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EFFECTS OF ELEVATED RADON LEVELS ON KANNE TRITIUM MONITORS

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Introduction

The Savannah River Site has used Kanne ionization chambers since the late 1950's to monitor for airborne tritium in reactor facilities [1]. Two Kanne monitors indicated elevated airborne tritium levels while monitoring a non-ventilated room used to store tritiated liquid moderator in the 105-L Reactor Building. Subsequent air sample analysis failed to reveal the presence of airborne tritium. It was suspected that elevated radon levels caused the Kanne monitors to falsely indicate tritium activity. Two commercially available monitoring systems were used to quantify radon levels in the 105-L Final Storage Room. In addition, a high efficiency filter was installed on a Kanne monitor to capture the particulate radon progeny and compare its background response to an unfiltered monitor. Kanne monitor detection capability for various moderator spill scenarios was also reviewed during this evaluation.

Summary

Measurements performed during this evaluation found that radon caused the Kanne monitors in the 105-L Final Storage Room to falsely indicate the presence of airborne tritium. A side-by-side comparison of a filtered versus an unfiltered Kanne monitor found that a high efficiency particulate filter reduced monitor response to near background under high radon conditions. It was recommended that a high efficiency filter be installed on the dedicated Final Storage Room Kanne monitor and that the room be de-posted as an Airborne Radioactivity Area (which will also eliminate the tritium bioassay requirement for room entry). It was also found that the Kanne monitors would detect a spill from a single drum of moderator within minutes and the dose rate due to tritium exposure at 20 hours following this spill would be 4.56 rem/hour.

Discussion

The Final Storage Room is currently used to store tritiated liquid moderator in palletized 55 gallon drums. Kanne monitors provide early detection of airborne tritium in the unlikely event that a drum leaks. Kanne monitors are of particular importance in the Final Storage Room as air flow is stagnant and building ventilation would not allow for the eventual detection of a tritium release by the building stack monitoring system. Two Kannes monitoring the Final Storage Room were observed to have background readings exceeding 1 DAC for tritium oxide, which resulted in the room being posted as an Airborne Radioactivity Area (ARA). The ARA posting also required that all personnel entering the Final Storage Room participate in the tritium bioassay program, even though tritium air sample (bubbler) results did not detect airborne tritium [2]. It was suspected that the elevated Kanne background readings were caused by high radon levels. Hoy [1] stated that Kanne monitors could detect beta-gamma emitting gases (e.g., radon) other than tritium. The Final Storage Room is concrete walled and had an earthy smell often found in poorly ventilated rooms exhibiting elevated radon levels at SRS facilities.

A proposed solution to reduce the elevated Kanne background was to install a high efficiency particulate filter on a job-specific Kanne and compare its background readings, over time, to the dedicated Final Storage Room Kanne monitor. The Final Storage Room radon levels were measured by the WSRC Health Physics Services Group, which had just finished evaluating two different radon monitoring systems, one that measured the particulate radon component and the other measuring the gaseous component [3,4]. It was felt that the filter comparison and radon measurement results should determine why the Kannes were falsely indicating elevated tritium backgrounds.

Radon Measurement Methodology

Two radon monitoring systems were used to quantify ambient radon levels. A Durridge RAD7 Radon Detector was used to measure the gaseous radon component in units of picoCuries per liter (pCi/l). The Pylon Working Level Measurement System monitored the levels of radon progeny (particulate) and provided results in units of Working Level (WL - defined as any combination of the short-lived radioactive progeny in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of 130,000 MeV of alpha energy [5]). Occupational dose to radon is typically measured in exposure-based units (Working Level Month or DAC-hrs) versus concentration-based units due to the dynamic nature of radon and its associated decay products. The decay of gaseous radon into particulate progeny was shown to cause significant exposure via direct irradiation of the lungs to specific worker populations (i.e., miners) [6]. Ambient levels of radon in buildings are usually measured in pCi/l. The RAD7 monitor is normally used at SRS to determine if a particular building or workspace exhibits unusually high radon levels. If it was determined that workers were being occupationally exposed to radon, then the Pylon would be the measurement system of choice to record WL.

Regulatory Considerations

Naturally occurring radon is defined by 10 CFR 835, *Occupational Radiation Protection Rule* [5], to be background radiation and as such, dose received from exposure to radon is not required to be considered when determining compliance with occupational dose limits [see 835.1(c)].
10 CFR 835.2(a)(2)(iv) furthers elaborates that "*Background means radiation from radon and its progeny in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities*".

