REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**222-8203**
SRP Section:	**11.05 – Process and Effluent Radiological Monitoring Instrumentation and Sampling Systems**
Application Section:	**11.5**
Date of RAI Issued:	**09/23/2015**

Question No. 11.05-3

Because the reactor coolant system (RCS) is a safety-related system, steam generator (SG) tube integrity is a safety-related issue. 10 CFR 52.47(b)(1) requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, that a plant that incorporates the design certification is built and will operate in accordance with the design certification and the provisions of the Atomic Energy Act, and NRC regulations. The applicant has not provided adequate Tier 1 ITAAC information to verify the compliance with the design criteria.

The ITAAC should address the sensitivity, response time, and alarm limit for the SG Tube leakage detection instrumentation. The staff requests the applicant to provide ITAAC for this system in the DCD Tier 1.

Please address this item and provide a markup for the proposed DCD changes.

Response - (Rev. 2)

Please see the response to RAI No.116-8054, Question No. 14.03.08-5 for information on the SG tube leakage detection instrumentation.

The APR1400 design provides for the monitoring of radioactive releases from the MSSV and MSADV during SGTR using the Main Steam Line Effluent Detectors, which is an additional function of RE-217 ~ RE-220.

TS

This is required by RG 1.97 Rev.3 and the RMS purchase specifications require the supplier comply with this requirement. Please refer to DCD Tier 2, Subsection 11.5.2.2.5.m and Figure 11.5-3C.

Concerning the request for the sensitivity, response time and the alarm limit, please note that the SG tube leak detectors are not for the DBA. Therefore, the information is in general not included in the ITAAC tabulation.

DCD Tier 2 Appendix 11B will be revised to provide more detail.

In addition, the applicant will revise the Table 11B-1 and 11B-2 of Appendix 11B to add footnotes for some parameters.

Impact on DCD

DCD Tier 2 Subsection 11.5.2.2.5.m, Figures 11.5-2K, 11.5-2L, 11.5-2M, 11.5-2BB and Appendix 11B will be updated. Figure 11.5-3C will be added.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

i. Gaseous radwaste system exhaust monitor (RE-080)

A monitor with gas channels is provided to monitor the radiation level of gaseous radwaste system exhaust to the compound building vent stack.

j. Compound building HVAC effluent monitor (RE-082)

One monitor with air particulate and iodine sampler is provided to monitor compound building HVAC effluent.

k. Compound building exhaust ACU inlet monitor (RE-083)

A monitor with air particulate, iodine, and gas channels is provided to monitor the compound building plant area.

l. Compound building hot machine shop monitor (RE-084)

Replaced with "A"

One monitor with air particulate, iodine, and gas channels is provided to monitor the compound building hot machine shop.

~~m. Main steam line area and N-16 radiation monitors (RE-217, 218, 219, and 220)~~

~~These monitors are located near the main steam safety valves and main steam atmospheric dump valves. Alarms are provided in the MCR to alert the operator when these monitors detect the PTS leakage due to a steam generator leakage. The method of detecting the SG leak rate is described in Appendix 11B.~~

The RMS for the release point in the high-energy line break (HELB) area, auxiliary building, and compound building is described in Subsection 9.4.

11.5.2.3 Liquid PERMSS

Each liquid process and effluent monitor is described in the following paragraphs. A list of each monitor and associated parameters is given in Table 11.5-2.

A(1/2)

m. Main steam line effluent and N-16 radiation monitors (RE-217, 218, 219, and 220)

Main steam line effluent monitors detect the radioactive effluent discharge to the environment through main steam safety valve (MSSV), main steam atmospheric dump valve (MSADV), and auxiliary feedwater pump turbine exhaust. The monitor performs the function required by NRC RG 1.97. The monitor also serves to quickly detect gaseous N-16 that exists in a leak from the primary to the secondary steam line. Depending on the gaseous PERMSS supplier, the two detectors (main steam line effluent and N-16) are assembled as one unit or could be enclosed in two separate units adjacent to each other.

