A Method of Quantifying Noble Gas Releases

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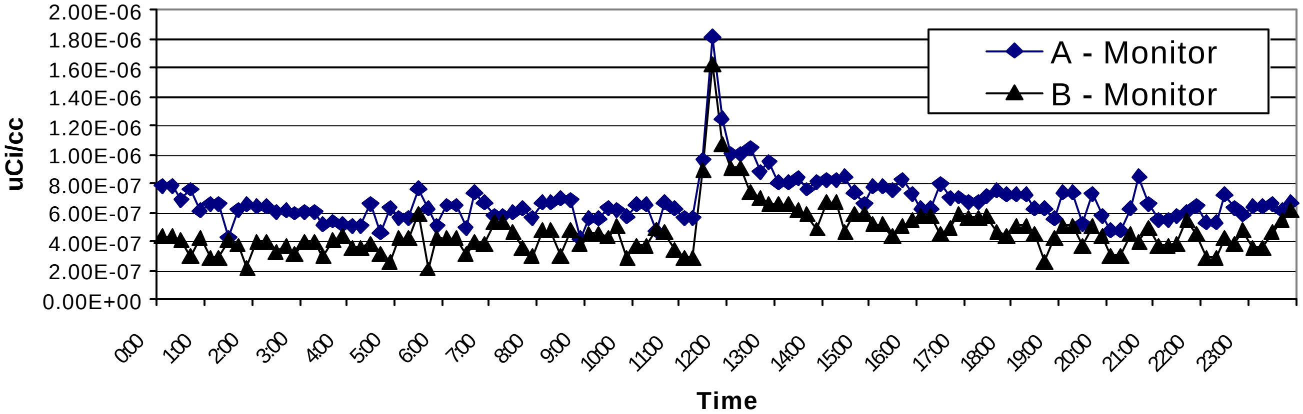
The Plant Technical Specifications through the ODCM require monitoring of the ventilation systems for radioactive gases, using a combination of plant radioactive gaseous effluent monitors and periodic grab sampling. The Radiation Monitoring Display System (RMDS) at Limerick is used to monitor gaseous radioactive effluent releases from various plant areas. The ODCM requires that the effluent radiation monitors have a sensitivity of 1 E-06 uCi/cc (based on Xe-133). General Atomic, the manufacturer of the radiation monitoring system has indicated that the lower limit of detection for the instrumentation is in the E-07 uCi/cc range. Routine RMDS activity levels range from 2 to 8 E-07 uCi/cc. The RMDS is designed to alert plant operators, when abnormal levels of radiation are present in the ventilation system. In addition, the results from the noble gas grab sampling and the RMDS are compiled and reported in the Annual Radioactive Effluent Release Report. Data from this report are used by both ANI and INPO. ANI uses the data in the Engineering Rating Factor that is used in determining Limerick's nuclear liability insurance rates. And INPO uses the data to determine a station's ranking related to curies released.

In 1997 through 1998 the RMDS experienced a severe computer failure. Although the system continued to function, data was not stored for more than a one-hour period. The data was then overwritten with new data. Consequently, the station relied upon the noble gas grab samples as the method for quantification of noble gas releases from the station. Based upon the monthly noble gas grab sampling, the station reported zero noble gas released in these two years. However, during a routine NRC inspection, a violation was issued for failure to maintain records of effluent releases. The violation was given, because Limerick failed to take the necessary steps to record and quantify the effluent releases from the effluent radiation monitors. In addition, the inspector expressed his philosophy that Nuclear Power Plants are not zero gaseous release plants. Nuclear plants are always releasing activity even if it is not detected in the noble gas grab sample. From the inspector’s perspective, if an intervener had you on the witness stand would you say that your station released zero noble gas activity as reported in the annual radioactive effluent release report? Reviewing Figure 1 below shows what appears to be a release that occurred during a one-hour period? Although the noble gas grab sample showed no activity for the month would you conclude that no release occurred? How would you quantify it? It is unlikely that one could react fast enough to take a gas grab sample to quantify the release.

