IMPLEMENTATION OF SAFETY PROTOCOLS FOR THE OIL AND GAS INDUSTRY THROUGH EDUCATION, ON-SITE RADIATION EVALUATION AND ADVANCED DOSIMETRY

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ABSTRACT

Worker safety is a vital part of the oil and gas industry. Enviroklean Product Development Inc. (EPDI) increases worker safety through education and training on Naturally Occurring Radioactive Material (NORM). EPDI offers several different training levels including NORM awareness, NORM worker, NORM surveyor and NORM Radiation Safety Officer (RSO). Education combined with enhanced surveys and analysis of NORM by gamma spectroscopy allows for accurate readings of NORM on a job site. The gamma spectrometer is an instrument that measures the energy and intensity of radiation in a sample such as soil, scale or sludge. EPDI in conjunction with the Nuclear Engineering Teaching Lab at the University of Texas has developed a gamma spectrometer and computer program that allows for real time on-site results within 15 - 30 minutes. We have also used MCNP (Monte Carlo N-Particle) to establish a comprehensive and flexible computer model to realistically estimate the radiation dose absorbed by a field worker.

INTRODUCTION

NORM is the radioactive waste produced during the exploration and processing of crude oil and natural gas. The waste takes the form of precipitation, such as scale in the pipelines and sludge in the storage tanks and separators, as well as deposition in the soil. The main radionuclides that pose a concern are Radium-226 and Radium-228 and in some cases Lead-210. The NORM concentrations can vary depending on a variety of factors including age of the well, geological location, well depth, formation conditions and type of production [1]. The NORM material that has built up is not only a safety hazard but can also decrease the production of oil. The oil and gas industry has always had a problem with NORM accumulation on production material and waste products associated with oil and gas exploration. It was not until the past few decades that the rules and regulations were put in place to help manage to contamination from NORM material. In the 1980's rules and regulations were created at the state level to deal with the potential hazards to both the workers and general public. Since there are no federal guidelines each state may vary in the way that they handle NORM from the oil and gas industry while other states may not have any current regulations [1]. These new guidelines have changed many ways in which companies can handle and dispose the products contaminated with radionuclides. As these changes take place and are enforced many state government agencies are requiring that more training classes be given to workers in the oil and gas field. Improved teaching methods are being put into place to ensure that the people working in the field have a comprehensive knowledge of NORM.

TRAINING

Proper training is a vital part of the oil and gas industry from respiratory protection, to H_2S training to confined space training. This training also needs to include specific training on working with radioactive material on a job site. There are 4 different radioactive training levels in the oil and gas industry which include NORM awareness, NORM worker, NORM surveyor and NORM RSO (Radiation Safety Officer). The training is not only limited to employees directly dealing with the NORM in the field but to any employee working in the oil and gas industry. For example, the NORM awareness class is also beneficial for employees in management positions to be trained in health and safety and current regulations. It is a valuable resource for other companies in the oil and gas field to have their employees trained in NORM awareness so that they understand the risks and regulations of working with this part of the oil and gas industry. The class needs to comprise a general introduction to radiation as well as worker

safety and health concerns. This includes going back to the fundamentals of general chemistry including an atom and its components. Taking the extra time and care to go over the basics will provide benefits in both health and safety and avoid any potential violations. Next it is important to determine where the radiation in the oil and gas field comes from using decay series and visual aids. A general description of where NORM collects during the process is also useful. One of the most important concepts taught in all of the classes offered is the As Low As Reasonably Achievable (ALARA) principle which states that the radiation exposure cannot be completely eliminated but it is should be kept as low as possible. The NORM worker, surveyor and RSO training gives employees of all levels the tools and knowledge to work safely and effectively on a NORM jobsite. This includes emergency preparedness, worker safety, personal protection equipment (PPE), radiation survey instruments. radiation units of measurement and dose limits. With the surveyor and RSO courses it gives the training to preform NORM surveyors to ascertain if the jobsite has radioactive material including hands on experience with a Geiger Muller counter and Scintillation probe. With the proper training the RSO will be able to manage the job site putting into place protective measures such as posting signs, PPE required, the time-distance- shielding rule or the ALARA principle. The risk to and employees and the general public goes down significantly if there is proper training and work procedures are put into place [2].

GAMMA RAY SPECTROSCOPY

he gamma ray spectrometer is an instrument used to measure the intensity of radiation and has the ability to determine the amount of energy produced by a particular radionuclide in a sample. Each peak in the spectrum represents the radiation energy of a specific radionuclide. NORM is not easily discernable from non-radioactive material in the oil and gas industry; sludge and scale build up are found ubiquitously throughout oil and gas equipment. The only way of knowing if this type of buildup is radioactive is by preforming NORM surveys (with a Geiger counter) and sending in samples for lab analysis by gamma ray spectroscopy. Lab analysis samples use gamma spectroscopy for the analysis of NORM samples but may take up to several days to 2-3 weeks to get the results. EPDI has designed a computer program that works with a portable gamma ray spectrometer for fast and accurate readings. The program allows for results to be obtained within 15-30 minutes which are displayed in pCi/g [Figure 1 and 2]. These readings can help discern how much NORM is on a job site and allows a company to implement proper safety and disposal procedures. The operation of a gamma-ray spectrometer must be made simple enough so that training of field workers is adequate enough so that each individual can get a quick response if the sample is above or below the legal limit of 30 pCi/g [3].

