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REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 1.82

SUMPS FOR EMERGENCY CORE COOLING AND CONTAINMENT SPRAY SYSTEMS

A. INTRODUCTION

General Design Criteria 35, "Emergency Core Cooling," 36, "Inspection of Emergency Core Cooling System," 37, "Testing of Emergency Core Cooling System," 38, "Containment Heat Removal," 39, "Inspection of Containment Heat Removal System," and 40, "Testing of Containment Heat Removal System," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50,"Licensing of Production and Utilization Facilities," require that a system be provided to remove the heat released to the containment following a postulated design basis accident (DBA) and that this system be designed to permit appropriate periodic inspection and testing to assure its integrity, capability, and operability. General Design Criterion 1, "Quality Standards and Records," of Appendix A to 10 CFR Part 50, requires that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed. This guide describes a method acceptable to the Regulatory staff for implementing these requirements with regard to design, fabrication, and testing of sump or suction inlet conditions for pumps in the emergency core cooling and containment spray systems. This guide applies to pressurized water reactors. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

Sumps or pump intakes serve the emergency core cooling system (ECCS) and the containment spray system (CSS) by providing for collection of reactor coolant and chemically reactive spray solution and allowing its recirculation for additional cooling and fission product removal.

For optimum use of the available coolant, the sumps should be placed at the lowest level practical. There may be numerous places within the containment structure where coolant could accumulate during containment spray application, and these areas should be provided with drains or flow paths to the sump location to minimize coolant holdup in areas away from the sumps. This guide does not address design of the drains. Because a certain amount of debris may flow toward the sump, the drains entering the sump area should terminate in such a manner that the emerging flow would not tend to impinge upon the coolant sump.

The debris resulting from a loss-of-coolant accident (LOCA) may be divided into two categories: (1) the pieces that by virtue of weight and volume will tend to float or sink slowly and (2) the heavy pieces that will drop to the floor surface. Every effort should be made to prevent either category of debris from accumulating at the sump location. Because the small drainage sump for collecting and monitoring normal leakage within the containment is separate from the coolant sump intended to serve the ECCS and CSS pumps, the floor would normally slope down toward the drainage sump. These sumps for routine building drainage should be at a slightly lower elevation than the coolant sumps so that water from minor leaks and spills can not enter the ECCS-CSS sumps. The coolant sump location should be away from the drainage sump, so that the normal floor slope would assist in preventing heavier debris from accumulating at the coolant sump. In addition, the floor around the coolant sump should slope down and away from that sump to discourage debris from collecting on part of that sump structure.

Pump intakes should be protected by screens and trash racks (coarse outer screens) of sufficient strength to resist impact loads that could be imposed by missiles that may be generated by the initial LOCA or by trash. Isolation of the coolant sump from high-energy pipe lines is an important consideration in missile protection. The screen and trash rack structures should be located above floor level to minimize the adverse effects from debris collecting on the screen structure. Redundant coolant sump screens and pump suction pipes should be separated as much as practical to reduce the possibility that a partially clogged screen or missile damage to one screen could adversely affect other pump circuits. In addition, the design of suction intakes should consider the avoidance of flow degradation by vortex formation.

It is expected that the water surface will be above the top of the screen structure after completion of the safety injection. However, the uncertainties about the extent of water coverage on the screen structure, the amount of floating debris that may accumulate, and the potential for early clogging do not favor the use of a horizontal top screen. Therefore, no credit should be taken in computation of the available surface area for any top horizontal screen, and the top of the screen structure should preferably be a solid deck.

Slowly settling debris which is small enough to pass through the trash rack openings could clog the inner screens if the coolant flow velocity is too great to permit the bulk of the debris to sink to the floor level. The inner screen should be vertically mounted to minimize settling of debris on the screen surface, and sufficient screen area should be provided to keep the coolant flow velocity at the screen approximately 6 cm/sec (0.2 ft/sec). Such a velocity will allow debris with a specific gravity of 1.05 or more to settle before reaching the screen surface.