Figure 1
Gaseous Effluent Radiation Monitor Response for the North Stack on 4/23/03



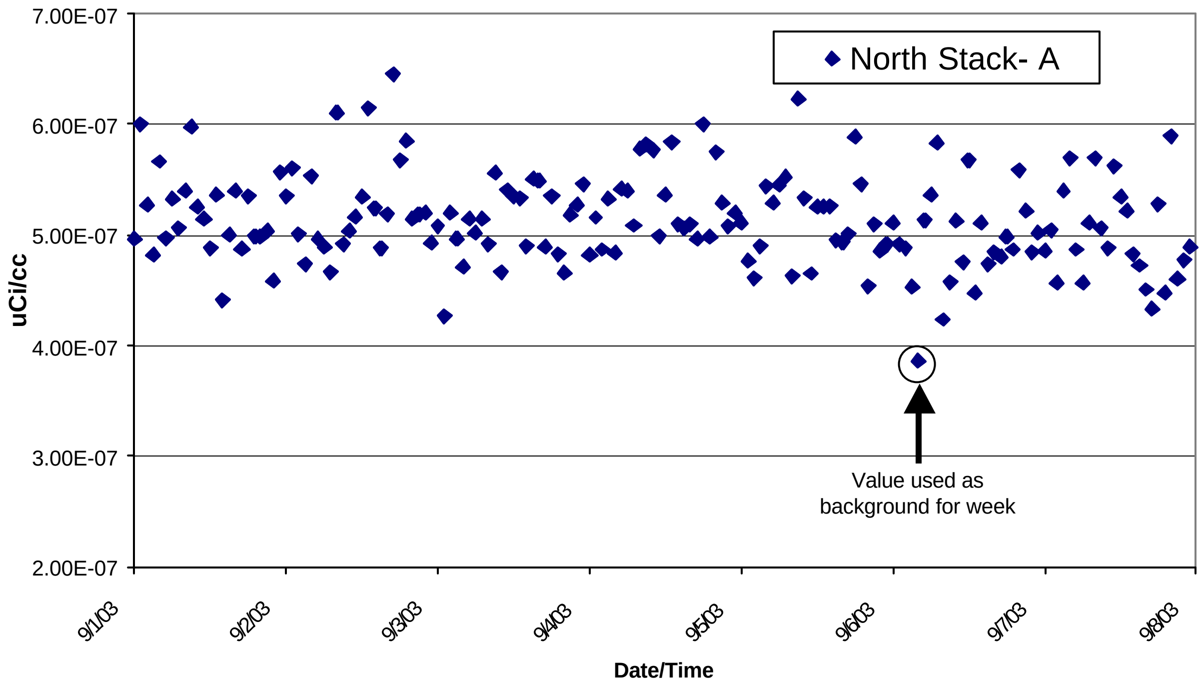
I have concluded that the noble gas grab sample is a qualitative analysis. That is it determines what the nuclide mixture is that is applied to the RMDS quantitative analysis to determine the quantity released.

Historically, the noble gas grab sampling of the plant ventilation system has shown gaseous radioactivity values below the minimum detectable activity (MDA) for the analysis and detection method. In the absence of the qualitative nuclide mixture data, one must rely on either the nuclide mixture as reported in the FSAR or the most restrictive dose potential nuclide.

In 1999 a new RMDS computer system was installed at Limerick. It is capable of providing 1-minute, 15-minute and hourly average readings from the plant vents. However, the major drawback of this system is that the output data from the RMDS is not readily available for trending. The data is available visually and as a hardcopy paper output, but not easily available electronically for manipulation using Excel or other statistical software.

