A Study on MSPI Performance Criteria for CCWS at UCN 3 Using a Generation Risk Assessment

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1. Introduction

Several years ago, Mitigating Systems Performance Index (MSPI)[1] was suggested and studied and now all US nuclear power plants should monitor the MSPI for 5 systems such as Aux. Feedwater system, High Pressure Safety Injection System, Component Cooling Water System(CCWS), etc.

As discussed in Ref.[2], since the Birnbaum Importance Measure(IM)[3] for CCWS of UCN 3 is below 10^{-6}, the color change from Geen to White depends on the backstop value instead of ΔCDF(e.g., 10^{-6}).

In this paper, how to set up the backstop for CCWS of UCN 3, and the relationship between the backstop and the Reliability Performance Criteria(RPC) for the Maintenance Rule(MR)[4] are discussed.

Also the meaning of the backstop and RPC values is discussed by the Generation Risk Assessment (GRA)[5] results.

2. Methods and Results

2.1 Backstop for CCWS of UCN 3

The URI for MSPI can be represented as Eq. (1)[1].

$$URI = CDF_p \sum_{j=1}^{m} \left[\frac{FV_{URcj}}{UR_{pcj}} \right]_{\max} (UR_{Bcj} - UR_{BLcj}) \qquad (1)$$

In Eq.(1),

$\frac{FV_{UR}}{UR}$ = Birnbaum IM

As discussed in Ref.[1], if the Birnbaum IM of a system is small, then the number of failures needed to produce a change in the MSPI greater than 10^{-6} is large. Since the Birnbaum IM for the CCWS of UCN 3 is below 10^{-6} [2], even though many failures occur in the system, the MSPI falls short of the White performance band threshold.

The correlation of the backstop with the expected number of failures in a system is given as below[1]:

$$y = 4.65x + 4.2 \qquad (2)$$

where x = the expected number of failures in 3 years

y = backstop

Since the estimated failures of CCWS pumps could be 0.2688[6], the backstop is 6 from Eq.(2).

2.2 RPC for CCWS of UCN 3

The RPC for CCWS of UCN 3 is derived as one(1) in Ref.[6-7]. In Ref.[6], the criteria that the false alarm rate should be below 10% is applied.

2.3 GRA for CCWS of UCN 3

The possible generation loss of CCWS during a power operation is 0.366 EFPH/yr (where, EFPH= Effective Full Power Hours)[8]. Thus,

Generation Loss of CCWS = 0.366 EFPH/yr

= 0.366 EFPH/yr x 950Mwh÷12x 20$/Mwh

= $580/month

That is, if the current failure rate of the CCWS equipment is maintained, then the expected generation loss is $580/month.

Since the Risk Achievement Worths(RAWs) of the CCWS pump 01A basic events are calculated as shown in Table 1, the component RAW of CCWS pump 01A is calculated as 4.624 by using the 'Balanced Method'[9].

Table 1. Basic Events for CCWS Pump 01A

Event Name	Probability	FV	RAW
CCMPKALLQ	**7.41E-07**	**1.45E-03**	**1.96E+03**
CCMPR001PA	**5.26E-05**	**8.99E-04**	**6.44**
CCMPS001PA	**6.37E-04**	**1.55E-04**	**1.24**

Thus, if 5 failures of CCWS pump 01A occur before reaching the backstop 6 for CCWS, then

The Cumulative Expected Generation Loss caused by the failed CCWS pump01A
= $580/month x 5 times x 4.624
= $13,410/month

Decision maker may reduce the backstop by considering the Expected Generation Loss.

3. Conclusions

Both MSPI and RPC for the MR are monitoring the reliability trend of a system. However, MSPI has a characteristic to compare the trend with the industry mean value while RPC for the MR does not. Thus, the fact that the backstop(~6) for CCWS of UCN 3 is larger than RPC(~1) means that the reliabilities of the CCWS pumps of UCN 3 are very good by comparing them with the US industry mean.

If CCWS of UCN 3 is monitored by the RPC(~1), it looks as though it is internally controlled by backstop 2, which means that people can accept a Generation Loss of $2682/month (=$580/month x 1 x 4.624).

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