NORM CONTAMINATION: ALPHA/BETA BUT LITTLE GAMMA RADIATION

K. Krieger
Earth Tech Inc.
110 Broadway, Suite 320, San Antonio, Texas, 78205

ABSTRACT

Naturally occurring radioactive material (NORM) contamination usually can be easily detected on the outside of piping or tanks in refineries by taking external gamma measurements with simple count rate meters or more complicated gamma spectroscopy instruments, as radium and progeny emit many gamma rays when in equilibrium. However, due to special processes and certain circumstances, a significant amount of NORM may be present without the characteristic gamma signature of radium and its progeny. We found that during the process of cracking ethane and methane from crude oil, radium is not deposited while the daughters are deposited. When this occurs, measurements taken on the outside of piping indicate no elevated levels of gamma radiation; however, elevated levels of alpha and beta radiation may be detected on the inside of the piping. When analyzing the contents on the interior of the pipe for gamma radiation, the contents contain only lead-210 (^{210}Pb). This indicates that all parents have decayed or that ^{210}Pb was the only NORM that was deposited.

During the cracking process, the heat involved is believed to cause radon to enter the process while allowing radium to pass through the system. As one of the release criteria for piping material is an external dose rate of less than 50 microroentgens per hour ($\mu R\ hr^{-1}$), how much of this NORM-contaminated material has been released as noncontaminated throughout the years?

INTRODUCTION

Ever since its discovery in the oil field of the North Sea, NORM has become an increasing problem in the oil and natural-gas-processing industry.

NORM can be found in many geological formations, including where oil and gas are extracted. This presence of NORM has brought up radiological exposure concerns related to oil field personnel and the public. The long-lived radioactive material decay chains of uranium and thorium have had enough time to become in equilibrium with their daughters. While deep in the ground, many of the daughters are in solution. However, when oil is extracted both the equilibrium and the pressure of the system change. The chemical properties of the radionuclides also come into play when the oil is extracted. The addition of seawater to the formation creates chemical bonding and the precipitation of certain insoluble compounds — usually sulfate and carbonate. Radium compounds also precipitate along with barium and calcium compounds, as they are in the same chemical group. These precipitates occur as scale on the inside of pipes or on the bottom of tanks or vessels.

It is the radium and its daughter products that emit alpha, beta, and gamma radiation. It is the radium that gets deposited as scale and then functions as the parent of all its progeny. As radium has a long half-life (1600 years) the continual production of daughters is assured. It is the radiation from radium daughters, such as bismuth and lead, that make the detection of NORM relatively easy. There are three main ways to detect NORM depending on how much information is wanted. The easiest but least informative method of detecting NORM is by using a Geiger-Mueller detector; this will simply indicate whether elevated levels of radiation are present, but will not distinguish between alpha, beta or gamma radiation. Another method of detecting NORM is by using either a sodium iodide or germanium detector to perform gamma spectroscopy on a pipe to identify specifically which radionuclide is emitting elevated levels of radioactivity. The third and most time-consuming and expensive method is radiochemical analysis of a scale sample. For most purposes, either one of the first two methods are used to determine the presence of NORM. However, if there is little gamma radiation and no accessibility to insides of pipes, these methods of NORM detection are very limited.

Unique Situation

Under certain circumstances, radium does not seem to be deposited. Due to special handling and processing, it is radon and its decay products that are of concern. Radon is not of direct concern due to its short half-life, but it is this radionuclide that is affected by the processing of oil. When extracting small molecular weight hydrocarbons from oil, the similar boiling points of the dissolved gases in the oil cause radon to be extracted along with the compounds of interest. The boiling point of radon is between that of propane and ethane. So, when these compounds are extracted from oil, radon is extracted as well. Radon then follows the process piping and when it decays the daughter products are deposited in the piping. During the working lifetime of a processing plant, the radon level is constantly replenished and adds to the amount of daughters. Most radon daughters are short-lived, so when a processing plant ceases operations, the short-lived progeny decay quickly. These are the radionuclides that emit gamma rays that can be detected easily. What is left is the relatively long-lived radionuclide of lead-210, which emits alpha, beta, and a low energy gamma. So, when these short lived radionuclides decay away, it makes it difficult to detect this material on the outside of pipes and tanks, even though there may be detectable radiation on the inside of the pipe. Unless the pipe had an access point the radiation may not be detectable.

Disposal

NORM-contaminated material can be disposed of in several ways. If the scale can be separated from the piping, it can be either blended with other soil and be spread over an unoccupied land area or it can be converted into a slurry and injected in abandoned wells. If the scale cannot be separated from the pipe or tank, it will most likely be buried at an approved waste site. These methods are used to isolate the NORM.

When NORM-contaminated material is not detected before it is shipped for recycle or reuse, it can generate dose to people, either to workers at facilities or to the public, using this material of concern. Several tons of material are either recycled or reused every year. In some instances, this material has been used as framework for playground equipment or as structural material in houses. One of the release criteria for NORM-contaminated piping is that removable contamination on the external surface be below a certain level, but since the NORM is on the inside of a pipe this is rarely a problem. Another of the disposal criteria for NORM-contaminated piping is the external gamma radiation level on the surface must be less than 50 μR hr. However, when the contamination is emitting mostly alpha and beta radiation, the external radiation level will not indicate the presence of contamination. So, it is possible that piping can pass all the criteria for free release and still contain NORM contamination.

CONCLUSION

Although piping or tanks contaminated with NORM from a particular process could be missed during a survey and released for unrestricted use, the risk to individuals is minimal. All of the NORM is contained in the piping, so none of the alpha or beta radiation will interact with anyone on the outside of the pipe. Additionally, due to the low-energy gamma rays (47 kiloelectron volts, keV) associated with this particular type of NORM, only 10E-6 of the gamma rays will make it through the wall of a standard schedule-40 pipe. So, the whole body dose added to people from this material is many orders of magnitude smaller than other sources. As this situation only occurs in a very small percentage of the oil processing facilities, the amount of material that may be released is a relativity small amount. This small amount of material, compared to the entire amount of released metal and the very small doses associated with this NORM, poses very small risks to recycling facility personnel or to the public, if it is indeed missed.