Size of openings in the fine screens should be determined by the physical restrictions, including spray nozzles, that may exist in the systems which are supplied with coolant for the emergency sump. As a minimum, consideration should be given to building spray nozzles, coolant channel openings, and pump running clearances in sizing the fine screen. If the coolant channel openings in the core represent the smallest flow restriction, the minimum opening in the core channels which will allow design operation of the ECCS should be used in sizing the fine screen mesh size.

Consideration should also be given to partial screen blockage in sizing the fine screen in order to assure an adequate margin of conservatism on free flow area.

A significant consideration is the potential for degraded pump performance which could be caused by a number of factors, including net positive suction head (NPSH). If the NPSH available to a pump is not sufficient, cavitation may significantly reduce the capability of the system to accomplish its safety function. For the recommended design velocity at the fine inner screens considered in this guide, a negligible pressure drop is anticipated across the screens. The effect of partially blocked screens should be considered in the evaluation of the overall NPSH.

To assure the readiness and integrity of the rack and screens, access openings should be provided to permit inspection of the inside structures and pump suction inlet openings. Inservice inspection for trash racks, screens, and pump suction inlet openings should be performed on a regular basis at every refueling period downtime, and it should include visual examination for evidence of structural distress or corrosion. Inspection of the coolant sump components should be made late in the refueling program and thus help to assure the absence of construction debris in the coolant sump area. Any requirements for preoperational or periodic substantiation of adequate NPSH should be considered in the location and layout of the sump.

C. REGULATORY POSITION

Reactor building sumps which are designed to be a source of water for the emergency core cooling system (ECCS) and/or the containment spray system (CSS) following a loss-of-coolant accident (LOCA) should meet the following criteria:

1. A minimum of two sumps should be provided, each with sufficient capacity to serve one of the redundant halves of the ECCS and CSS systems.

2. The redundant sumps should be physically separated from each other and from high-energy piping systems by structural barriers, to the extent practical, to preclude damage to the sump intake filters by whipping pipes or high-velocity jets of water or steam.

3. The sumps should be located on the lowest floor elevation in the containment exclusive of the reactor vessel cavity. At a minimum, the sump intake should be protected by two screens: (1) an outer trash rack and (2) a fine inner screen. The sump screens should not be depressed below the floor elevation.

4. The floor level in the vicinity of the coolant sump location should slope gradually down away from the sump.

5. All drains from the upper regions of the reactor building should terminate in such a manner that direct streams of water, which may contain entrained debris, will not impinge on the filter assemblies.

6. A vertically mounted outer trash rack should be provided to prevent large debris from reaching the fine inner screen. The strength of the trash rack should be considered in protecting the inner screen from missiles and large debris.

7. A vertically mounted fine inner screen should be provided. The design coolant velocity at the inner screen should be approximately 6 cm/sec (0.2 ft/sec). The available surface area used in determining the design coolant velocity should be based on one-half of the free surface area of the fine inner screen to conservatively account for partial blockage. Only the vertical screens should be considered in determining available surface area.

8. A solid top deck is preferable, and the top deck should be designed to be fully submerged after a LOCA and completion of the safety injection.

9. The trash rack and screens should be designed to withstand the vibratory motion of seismic events without loss of structural integrity.

10. The size of openings in the fine screen should be based on the minimum restrictions found in systems served by the sump. The minimum restriction should take into account the overall operability of the system served.

11. Pump intake locations in the sump should be carefully considered to prevent degrading effects such as vortexing on the pump performance.

12. Materials for trash racks and screens should be selected to avoid degradation during periods of inactivity and operation and should have a low sensitivity to adverse effects such as stress-assisted corrosion that may be induced by the chemically reactive spray during LOCA conditions.

13. The trash rack and screen structure should include access openings to facilitate inspection of the structure and pump suction intake.

14. Inservice inspection requirements for coolant sump components (trash racks, screens, and pump suction inlets) should include the following:

a. Coolant sump components should be inspected during every refueling period downtime, and

b. The inspection should be a visual examination of the components for evidence of structural distress or corrosion.