One monitor on each of the four main steam lines is provided in the main steam line support structure. The monitors are placed as close as possible to the pipe as shown in Figure 11.5-3C, upstream of the main steam atmospheric dump valves and main steam safety valves.

APR1400 has four main steam lines and each line has one MSADV and five MSSVs. The steam line size is 31 inches O.D. pipe (wall thickness: 1.1 inch) and pipe material is carbon steel. The main steam line effluent monitor detects effluent releases and assesses amount of releases per NUREG-0737 and NRC RG 1.97. The measured variables are defined by NRC RG 1.97 as Type E. The required minimum range is $2.7 \times 10^{-9} \sim 2.7 \times 10^{-3}$ μCi/cc with the duration of releases expressed in seconds and mass of steam releases per unit time. The monitors are capable of providing approximate linear response to gamma radiation photons with energies from approximately 0.5 to 3 Mev. Effluent concentrations are expressed in terms of gamma emitting noble gases nuclide within the specified energy range.

A(2/2)

Calculation software estimates concurrent releases of lower energy noble gases that cannot be detected or measured by the methods or techniques employed. The monitor is an on-line type without actually drawing steam samples but satisfies the volumetric measurement requirements specified in the NRC RG 1.97. The calculation accurately estimates the amount of effluent releases using the measurement of the monitor plus open/close status of MSADVs and MSSVs as well as AFWP running status. The calculation is performed based on the following:

a) The time period that the safety relief valves are open and valve flow capacity. The valve flow capacity is provided as a constant value.

b) The time period that the atmospheric dump valves are open and valve flow capacity. The valve flow capacity is provided as constant value.

c) Fixed steam flow value for AFWP turbine for the duration of turbine operation.

The calculation is initiated upon detection of high radiation in the steam line and either:

a) Any valve out of 1 ADV and 5 MSSVs is open and/or,

b) AFWP turbine is running.

The monitors provide indication and alarm to the MCR, RSR, and local RMS skid.

The monitors are located in Auxiliary Building as shown in Figure 11.5-2L (RE-217), Figure 11.5-2K (RE-218), Figure 11.5-2BB (RE-219), and Figure 11.5-2M (RE-220).

The method of detecting the SG leak rate is described in Appendix 11B.

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 11.5-2K Location of Radiation Monitors at Plant (Auxiliary Building El. 137′-6″)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 11.5-2L Location of Radiation Monitors at Plant (Auxiliary Building El. 137′-6″)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 11.5-2M   Location of Radiation Monitors at Plant (Auxiliary Building El. 137′-6″)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 11.5-2BB Location of Radiation Monitors at Plant (Auxiliary Building El. 137′-6″)

Added

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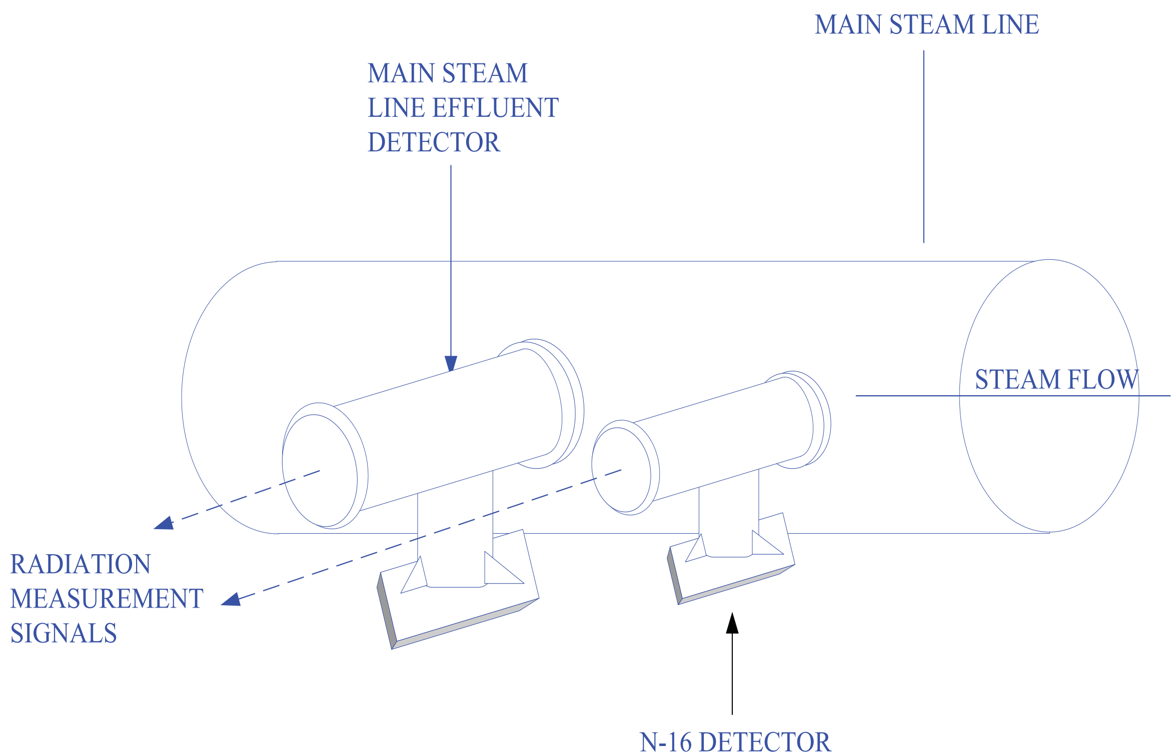

