Operational Topic

Some NORM contamination on the inside of refinery tanks or piping can be difficult to detect or evaluate from the outside.

NORM Contamination—Now You See It, Now You Don't

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Abstract: *Contamination from naturally occurring radioactive material on the inside of piping or tanks in refineries can usually be easily detected from the outside by external gamma measurements with simple count rate meters or more complicated gamma spectroscopy instruments. Usually, such contamination is from radium in equilibrium with its progeny. A number of different gamma rays are emitted by this mix. However, due to certain processes or circumstances, a significant amount of NORM can be present without the characteristic gamma signature of radium and its progeny. The process of cracking low molecular weight hydrocarbon gases from crude oil allows radon through but leaves radium behind. The radon enters the process piping and decays, depositing its short-lived decay products or progeny. When the short-lived progeny decay, all that is left are alpha and beta emitters. 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 can be detected on the inside of the piping. ^{210}Pb is usually the only gamma emitter detected on the inside of the piping and, its gamma ray energy is such that little if any penetrates the walls of the piping. Since one of the release criterion for piping material is an external dose rate of less than 50 μR h^{-1}, it is possible that a survey from the outside of the piping can be negative when, in fact, thee can be appreciable contamination on the inside of the piping. Health Phys. 89(Supplement 2):S20–S21; 2005*

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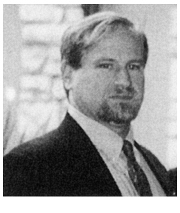
INTRODUCTION

Although it has been known for some time that radioactivity is present in natural gas reservoirs (Sattely and McLennan 1918), only after the discovery of NORM in the oil fields of the North Sea in 1981 (NYSDEC 2003) has NORM become recognized as a problem in the oil and natural-gas-processing industry.

NORM can be found in many geological formations, including areas 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 come to equilibrium with their progeny, so the entire chain is present. While deep in the ground, many of the progeny are in solution. However, when oil is brought to the surface, 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 (Lysebo et al. 2003)—usually sulfates and carbonates. Radium compounds also precipitate along with barium and calcium compounds, as they are in the same chemical group. These precipitates become part of the scale on the inside of pipes or on the bottom of tanks or vessels.

Radium and its progeny emit alpha, beta, and gamma radiation. Radium becomes deposited as scale and then functions as the parent of all its progeny. As radium has a long half-life (1,600 y) the continual production of progeny is assured. Radiation from radium progeny, such as bismuth and lead, make the detection of NORM relatively easy. There are several 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 specific radionuclides. The third and most time-consuming and expensive method is radiochemical analysis of a scale sample. For most purposes, either of the first two methods is used to determine the presence of NORM. However, if there is little gamma radiation and no accessibility to the insides of pipes, these methods might



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give limited information about the presence of NORM.

Radon extraction

The boiling point of radon is between that of propane and ethane. So, when small molecular weight gasses are being extracted from oil, radon is extracted along with the compounds of interest. Radon enters the process piping where it decays into radioactive particulates that are deposited in the piping (Bland 2002). During the working lifetime of a processing plant, radon is constantly entering the system and adding to the level of radioactive progeny. Most radon progeny are short-lived, so when a processing plant ceases operations, the short-lived progeny decay quickly. These short-lived radionuclides are the ones that produce the signature gamma ray spectrum that can be detected easily on the outside of the piping. As the short-lived radon progeny decays, it becomes more and more difficult to detect activity from the outside of pipes and tanks, even though there may be detectable radiation on the inside. As the short half-lived progeny decay away, the only radionuclides remaining are the relatively long-lived ^{210}Pb ($T_{1/2}$ = 21 y) and its progeny. ^{210}Pb emits a gamma ray at 47 keV and has a transmission of only about 10^{-7} to 10^{-6} through a schedule-40 pipe. Unless the pipe had an access point, internal contamination might not be detectable from the outside.

DISPOSAL

NORM-contaminated material is disposed of in several ways. If the scale can be separated from the piping, it can be blended with other soil and spread over an unoccupied land area; it can be converted into slurry and injected into abandoned wells; or, depending on circumstances, it can be discharged to large bodies of water. If the scale cannot be separated from the pipe or tank, then burial of the piping and tank at a low-level radioactive waste disposal facility might be required.

One of the release criterion 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 usually not a problem. A second release criterion is that the fixed contamination *on the outside surface* be below a certain level. Again, if the contamination is on the inside of the pipe it is not fixed contamination. Another of the free release criterion for NORM-contaminated piping is the external gamma radiation level on the surface must be less than 50 μR h^{-1}. However, when the contamination is emitting mostly alpha and beta particles and any associated gamma rays are low in energy, the external radiation level might not indicate the presence of contamination. It is possible that piping can pass all the criteria for free release and still contain NORM contamination, although the inability to detect this NORM contamination from the outside can lead to these contaminated materials being recycled. However, the potential dose to people from this NORM material and, from NORM in general, is considered to be orders of magnitude smaller than from other radiation sources (Underhill 1993).

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 the NORM is contained in the piping, so none of the alpha or beta particles can interact with anyone on the outside of the pipe. Additionally, due to the low-energy gamma rays (47 keV) associated with this particular type of NORM, only 10^{-7} to 10^{-6} of the gamma rays will make it through the wall of a standard schedule-40 pipe. As this type of gas extraction only occurs in a very small percentage of the oil processing facilities, the amount of material that could be unrestrictedly released is relativity small.

Author's Note: A literature search for information about this type of NORM yielded few references. The author would appreciate receiving or being made aware of any additional information on this type of NORM.

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