The Regeneration of Environmental Qualification Test Envelope for 3-Loop Westinghouse Type NPP

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Abstract -This study is to present the re-evaluation of the EQ test curve with profile of Main Steam Line Break (MSLB) and Loss of Coolant Accident (LOCA) including small LOCA. Currently thermal lag analysis methods by NUREG-0588 are using four times condensing heat transfer coefficient on the passive heat sink surface, the forced convection heat transfer coefficient whenever the condensing is not occurring and during blow down stage. Normally thermal lag analysis method makes lower peak temperature, however, time duration on the current EQ test curve is 10 hours which is not met EQ criterion for some components. In order to solve this issue plant specific analysis was performed. The result shows that the peak temperature is higher and time duration is shorter than that of current EQ curve and it is satisfied for EQ test.

1. Introduction

Equipment that is used to perform a necessary safety function in Nuclear Power Plant (NPP) must be capable of maintaining functional operability under all service condition postulated to occur during the installed life for the time it is required. EQ is verification of equipment design by demonstrating functional capability under significant operational and environmental stresses from all service condition. This study contains a description of comparison between current EQ curve applied thermal lag analysis method and new proposed EQ test curve for Westinghouse model F steam generator(S/G) and analysis process, the results as well.

2. ANALYSIS METHOD

2.1 Thermal Lag Analysis

According to NUREG-0588, nuclear power plant where equipment qualification has been completed but only Loss-of-Coolant-Accident (LOCA) conditions were considered, it must be demonstrated that the LOCA qualification conditions exceed or are equivalent to the maximum calculated MSLB conditions by showing that the peak surface temperature of the component to be qualified does not exceed the LOCA qualification temperature by thermal lag analysis.

The Design Based Accident (DBA) of NPP creating harsh environmental conditions are principally those caused by certain postulated pipe ruptures such as MSLB within a containment structure. The temperature analyses for MSLB provide the bounding test envelope inside containment for the operability evaluation of safety equipments in harsh environmental condition. NUREG-0588 and Regulatory Guide 1.89 identify several computer codes considered by the NRC as acceptable for defining accident environmental conditions. [1, 2]

A transient thermal lag analysis can be used to predict peak equipment or internal component temperatures. Such an analysis is often useful for determining whether a given short-duration ambient temperature excursion is covered by the existing test data. The thermal analysis is governed by surface and internal heat transfer mechanisms, the equipment's physical dimensions, and thermal characteristics of materials.

Figure 1 is the EQ temperature test curve reflected thermal lag analysis method. As shown the figure 1 the peak temperature is 3000F and time duration is 10 hours.

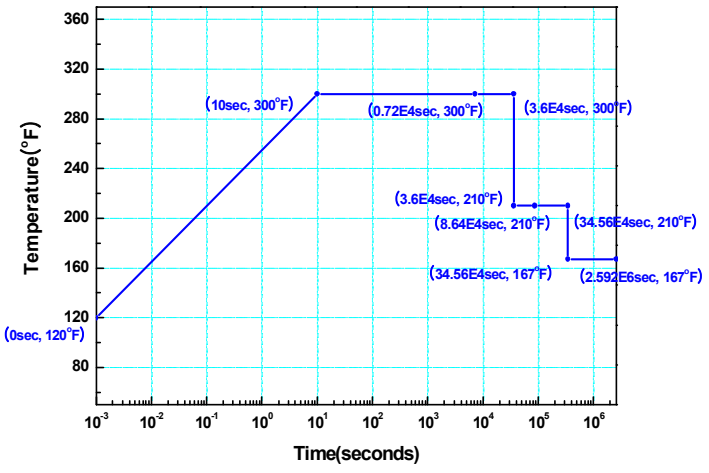

Figure 1 Current EQ test curve applied thermal lag method

2.2 Mass and Energy Release Analysis

In order to generate the Plant Specific Temperature EQ Curve, the profile of LB-LOCA, SB-LOCA and Main Steam Line Break(MSLB) should be included as mass and energy input.

The LOFTRAN model is a representation of the entire Nuclear Steam Supply System (NSSS) that

calculates the mass and energy releases [3, 4, 5]. These releases are input into either a containment integrity calculation or an EQ calculation. The LOFTRAN model requires the input of the time dependent break quality, since LOFTRAN does not have the capability to perform this calculation.

Total 8 cases of MSLB are considered in this analysis, which is identified by four power level from 0 to 102 percent power and split break spectrum, and two types of single failure such as one train failure of diesel generator (DG) or one train failure of main steam isolation valves (MSIV). Mass and energy release rates as a boundary source term for CONTEMPT code.

2.3 Containment Temperature Analysis

More realistic approach is also permitted by NUREG-0588 which provides the NRC position regarding accident analysis areas of environmental qualification of safety-related electrical equipment. When the atmosphere is superheated, a maximum of 8 percent of the condensate may be assumed to remain in the vapor region and vaporized by the superheated atmosphere. This vaporization process makes lower the containment temperature. CONTEMPT-LT028 is used for the containment pressure and temperature analysis to produce the EQ test envelope.

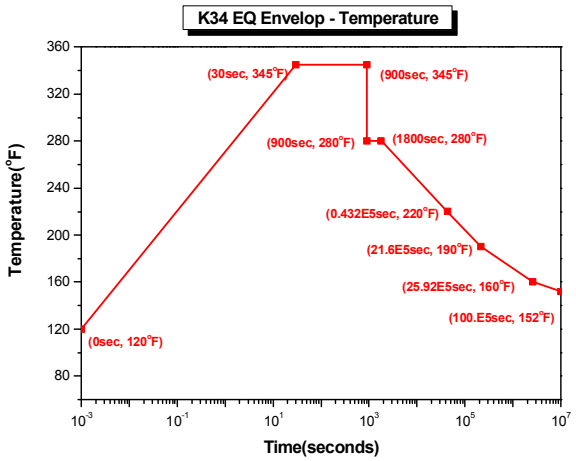

Figure 2 New proposed EQ curve based on plant specific analysis

3. Conclusions

From the thermal lag analysis, it is known that the previous test envelope determined by considering of LBLOCA is also effective on MSLB cases. However it is necessary to meet EQ criteria for some components which were violated. In conclusion, this plant specific analysis methodology can be used to provide an improved temperature profile for environmental qualification following MSLB accident and LOCA as well.

REFERENCES

[1] USNRC, Interim Staff Position on Environmental Qualification of Safety Related Electrical Equipment, NUREG-0588, Rev.I, (1981).
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[4] Westinghouse Co., LOFTRAN Base Deck, SAS 19.0 Rev 4, (1997).
[5] Westinghouse Co., WCAP-8860, Mass and Energy Releases Following a Steam line Rupture, (1976).