The 105-L Final Storage Room clearly meets this definition and current WSRC guidance [7] on radon control directs the Radiological Control Organization to perform measurements when elevated radon levels are suspected and then take specific actions based upon the levels detected. These actions include follow-up measurements if radon concentrations exceed 4 pCi/l and work stoppage if radon concentrations exceed 20 pCi/l. However, the WSRC guidance did not recommend assessing and assigning dose from radon exposure to workers. When this memorandum was issued (1993), regulatory guidance issued by DOE did not explicitly address occupational radon exposure, except when the source of the radon was from a process that has been technologically enhanced. Since that time, 10 CFR 835 and it's supporting Internal Dosimetry Standard [8] have been issued and provide additional detail on control of radon in the workplace that does not contradict the guidance contained in Reference 7.

Radon Measurement Results

The 105-L Final Storage Room was monitored for 48 hours with the RAD-7 and Pylon monitors. The RAD-7 monitor recorded an average radon concentration level of 4.99 pCi/l while the Pylon monitor measured an average Working Level (WL) of 0.027. By using a Radon Equilibrium Concentration factor (from Reference 8) and multiplying times the radon concentration, the RAD-7 can estimate the WL (0.020 for these measurements). The same equilibrium values can be applied to the Pylon results to estimate the concentration level (6.74 pCi/l). These results show relatively good agreement (approximately 26 percent), which is acceptable as the Radon Equilibrium Concentration factor is actually a default value. Based upon these measurements, which are higher than the previously measured site radon levels stated in Reference 7, the 105-L Radiological Control Organization would perform follow-up measurements to track radon levels in the Final Storage Room per existing WSRC guidance.

Kanne Background Response to Radon

A high-efficiency particulate filter was installed on the job-specific Kanne monitoring the Final Storage Room. The dedicated Kanne monitoring this room was not equipped with such a filter and the background levels of each monitor were recorded over a period of 37 weeks to ascertain if the filter captured the particulate radon progeny and effectively lowered the Kanne background. The job-specific filtered Kanne background rarely rose above the normal instrument background of 1E-5 uCi/cc during the entire test period. It was found that over the winter (lower humidity and therefore lower radon levels) the background between the two monitors differed by only 15 percent. However, during the spring and summer months (with high humidity and elevated radon levels), the difference in background averaged 42 percent. The average over the entire test period was 32 percent, so it can be concluded that the use of a high efficiency filter on the dedicated Kanne monitor would effectively lower the radon background to less than 1 DAC for tritium oxide.

Kanne Response and Associated Dose Following a Tritium Spill

During this evaluation the effectiveness of the Kanne monitor for detecting a leak of tritiated moderator was questioned. An engineering calculation was performed that included a detailed dose assessment due to moderator leaks and/or spills in the 105-L Final Storage Room [9]. This calculation can also be used to estimate the airborne concentration of tritium from a given dose scenario. Several scenarios were discussed with the limiting case for Kanne detection being a leak of a single 55 gallon drum in the Final Storage Room. Assuming that 20 hours elapses following the leak of 55 gallons of moderator (which allows the water vapor in air to be nearly saturated with tritium), the dose rate to a worker from inhalation and skin absorption of the airborne tritium is 4.56

rem/hour (moderator activity decay corrected to October 2003). If a drum handling accident spill is considered (12 drums, 660 gallons) then the dose rate raises to 5.04 rem/hr. It is interesting to note that the dose rate resulting from a seismic event that ruptures all of the drums in the Final Storage Room (71,500 gallons) would not create a greater dose rate than that from the drum accident scenario. This is due to the fact that the 660 gallon spill would cover the floor and the dose rate from any additional moderator is limited by the surface area available to saturate the room air.

In the case of a 55 gallon drum leak, the tritium Derived Air Concentration (DAC) can be determined by dividing the dose rate (from Reference 9) by 2.5 mrem/DAC-hr. The DAC value could then be compared to the minimum detection capability of the Kanne monitor (1.0E-5 uCi/cc or 0.5 DAC tritium oxide). For the post 20 hour spill dose rate of 4.56 rem/hr, the calculated DAC value would be 1824 DAC, or 3.65E-2 uCi/cc. An example of more interest in regards to personnel safety is the DAC value shortly after a spill. For the case 10 minutes following a 55 gallon spill, the dose rate would be approximately 170 mrem/hr which equates to 68 DAC, or 1.36E-3 uCi/cc which is easily detected by the Kanne monitor. Even when the decay of tritium is considered, Kanne monitors will provide a significant early warning capability for moderator leaks and spills into the foreseeable future.

Recommendations

Based upon the results of this evaluation, the following actions are recommended:

- Remove the Final Storage Room job-specific Kanne monitor from service;
- Install a high efficiency particulate filter on the dedicated Final Storage Room Kanne monitor;
- De-post the Final Storage Room as an ARA;
- Revise the RWP to discontinue tritium bioassay sampling for routine entry into the Final Storage Room;
- Ventilate the Final Storage Room when extended work is being performed to mitigate radon levels and consider installing ductwork into the room to supply permanent ventilation; and,
- Review the current WSRC guidance on occupational control of radon in the workplace and proceduralize those actions that are necessary to ensure compliance with 10 CFR 835 requirements.

References

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