MONTE CARLO N-PARTICLES (MCNP) MODELING

Computer modeling is employed to estimate radiation absorption dose rate (mrem/h) of human bodies in the oil field from the collected activity concentration (pCi/g) data. Previous studies of the radiation level in the oil field have been conducted with in situ measurements and estimations using conversion factors [4-5]. However, activity concentrations of NORM vary significantly from site to site, a conclusive dosage study using in situ measuring equipments would be greatly effort-consuming. Moreover, NORM wastes in the oil field often take complex geometric forms, making dose calculation difficult to achieve. Therefore, to realistically estimate the radiation dose absorbed by the oil field workers, a comprehensive and flexible computer model is required. In this work, simulations were realized with the MCNP code [6] developed by the Los Alamos National Laboratory. The model mainly focuses on scale formed along the inside of pipelines, sludge deposited at the bottom of storage tanks and separators, and condensation in the soil environment. The exposure pathway considered is the external exposure to gamma rays, since the NORM wastes are usually confined within the equipment or the body of soil, which are capable of shielding most alpha and beta radiation. So far, a partial model of the NORM contaminated soil has been constructed with dimensions according to previous relevant work in natural soil modeling [8], and tested with radioactivity data from a Texas oil field (Table I). A human phantom built by Oak Ridge National Laboratory [7], as shown in Figure. 3, was employed to simulate the workers. Absorbed dose in each body part can be quantified individually. For the soil model only, the energy deposition rate in various organs of the phantom has been calculated and listed in Table II. As expected, the lower body parts such as leg bones, genitalia, testes and urinary bladder absorbed relatively higher amount of radiation, while brain and upper body bone structure were less exposed. The whole body dose rate was calculated to be 8.75 mrem/h, which is the equivalent of 17.51 rem/yr for 2000 working hours per year. For comparison, the annual dose limit for radiation workers is 5.0 rem/yr as regulated by the United States Nuclear Regulatory Commission. More considerations about the realistic in-field working hours will need to be made. However, it is evident that NORM in the soil alone is capable of posing a threat to the health of the workforce.

CONCLUSIONS

The use of training, on-site gamma spectrometry and MNCP modeling can greatly enhance safety protocols in the oil and gas industry. The accurate readings of radiation levels can help implement the proper safety methods that have been taught in the training courses. The MNCP modeling can help predict how much dose the oil and gas employee is exposed to in a given year. This will allow companies to implement better and more specific safety procedures depending on the levels of radiation at each particular jobsite. This will also permit the employee to understand how the proper radiation protection and surveys may help reduce their dose for radiation making the work environment a safer place.

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Table I. Activity concentration (pCi/g) of ^{210}Pb, ^{226}Ra and ^{228}Ra in NORM samples from a Texas oil field [9]

Radionuclide	Sludge	Scale	Soil
^{210}Pb	139.1±6.0	37.0±2.0	618.6±20.0
^{226}Ra	1594.6±8.1	71.1±4.0	1764.8±89.1
^{228}Ra	770.3±40.4	15.3±1.1	4.2±0.3

Table II. Dose absorption rate (mrem/h) in various parts of the body

Adrenals	0.171
Arm bones	0.267
Brain	0.230
Clavicles	0.255
Colon	0.306
Esophagus	0.056
Facial Skeleton	0.319
Gall Bladder	0.256
Kidneys	0.308
Leg bones	0.960
Liver	0.268
Lungs	0.650
Male Genitalia	0.783
Pancreas	0.228
Pelvis	0.356
Rib Cage	0.179
Scapulae	0.006
Skin	0.735
Skull-Cranium	0.084
Small Intestine	0.345
Spine	0.178
Spleen	0.228
Stomach	0.199
Testes	0.588
Thymus	0.112
Thyroid	0.318
Urinary Bladder	0.543
Ventricles	0.151

Figure 1- Overview of Gamma-ray Spectrometer, NaI(Tl) and 20 gram sample.

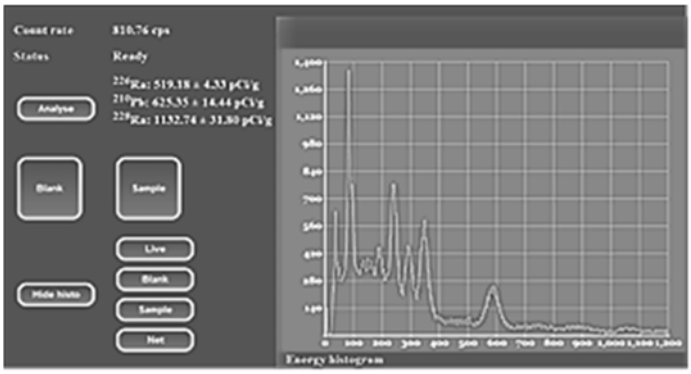

Figure 2- Gamma-Ray Spectrum Output and Automated Results.

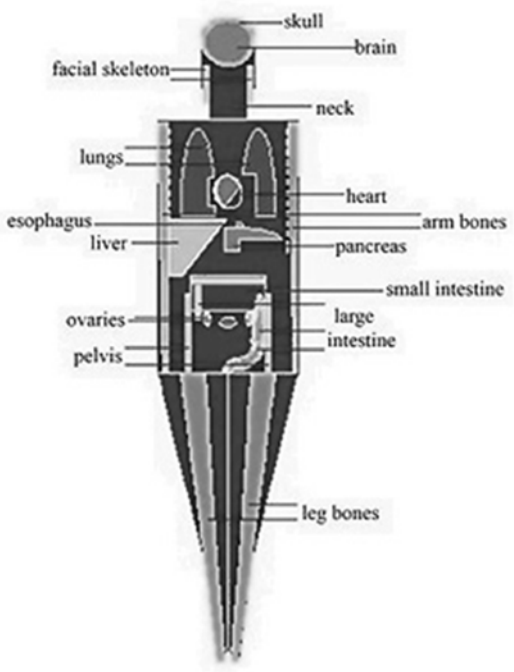

Figure 3 - Diagram of ORNL human phantom with individual body part marked