A Study on the Improvement of RCS Leak Rate Calculation Program

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1. Introduction

The on-line computer program calculating the reactor coolant system (RCS) leak rate has been used for YGN 3&4 and UCN 3&4 in Korea since 1994 and 1997, respectively. However this program using a snapshot approach [1] is able to calculate the RCS leak rate at the very stable condition only (i.e., normal power operation within 0.2 % of power variation) even with a large uncertainty, and its fluctuating calculation results could not be relied on sometimes. For resolving these problems and better use, it is necessary to improve the computer program calculating the RCS leak rate by applying the new algorithm to produce the reliable calculation results, by adding the function of on-line monitoring with graphic display, and by providing the useful feature for the operator, which is believed to enhance the safety of the plant.

2. Contents and Scope

This study improves the calculation program by adopting the new algorithm using the linear regression approach, which is a widely accepted statistical method of developing a straight-line equation for correlated data points [2]. The information for the RCS leakage is displayed on the screen with a graphical trend.

The operational conditions to which this program is applicable include the make-up, draining, and power maneuvering as well as full power operation, and even for the safety injection operation this program works. Additionally calculation time interval is changed from only one hour to various time intervals (i.e., 10 min, 30 min, 1 hour, 2 hour) for operator's convenience.

3. Results and Conclusions

The computer simulation results show that the leak rates calculated by the improved computer program using a linear regression approach are far more reliable than those by the previous program using a snapshot method, and the reasonable scanning time for UCN 3&4 is 10 seconds. Table 1 shows the effect of key input parameter values on RCS leak volume. Table 2 [3] and Table 3 show the leak rate uncertainties during normal power operation and power decrease with different calculation time intervals respectively. Figure1 and Figure 2 show the calculated leak rates with snapshot and linear regression methods during normal power operation and power decrease respectively. The leak rate comparison with different time intervals during normal power operation is given in Figure 3. The figures show that the linear regression calculation has enhanced the leak rate accuracy in comparison with snapshot calculation.

With a limited capacity of the plant computer system for UCN 3&4, it was not easy to develop a program with a lot of memory and a fancy display. However the improved program can be used diversely for monitoring and measuring the RCS leak rate with higher accuracy during normal power operation and limited transient conditions. The application of this program to other plants may need some modification in consideration of the capability of each computer system, but the basic principle of the program and the algorithm is applicable to all pressurized water reactors.

Acknowledgement

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References

[1] USNRC,NUREG-1107,ReactorCoolantSystemLeakRateDeterminationforPWRs,Dec.,1984.

[2] CraigT.OlsenandMyraS.MaCarthy,"LinearRegressionLeakRateCalculationHelpsAvoidPrematureShutdown", PowerEngineering,Dec.,1994.

[3] KHNP,TechnicalSpecificationsforUlchinNuclearPowerPlantUnits3and4,Jul.,2004.

Table 1. Effect of key input parameter values on RCS leak volume change.

Input Parameters	Max - Min Value (Conversed Volume Change , gallon)		
	*No. of data =1	No. of data =10	No. of data =20
PZR Level(%)	0.100 (13.367)	0.011 (1.497)	0.005 (0.668)
VCT Level(%)	0.014 (0.549)	0.003 (0.101)	0.001 (0.077)
RDT Level(%)	0.014 (0.763)	0.001 (0.073)	0.001 (0.039)
EDT Level(%)	0.012 (1.376)	0.001 (0.137)	0.001 (0.068)
PZR Pressure (kg/cm^2)	0.070 (3.713)	0.0090(0.303)	0.005 (0.152)
RCS Temp.(□)	0.090(22.645)	0.031 (7.798)	0.013(3.525)

* No. of data is the number of input data used to obtain the averaged value.

Table 2. Leak rate uncertainty with different calculation time interval (normal power operation of UCN 3).

Calc. Time Interval	Uncertainty of Unidentified Leakrate (gpm)	Remark
10 min	± 1.50	For Reference
30 min	± 0.35	For Reference
60 min	± 0.10	For Reference
120 min	± 0.05	Use For SR in Tech Spec

Table 3. Leak rate uncertainty with different calculation time interval (power decrease of UCN 3).

Calc. Time Interval	Uncertainty of Unidentified Leakrate (gpm)	Remark
10 min	± 1.50	For Reference
30 min	± 0.50	For Reference
60 min	± 0.35	For Reference
120 min	± 0.20	For reference

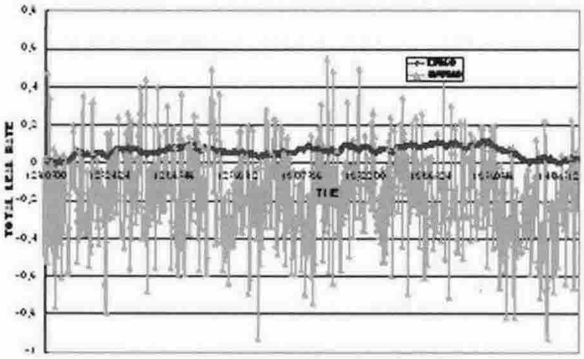

Figure 1. Leak rate comparison with 'snapshot ' (SNT060) vs 'linear regression' (LT060) method (during normal power operation /60min).

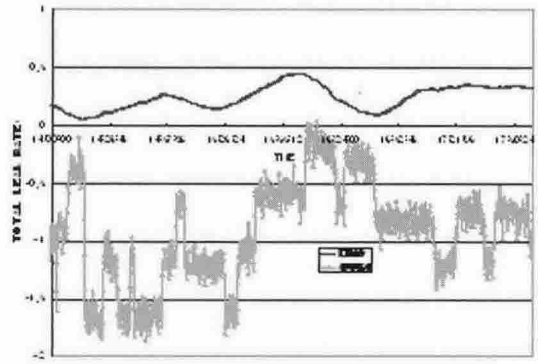

Figure 2. Leak rate comparison with 'snapshot' (SNT060) vs 'linear regression' (LT060) method (during power dcrease/60min).

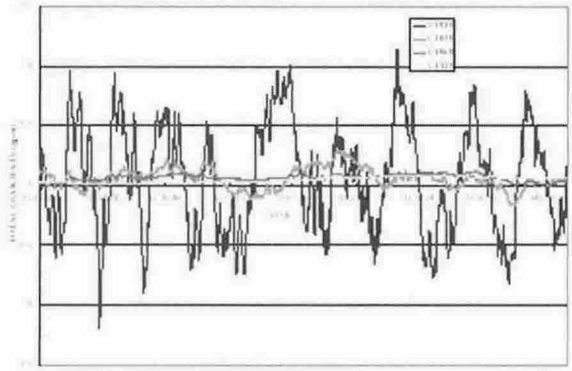

Figure 3. Leak rate comparison with different calculation time interval during normal power operation (calculation time interval=10,30,60,120min/scanning time=10 seconds).