

A Study on Sign Test Procedure in MARSSIM Used to Site Release of Haddam Neck Nuclear Power Plant

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1. Introduction

In order for the nuclear power plant to ultimately be released after the completion of dismantling work, licensee must demonstrate that the level of residual radioactivity at the site meets the criteria for site release. This demonstration can be carried out by MARSSIM (Multi-Agency Radiation Survey and Site Investigation Manual) (NUREG-1575). According to the site condition, MARSSIM proposes WRS test and Sign test as the methods to confirm whether residual radioactivity concentration level at the site satisfies DCGL (Derived Concentration Guideline Level), which is a measurable value corresponding to the site release criteria. This paper describes Sign test process of the US Haddam Neck Nuclear Power Plant (HNP), which completed the site release by performing Sign test.

2. Purpose of the Sign test

The Sign test is a non-parametric statistical test used where concerned radionuclides are not at the site. Through the equation of the Sign test, the required number of sample measurements for the survey unit, which is a physical area configured to the specified size, is obtained and the concentrations of the samples are compared with DCGL to determine whether the residual radioactivity of the site meets the site release criteria.

3. Methods

The survey unit measurements N can be obtained as shown in Equation (1) below.

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(\text{Sign}p - 0.5)^2} \quad (1)$$

$Z_{1-\alpha}$ and $Z_{1-\beta}$ are percentiles represented by the selected decision error levels, α and β respectively (see NUREG-1575 Table 5.2), where α is the

probability of incorrectly permitting releasing a survey unit and β is the probability of incorrectly failing to release a survey unit. Sign p is the estimated probability that a random measurement from the survey unit will be less than the DCGL when the survey unit median is actually at the LBGR (see NUREG-1575 Table 5.4), where LBGR (Lower Bound of the Gray Region) is a site-specific parameter and Initially selected to equal one half the DCGL.

The spacing, L between samples can be obtained by applying the area A and the number of samples N into the following equation (2).

$$L = \sqrt{\frac{A}{0.866N}} \quad (2)$$

The main steps of the Sign test can be listed [1]: (1) List the survey unit measurements, X_i , $i = 1, 2, 3 \dots, N$. (2) Subtract each measurement, X_i , from the DCGL to obtain the differences: $D_i = \text{DCGL} - X_i$. (For multiple nuclides, DCGL is set to 1 by unity rule and the measurements of the survey unit are replaced by weighted sums, WS) (3) Discard each difference that is exactly zero and reduce the sample size, N , by the number of such zero measurements. (4) Count the number of positive differences. The result is the test statistic S^+ . (5) Large values of S^+ indicate that the survey unit does not exceed the release criterion. The value of S^+ is compared to the critical values (see NUREG-1575 Table I.3). If S^+ is greater than the critical value, k , in that table, the survey unit is released.

4. Result & Conclusion

The Sign test was applied to survey unit 9312-0002 (Southwest 115kV Switchyard, 1,486 m²), which was found to be highly polluted in HNP

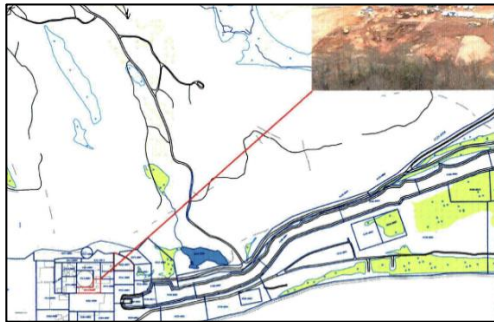


Fig. 1. The location of 9312-0003 in HNP.

Cs-137, Co-60 and Sr-90 were selected as the concerned radionuclides in the HNP site through the Historical Site Assessment [2]. These were considered to be able to exceed the site release criteria through preliminary investigation and the required number of samples for the survey unit was determined in order to confirm the availability of site release.

The value of Sign P is 0.977250 and the percentiles $Z_{1-\alpha}$ and $Z_{1-\beta}$ corresponding to the site-specific decision errors α and β of 0.05 of HNP are found to be 1.645. The number of 15 required soil samples, which are rounded values increased by 12 to 20%, were calculated, because of uncertainties such as missing samples expected to occur in the survey unit. In addition, the site history and characteristics survey data were reviewed, and three samples were further collected by judgment.

The sample spacing L was 10.73 m by applying the survey unit area, A 1,486 m² and the number of sample, N 18. The location of the 15 samples was specified using AutoCAD-LT software, and the location of 3 samples by judgment were specified based on the results of the previous survey.

The locations of 18 samples in 9312-0003 are shown in Fig. 2 below.

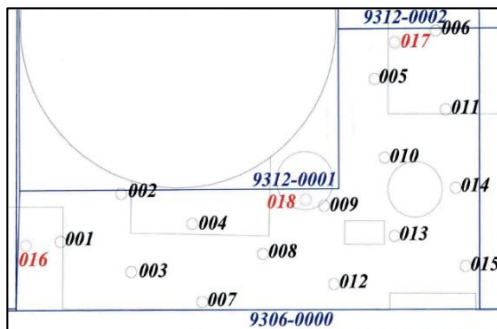


Fig. 2. The location of the samples in 9312-0003.

As a result of the analysis, Cs-137, Co-60 and Sr-90 were not identified in the three judgement samples and the Sign test results for 15 samples are shown in the following table.

Table 1. Sign test result for 9312-0003

Nuclide	CS-137	Co-60	Sr-90		
DCGL	4.75E+00	4.75E+00	9.30E-0.1		
CS-137 (pCi/g)	Co-60 (pCi/g)	Sr-90 (pCi/g)	Ws	1-Ws	Sign
-6.38E-02	6.35E-03	-1.38E-02	-0.03	1.03	+1
-1.90E-03	6.19E-03	-2.55E-03	0.00	1.00	+1
-1.28E-02	1.83E-03	1.20E-02	0.01	0.99	+1
1.19E-02	-2.21E-02	1.91E-02	0.01	0.99	+1
-9.37E-03	1.78E-02	3.25E-03	0.01	0.99	+1
-3.58E-03	-2.86E-03	-1.19E-02	-0.01	1.01	+1
-1.38E-02	1.06E-02	3.65E-02	0.04	0.96	+1
2.25E-02	-7.12E-03	-1.60E-03	0.00	1.00	+1
-8.06E-04	4.92E-03	1.08E-03	0.00	1.00	+1
1.21E-02	1.60E-02	4.06E-03	0.01	0.99	+1
-3.38E-02	-4.28E-03	1.54E-02	0.01	0.99	+1
-6.57E-02	-1.55E-02	1.98E-03	-0.02	1.02	+1
-6.68E-02	1.09E-02	-5.04E-04	-0.01	1.01	+1
-5.37E-02	4.24E-03	-8.62E-03	-0.02	1.02	+1
-3.55E-02	-2.82E-03	-2.50E-03	-0.01	1.01	+1
The number of positive differences (S+)					15
Critical Value : 11			Survey Unit : Meets Release Criterion		

As a result of the Sign test for 9312-0003, the number of difference (S+) in the amount between DCGL 1 and the weighted sum of the measurements is 15 and this is larger than the critical value 11. Therefore, 9312-0003 has been found to meet the release criteria.

REFERENCES

- [1] NRC, "Multi Agency Radiation Survey and Site Investigation Manual (MARSSIM) Revision 1", NUREG-1575, 2000.
- [2] Connecticut Yankee Atomic Power Company, "Final Status Survey Final Report Phase VII", Haddam, 2006.