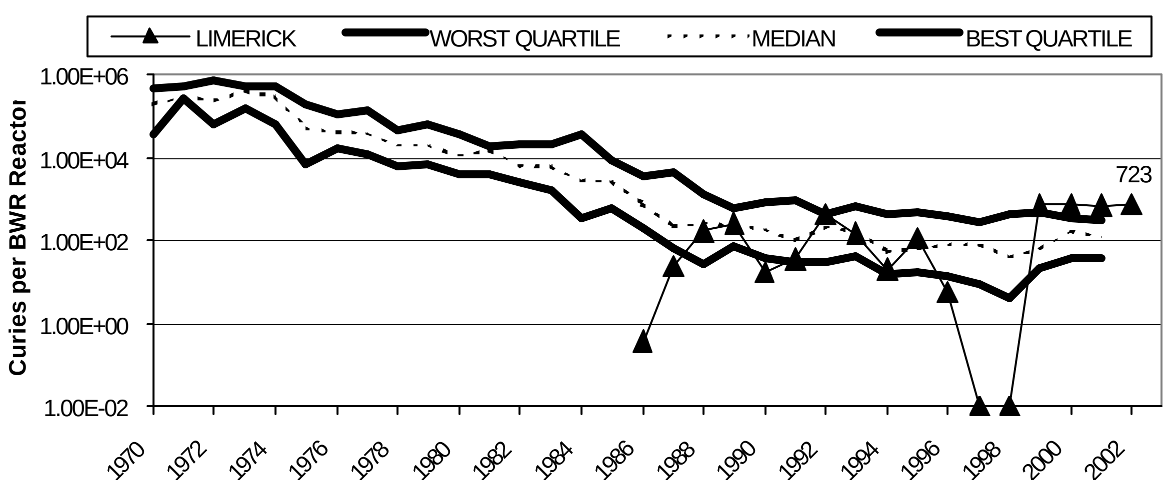
The original method used by chemistry to quantify the noble gas activity released from the station is to manually review the hourly average readings from the RMDS printouts and to apply a formula where for each day in the week, the highest hourly reading was averaged with the lowest hourly reading to obtain a daily average. Background was assumed to be the lowest hourly average for the week. The background value was then subtracted from each daily average reading for the week to produce a net release value. The value is then multiplied by the highest weekly stack flow reading to produce microcuries released. Figure 2 shows a typical weekly radiation monitor 1-hour average output.

Figure 2
Hourly Average Radiation Monitoring Readings for a 1-week Period



This noble gas quantification method has resulted in Limerick reporting publicly through its Annual Radioactive Effluent Release Report that approximately 1400 curies of gaseous activity is released to the environment each year. Reported noble gas activity of this magnitude has caused Limerick to be an outlier in the nuclear industry. As measured by INPO, Limerick is in the worst quartile for fission and activation gaseous releases (Figure 3).

Figure 3
Limerick Generating Station Airborne Fission and Activation Gaseous Effluents Comparison by Year per BWR Reactor (Total Curies)



Additionally, American Nuclear Insures (ANI) has determined that Limerick's liability premium is assessed a surcharge due to its Engineering Rating Factor (ERF) performance. Five of the twelve subfactors that make up the ERF are related to environmental releases of radioactivity. Limerick's current surcharge is about $200,000 per year, mostly due to large radwaste shipments that occurred in 2000 and 2001. However, part of this surcharge is due to the large quantity of noble gas that Limerick reports. Since 1999, Limerick has reported over 1400 curies of noble gas released from the site each year, even though the results of the noble gas grab sampling program were usually zero. Releases using this method are grossly overestimated.

In 2000, I presented results of a gaseous effluent survey that I had conducted. Among the nineteen plants that participated, I found most (11) assigned zero activity for the month, when the noble gas grab sample showed no activity. A few stations trended their effluent radiation monitors and would either subtract "background" and quantify or only quantify those results that show a definite positive increase (e.g. factor of three increase).

The results of this survey left me with several questions?

- Is it appropriate to rely on the monthly noble gas grab sampling as the stations sole record of noble gas releases?
- If no noble gas activity were found in the grab sample, should you report zero activity for the month?
- Are INPO's rankings comparing apples to apples?
- What is background?

The Limerick Chemistry Department established a goal move out of INPO's worst quartile for noble gas releases. To accomplish this goal we had to develop another method that would more accurately reflect the stations net gaseous effluent releases. The method had to be rigorous and defensible. The principal challenges were determining what background was and developing a means of quantifying those releases above background.

