Solid angle subtended by a gas pipeline and a scintillator detector calculated using Monte Carlo Techniques

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Nuclear and radiation technologies are increasingly being applied in industrial plants, especially in the oil and gas industries. Because they are projected to measure the flow continuously, it is necessary to calibrate these sensors periodically to guarantee a safe operation. In many cases, the efficiency of the process depends on the result of data compared from different probes, so it is crucial to guarantee an accurate measurement for the gamma photons registered by the detector. To calibrate a gamma radiation detector is essential to know the correct number for the gamma rays scattered into a solid angle Ω and definition for Ω is: [1, 2, 3]

$$\Omega_P = \iint_S \frac{\vec{n}.\left(\overrightarrow{r-r_P}\right)}{\left|\left(\overrightarrow{r-r_P}\right)\right|} dS \qquad (1)$$

In this work, the ATOMUM_GEOFACTOR software was used to calculate the solid angle and active volume for different detection geometries within the duct-detector system and it was applied to simulate different geometries for the duct-detector system, varying both the air gap and the collimation. Three different situations were studied, considering a stainless steel duct (internal radius = 10.16 cm and wall thickness = 0.3 cm); a NaI scintillator detector 2"x 2" (radius = 2.54 cm and height = 5.08cm) shielded by a cylindrical lead shell (3.5 cm). Figure 1 shows this system.

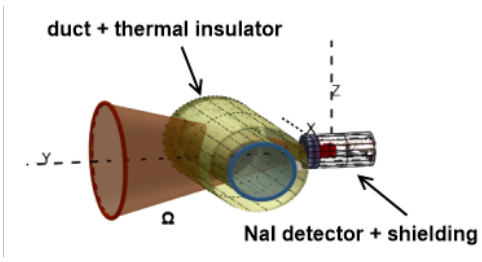

Figure 1: Geometric representation for the duct and the shielding NaI scintillator detector.

The first simulation was iwith the thermal isolator removed and installing the detector near the duct wall; the second was with the scintillator detector near the thermal insulator. The third was in the scintillator detector, far from the insulator wall, and for this situation, the software was used to fit the best geometry. Figure 2 shows the plane XY projection for these three situations. To better identify the limits for the solid angle, the thermal insulation layer and the lead shielding are not shown in the figure.

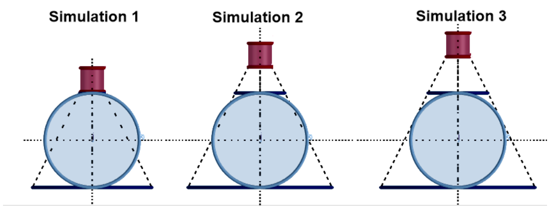

Figure 2: Solid Angle (projection plane XY) for the three simulations

If the thermal insulator is removed, the scintillator detector is stalled near the duct wall (simulation 1). In Figure 2, the dashed line shows that part of the duct is out of the solid angle, and the radiotracer in this external volume will not be considered and registered by the scintillator detector. For this situation, the active volume is 5.039 L. This set also happens an external volume, and the active volume is 6.758 L. The best condition is determined by varying the air gap until the solid angle includes all the duct diameter, as shown in situation three. For this case, the air gap is 2.2 cm, and the active volume is 7.47 L. The results proved that it is unnecessary to remove the thermal layer to measure the correct gamma activity to determine the leak.

References

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