Notes:

1. The main steam line (MSL) effluent monitor detects the radioactive effluent discharge through MSSV's, MSADV and AUX feedwater pump exhaust. This detector performs the function required by NRC RG 1.97.

2. The N-16 detector senses the SG tube leak.

3. Depending on the supplier, the two detectors (MSL and N-16) is assembled as one unit or the two are mounted as two separate but adjacent unit as shown above.

Figure 11.5-3C Monitor Assembly for Main Steam Line Effluent + N-16 Detectors

Added

g. The N-16 monitors are assumed to be installed at 0.61 m (2 ft) away from the containment wall.

The count rate of the N-16 monitor is determined using the following equation:

$$\text{Count rate} = A_V \cdot k$$

Where:

count rate = detector count rate in count per second (cps)

k = detection efficiency in (cps)/(Bq/cm^3), which represents the conversion factor between the detector count rate in cps and the N-16 concentration in Bq/cm^3

A_v = N-16 concentration in Bq/cm^3 corresponding to an SG leak rate

Parameter k is dependent on the configuration of the detection such as thickness of the pipe, types of material in the pipe and insulation, and distance between the probe and the pipe. The value A_v is determined as follows:

$$A_V = 0.2778 \frac{L \cdot A_p}{Q_p \cdot A_s} \exp\left(-\lambda t\right)$$

Where:

0.2778 = unit conversion factor. (cm^3/sec) / (L/hr)

L = SG leakage rate, L/hr

A_P = N-16 activity concentration at the leakage location, which is proportional to the core power, Bq/cm^3

Q_P = ~~steaming rate for a corresponding power level, which is the flow rate of the steam in the secondary loop~~ steam flow rate in the secondary loop, cm/sec

A_S = ~~surface area of main steam line~~ cross-sectional area of main steam line, cm^2

λ = decay constant of N-16, sec^{-1} (=0.097 sec^{-1})

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t = transit time ($t = t_1+t_2$) of N-16 from the leakage location to the N-16 detector, sec.

t_1 = transit time between the leak location and the SG outlet nozzle in the SG

t_2 = transit time from the SG outlet to detector

N-16 activity concentrations at the detector location calculated at a leak rate of 4.73 L/hr (30 gpd) with varying power levels are given in Table 11B-1 and Figure 11B-1. According to the calculation, the SG leakage rate of 4.73 L/hr (30 gal/day) can be detected within the N-16 concentrations range from 3.68 x 10^{-4} Bq/cm^3 (10% power) to 1.68 x 10^{-1} Bq/cm^3 (100% power). Figure 11B-2 presents the N-16 concentration in the main steam line as a function of SG leakage rate for different power levels. For the SG leakage rate of 23.66 L/hr (150 gal/day), which is the limiting condition of operation in the Technical Specifications, the N-16 concentrations range from 1.84 x 10^{-3} Bq/cm^3 (10 % power) to 8.38 x 10^{-1} Bq/cm^3 (100 % power).