The new approach that Chemistry took was to:

1. Obtain the 2003 RMDS one-hour average gaseous effluent radiation monitor data electronically from the Information Technology.
2. Plot that data and observe and investigate all anomalous results. An anomalous result could be one of the effluent radiation monitors is elevated, while the backup monitor does not show the same response.
3. Obtain the 2003 RMDS 15-minute average for the days that the noble gas grab samples were obtained, as well as, for periods that appeared to show a release from the one-hour data.
4. Background was arbitrarily determined by taking the 15-minute average data for one hour before and one hour after collection of the noble gas grab sample; averaging the values and applying two standard deviations to the mean. It was assumed that if the noble gas grab sample showed no activity, then the monitor reading at time of collection represented no activity. This calculation was performed for each of the six effluent radiation monitors (2 per release point) that monitor the three release points.

5. If the 15-minute average effluent radiation monitor data was not available or suspect (unusually high) then the data from the previous month was used as background. Likewise, if positive activity were found in the gas grab sample, then again the background for the month would have been based on a value from a previous month, when no activity was found.

6. Each monitor's calculated mean + 2SD was used as background for the month and subtracted off of each valid hourly reading. Table 1 shows for each effluent radiation monitor the calculated values used for background subtract. Note that only 3 of 72 values were above the required sensitivity of 1E-06 uCi/cc.

Table 1 Mean plus two standard deviations of the mean of the 15-minute average effluent radiation monitor data obtained one hour prior to and one hour after collection of the noble gas grab sample

Month	Common North Stack A	Common North Stack B	Unit 1 South Stack A	Unit 1 South Stack B	Unit 2 South Stack A	Unit 2 South Stack B
Jan	7.59E-07	6.54E-07	5.71E-07	6.83E-07	7.73E-07	5.44E-07
Feb	7.91E-07	5.34E-07	6.40E-07	8.11E-07	7.85E-07	3.44E-07
Mar	7.63E-07	5.65E-07	5.63E-07	6.85E-07	6.22E-07	4.99E-07
Apr	7.62E-07	6.40E-07	6.12E-07	1.05E-06	8.17E-07	4.05E-07
May	7.58E-07	5.08E-07	6.46E-07	8.57E-07	1.06E-06	3.53E-07
Jun	6.31E-07	5.77E-07	5.17E-07	8.47E-07	6.82E-07	4.88E-07
Jul	7.01E-07	5.08E-07	4.84E-07	1.32E-06	5.63E-07	3.30E-07
Aug	6.56E-07	4.42E-07	5.73E-07	7.12E-07	7.12E-07	3.38E-07
Sep	7.28E-07	4.97E-07	5.71E-07	9.34E-07	6.08E-07	4.57E-07
Oct	7.48E-07	5.71E-07	6.10E-07	6.49E-07	8.48E-07	4.12E-07
Nov	6.04E-07	4.73E-07	5.22E-07	6.49E-07	7.47E-07	3.48E-07
Dec	7.16E-07	4.73E-07	5.05E-07	5.77E-07	7.45E-07	4.88E-07

7. The data in Table 1 was then used for the monthly background number and subtracted from each hourly average value for each radiation monitor, respectively.

8. The net activity from the A and B monitors were then averaged to obtain the net activity in uCi/cc. Net activity below zero was classified as zero or "no release".

9. For each hour of positive release, the number of microcuries released was determined by the following formula.

$$mCi / hr = \frac{Stack \quad Volume \quad (cc)}{604800 \quad (\sec)} * mCi / cc * 3600 \quad \sec / hr$$

Where:

Stack Volume (cc)	=	Total weekly stack volume
604800 (sec)	=	Number of seconds in a week
uCi/cc	=	Net average hourly rate for the A and B monitor
3600	=	conversion from seconds to hour

10. The total number of microcuries released for each week was determined by summing the individual hourly values for the week. For purposes of calculating dose, the nuclide mix as reported in the FSAR (updated) was assigned to the microcuries released.

Using this method, Limerick reported in their 2003 Annual Radioactive Release Report 4.26 curies of fission and activation gases. This is significantly lower than the 1447 curies reported for 2002. Reporting less than 5 curies of noble gas wil move Limerick from INPO's worst quartile to best quartile (Figure 4), and it will contribute to the reduction in the ANI surcharge in future years.

Figure 4
Limerick Generating Station Airborne Fission and Activation Gaseous Effluents Comparison by Year per BWR Reactor (Total Curies)