

6C Containment Debris Protection for ECCS Strainers

6C.1 Background

USNRC Bulletin No. 93-02, “Debris Plugging of Emergency Core Cooling Suction Strainers,” references guidance and highlights the need to adequately accommodate debris in design by focusing on an incident at the Perry Nuclear Plant. The concerns addressed by Bulletin 93-02 are reviewed and it is determined that the Lungmen NPS design is more resistant to these problems for a number of reasons as discussed in the following.

The ultimate concern raised by the Perry incident was the deleterious effect of debris in the suppression pool and how it could impact the ability to draw water from the suppression pool during an accident. The Lungmen NPS design has committed to following the guidance provided in Regulatory Guide 1.82 and additional guidance as described below. The Lungmen NPS is designed to inhibit debris generated during a loss-of-coolant-accident (LOCA) from preventing operation of the Residual Heat Removal System (RHR), Reactor Core Isolation Cooling System (RCIC) and High Pressure Core Flooder System (HPCF).

6C.2 Lungmen NPS Mitigating Features

The Lungmen NPS has substantially reduced the amount of piping in the drywell relative to earlier designs and consequently the quantity of insulation required. Furthermore, there is no equipment in the wetwell spaces that requires insulation or other fibrous materials. The Lungmen NPS design conforms with the guidance provided by the NRC for maintaining the ability for long-term recirculation cooling of the reactor and containment following a LOCA.

The Perry incident was not the result of a LOCA but rather debris entering the Suppression Pool during normal operation. The arrangement of the drywell and wetwell/wetwell airspace on a Mark III containment (Perry) is significantly different from that utilized in the Lungmen NPS design. In the Mark III containment, the areas above the suppression pool water surface (wetwell airspace) are substantially covered by grating with significant quantities of equipment installed in these areas. Access to the wetwell airspace (containment) of a Mark III is allowed during power operations. In contrast, on the Lungmen NPS the only connections to the suppression pool are 10 drywell connecting vents (DCVs), and access to the wetwell or drywell during power operations is prohibited. The DCVs will have horizontal steel plates located above the openings that will prevent any material falling in the drywell from directly entering the vertical leg of the DCVs. This arrangement is similar to that used with the Mark II connecting vent pipes. Vertically oriented trash rack construction will be installed around the periphery of the horizontal steel plate to intercept debris. The trash rack design shall allow for adequate flow from the drywell to wetwell. In order for debris to enter the DCV it would have to travel horizontally through the trash rack prior to falling into the vertical leg of the connecting vents. Thus the Lungmen NPS is resistant to the transport of debris from the drywell to the wetwell.

In the Perry incident, the insulation material acted as a sepi to filter suspended solids from the suppression pool water. The Mark I, II, and III containments have all used carbon steel in their suppression pool liners. This results in the buildup of corrosion products in the suppression pool which settle out at the bottom of the pool until they are stirred up and resuspended in the water following some event (SRV lifting). In contrast, the Lungmen NPS liner of the suppression pool is fabricated from stainless steel which significantly lowers the amount of corrosion products which can accumulate at the bottom of the pool.

Since the debris in the Perry incident was created by roughing filters on the containment cooling units a comparison of the key design features of the Lungmen NPS is necessary. In the Mark III design more than 1/2 of the containment cooling units are effectively located in the wetwell airspace. For the Lungmen NPS there are no cooling fan units in the wetwell air space. Furthermore the design of the Lungmen NPS Drywell Cooling Systems does not utilize roughing filters on the intake of the containment cooling units.

In the event that small quantities of debris enter the suppression pool, the Suppression Pool Cleanup System (SPCU) will remove the debris during normal operation. SPCU is designed to provide a continuous cleanup flow of 250 m³/h. This flow rate is sufficiently large to effectively maintain the suppression pool water at the required purity. SPCU is intended for continuous operation and the suction pressure of the pump is monitored and provides an alarm on low pressure. Early indication of any deterioration of the suppression pool water quality will be provided if significant quantities of debris were to enter the suppression pool and cause the strainer to become plugged resulting in a low suction pressure alarm.

The Lungmen NPS design also has additional features not utilized in earlier designs that could be used in the highly improbable event that all suppression pool suction strainers were to become plugged. The alternate AC (Alternating Current) independent water addition mode of RHR allows water from the Fire Protection System (FPS) to be pumped to the vessel and sprayed in the wetwell and drywell from diverse water sources to maintain cooling of the fuel and containment. The wetwell can also be vented at low pressures to assist in cooling the containment.

6C.3 RG 1.82 Improvement

All ECCS strainers will at a minimum be sized to conform with the guidance provided in Reg Guide 1.82 for the most severe of all postulated breaks.

The following clarifying assumptions will also be applied and will take precedence:

- (1) The debris generation model will utilize right angle cones acting in both directions;
- (2) The amount of insulation debris generated will be assumed to be 100% of the insulation in a distance of 3 L/D of the postulated break within the right angle cones including targeted insulation;

- (3) All of the insulation debris generated will be assumed to be transported to the suppression pool;
- (4) The debris in the suppression pool will be assumed to remain suspended until it is captured on the surface of a strainer.

The sizing of the RHR suction conforms to the guidance of Reg. Guide 1.82 [2.3.3]. The sizing is based on satisfying NPSH requirements at runout flow, plus margin, with plated piping insulation debris in the SP accumulated on the pump strainers. The sizing of the strainers is such that they will not become more than 50% plugged following 100 days of post LOCA operation.

The sizing of the RCIC and HPCF suction strainers will conform to the guidance of Reg. Guide 1.82 and will assume that the insulation debris in the suppression pool is proportionally distributed to the pump suction based on the flow rates of the systems at runout conditions. The strainers assumed available for capturing insulation debris will include 2 RHR suction strainers and a single HPCF or RCIC suction strainer.

6C.4 Discussion Summary

In summary, the Lungmen NPS design includes the necessary provisions to prevent debris from impairing the ability of RCIC, HPCF, and RHR to perform their required post-accident functions. Specifically, the Lungmen NPS does the following:

- (1) The design is resistant to the transport of debris to the suppression pool.
- (2) The suppression pool liner is stainless steel, which significantly reduces corrosion products.
- (3) SPCU will provide early indication of any potential problem.
- (4) SPCU operation will maintain suppression pool cleanliness.
- (5) The equipment installed in the drywell and wetwell minimize the potential for generation of debris.
- (6) The ECCS suction strainers meet the current regulatory requirements unlike the strainers at the incident plants.
- (7) The RHR suction strainers will apply an additional factor of 3 design margins.