Therefore, the N-16 detector, which is capable of monitoring N-16 concentrations from 1.0×10^{-4} to 1.0×10^{2} Bq/cm^3, satisfies the minimum SG leakage rate of 4.73 L/hr (30 gal/day) as well as the Technical Specification limit of 23.66 L/hr (150 gal/day).

All the parameters are presented in Table 11B-1.

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Replace this Table with next pages.

Table 11B-1

N-16 Concentrations with Power Level at SG Leakage of 4.73 L/hr (30 gal/day)

Percent Power	N-16 Activity at Leakage Location, A_P (Bq/cm^3)	Steaming Rate, Q_P (cm/sec)	Surface Area of Main Steam Line, A_S (cm^2)	Transit Time, t (sec)	N-16 Activity at Detector Location, A_V (Bq/cm^3)
100	4.04E+06	3,784.397	4,146.694	7.24	1.68E-01
80	3.23E+06	2,905.354	4,146.694	9.07	1.46E-01
60	2.42E+06	2,057.705	4,146.694	12.19	1.14E-01
40	1.62E+06	1,291.133	4,146.694	18.22	6.79E-02
20	8.08E+05	585.8256	4,146.694	36.35	1.29E-02
10	4.04E+05	266.3952	4,146.694	73.96	3.68E-04

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Table 11B-1

Parameters Used to Determine N-16 Concentration at Detector Location

Design data for the Main Steam Line	
Nominal Diameter [in]	30.91
Nominal Wall Thickness [in]	1.15
Inside Radius [in]	14.30
Distance from the SG outlet nozzle to the containment [in]	1,261.56
Distance from the containment to the N-16 monitor [in]	24

Transit time (t_1) between leak location and the SG outlet nozzle in the SG (sec)			
Power Level (%)	Steam Flow per SG [1)] (10^6 lb/hr)	Weight of steam [1)] (lb)	Transit time t_1 (sec)
100	8.978	15,908.85	6.38
80	6.984	15,417.13	7.95
60	5.033	14,819.70	10.60
40	3.199	13,940.67	15.69
20	1.464	12,515.97	30.78
10	0.671	11,499.49	61.70

1) Design data from typical APR1400

Transit time (t2) from SG outlet to detector (sec)					
Power Level (%)	Steam flow per MS Line A (10^6 lb/hr)	Density of steam [1)] B (lb/ft^3)	Cross-sectional area A_s (cm^2)	Steam flow rate Q_p [2)] (cm/sec)	Transit time t_2 (sec)
100	4.4890	2.25	4,146.694	3,784.397	0.86
80	3.4920	2.28	4,146.694	2,905.354	1.12
60	2.5165	2.32	4,146.694	2,057.705	1.59
40	1.5995	2.35	4,146.694	1,291.133	2.53
20	0.7320	2.37	4,146.694	585.8256	5.57
10	0.3355	2.39	4,146.694	266.3952	12.26

1) Design data from typical APR1400

2) $Q_p = A/B/A_S \times 7.87$ cm^3/s/ft^3/hr

Table 11B-2

N-16 Concentrations with Power Level at SG Leakage of 4.73 L/hr (30 gal/day)

Power Level (%)	N-16 Activity at Leakage Location, A_P [1)] (Bq/cm^3)	N-16 Activity at Detector Location, A_V (Bq/cm^3)
100	4.04E+06	1.68E-01
80	3.23E+06	1.46E-01
60	2.42E+06	1.14E-01
40	1.62E+06	6.79E-02
20	8.08E+05	1.29E-02
10	4.04E+05	3.68E-04

1) A_p at 100% power level is derived from N-16 activity 5.68E+06 Bq/g (DCD Table 12.2-7) multiplying by the water density of 0.711 g/cm^3.