of the spray impinges on the walls, and 2) the spray heats up only a small amount before impingement, may lead to somewhat higher drywell airspace temperatures for a short period after the saturation temperature is reached. This is due to the reduced direct spray cooling of the drywell atmosphere when considering impingement. However, cooling of drywell wall/internals would be enhanced by spray impingement. Therefore, the long term drywell temperature response would be expected to be lower when considering impingement. The short time period when the drywell temperature is somewhat higher would be bounded by the existing conservative EQ envelope. The envelope was generated by assuming a linear temperature decrease from the time of saturated temperature (unaffected by impingement) to a conservative temperature at 0.28 days when impingement effects are expected to result in lower air temperatures.

Therefore, considering the conservatisms in the long-term EQ analysis method and the inherent conservatisms in the enveloping of several different break size results, it is concluded that consideration of impingement will not affect the EQ envelope.

Additional Margins

Additional margin is also available in the drywell spray flowrate. The FSAR and EQ analyses used drywell spray flow rates of 300 GPM and 685 GPM respectively (with a 1mm droplet size). The actual drywell spray flow rate for operation with one RHR pump is 720 GPM with the nozzle modification, the suppression pool return valve throttled, and torus spray in operation. This is a conservative flow rate because closure of either the suppression pool return valve or the torus spray header valve will result in an increase in the drywell spray flow rate. Operation with one RHR pump supplying one loop of drywell spray and no other RHR functions will produce a drywell spra[illegible]te of 1272 GPM. Drywell spray flow rates of 300 GPM (with an approxima[illegible] mm droplet size) are sufficient to remove MSLB induced superheat in the drywell atmosphere in approximately 40 to 100 seconds depending on the break size.

Request 4

While not the sole mitigating feature in reducing the consequences of pool bypass, drywell sprays do influence the plant's response to drywell pipe breaks with pool bypass, especially in limiting the break sizes of interest. Discuss the effect of reducing drywell spray flow rates on pool bypass capability.

Response 4

A reduction in drywell spray flow rate does not impact PNPS allowable pool bypass leakage area. The allowable pool bypass for Pilgrim is presented as an allowable leakage effective flow area $A/\sqrt{K}$ in Figure 5.2-22 of the Pilgrim FSAR. The minimum allowable $A/\sqrt{K}$ from this curve has been determined conservatively without taking credit for drywell sprays. The PNPS Technical Specifications 3.7.4.b & 4.7.4.b.(4) assure that the actual pool bypass leakage is less than the allowable value. Therefore, for design basis events it is not necessary to consider drywell sprays for control of pool bypass. The major mitigating feature in reducing the consequences of pool bypass during a steam line break is the wetwell sprays which have not been modified. The wetwell sprays will condense steam located in the wetwell airspace that bypassed the pool, reducing overall containment pressure and eliminating the possibility of containment overpressure from pool bypass.

To confirm that allowable pool bypass leakage area for PNPS is not dependent on drywell spray capability, an analysis was performed for the allowable leakage. The analysis was based on a small break LOCA since the sustained flow of steam into the drywell will determine the minimum allowable leakage. The allowable leakage was determined assuming that the wetwell spray is effective in terminating the pressure increase 15 minutes after the wetwell pressure reaches 35 psig. The allowable $A/\sqrt{K}$ is that which results in wetwell pressurization from 35 psig to 60 psig in 15 minutes with flow of saturated steam through the leakage area directly into the wetwell airspace. No credit for drywell sprays or heat sinks is considered in the analysis.

The analysis results show an allowable pool bypass leakage area of 0.17 ft^2. This area is 30% larger than the maximum FSAR value of 0.13 ft^2 shown in Figure 5.2-22, demonstrating the FSAR is conservative. Since the drywell sprays were not considered in the analysis, a reduction in the drywell spray flow rate will not impact the PNPS allowable drywell bypass leakage.

Request 5

Discuss the effect of reduced drywell spray flow capacity on the capability to limit or terminate pool chugging loads.

Response 5

Drywell sprays are used during chugging events to reduce drywell pressure. The conservative chugging criterion used to determine chugging duration was the simultaneous occurrence of a pool temperature less than or equal to 135°F, drywell air/steam mass ratio less than 1%, and a vent steam flux greater than or equal to 0.2 lbm/sq. ft.-sec. The maximum chugging duration of 580 sec occurs for the 0.1 ft^2 break. For all the cases, the chugging starts when the air/steam mass drops below 1% and ends with the vent steam flux falling below 0.2 lbm/sq ft-sec. Drywell spray initiation is not a factor in establishing chugging duration, as there are no events for which chugging is terminated due to the actuation of the drywell sprays.

NEDO-21888, Revision 2, "Mark I Containment Program Load Definition Report", of November 1982 defines the chugging duration accepted by the NRC in the Mark I Containment Program. For both intermediate and small break accidents, Table 4.5 1-1 (page 4.5.1-11) of NEDO-21888 specifies a chugging duration of 900 seconds. Chugging durations with the reduced spray flowrate at Pilgrim are all below the specified value of 900 seconds and are within the original MARK I definitions.

Request 6

It is noted that Pilgrim has experienced a problem with clogging of drywell spray nozzles and that the proposed modification would dramatically reduce the number of nozzles. The revised design is inherently more vulnerable to such an issue. Therefore, it is our view that BECo should provide for additional surveillance to assure that corrective actions have been successful in addressing the problem of rusting in the spray header and potential nozzle clogging. Describe the measures that will be taken to confirm clogging of drywell spray nozzles will not impair spray operability.

Response 6

Leakage past the drywell spray isolation valves into the drywell spray headers during Residual Heat Removal (RHR) surveillances was determined to be the root cause of Pilgrim's drywell spray nozzle clogging. BECo has installed a continuous 3/4 inch drain as a permanent corrective action. This drain removes any water introduced into the drywell spray headers during surveillance testing. The drain line will be inspected for operability during the next refueling outage (RFO #8).

An additional surveillance was incorporated into Procedure 8.5.3.4, "Drywell and Torus Header and Nozzle Air Test." This procedure implements the five year air test of PNPS Technical Specification 4.5.B.1.C. Revised procedure 8.5.3.4 requires removing four spray nozzles from each drywell spray header at approximately azimuth 10°, 100°, 190° and 280°. A visual examination of each spray header will be performed with a boroscope. The acceptance criterion for this visual inspection requires that no loose rust be observed in the drywell spray headers.

NRC Inspection Report 88-13, dated May 26, 1988, documents the NRC review of these corrective steps in the close out of NRC Inspector Follow Item 87-26-01.