POLICY

Hawk Energy, LLC has implemented this Program to ensure that no employee is exposed to naturally occurring radioactive materials (NORM) at levels in excess of permissible exposure limits (PEL). If exposures are above the action level, engineering controls, work practices or personal protective equipment (PPE) will be used to reduce exposure levels.

REFERENCES

- 29 Code of Federal Regulations:
  - §1910.1096—Ionizing Radiation
  - §1910.1097—Nonionizing Radiation

RESPONSIBILITIES

David Slim is the NORM Program Administrator, responsible for ensuring that employees are informed of the hazards of NORM, hazard avoidance and safe work practices when NORM may be encountered. David Slim is responsible for ensuring the following administrative controls, engineering controls and safe work practices are enforced.

TRAINING

- Employees will be trained in the hazards, location, methods to identify the hazards and methods used to protect themselves against potential exposures for both routine and emergency situations. Specialized instructions for respiratory protection will include the proper usage of respirators, filter selection (including HEPA) and limitations
- Employees of Hawk Energy, LLC will be trained upon initial hiring, before exposures occur, and annually thereafter in NORM awareness and safety to include normal and emergency situations. Methods for protection against radiation include time, distance and shielding. PPE and personal hygiene will also be addressed. The information in this section will be available to employees upon initial hiring

SAFE PRACTICES

- The job superintendent will convey specific worksite information regarding where exposures may occur and give instruction on the signal to be used at each job site in the event of an emergency release of NORM in the workplace. Employees will be instructed to immediately evacuate to the safe briefing areas in the event of such a release.
- Safe briefing areas used will have been predetermined as part of the H_2S emergency evacuation plan.
- All radiation hazard areas in the workplace will be properly designated with the signage specified in §1910.1096 and §1910.97. Specific work-site information on areas where exposure may occur will be supplied by the facility management of each particular job site where Hawk Energy, LLC contracts paired.
- The job superintendent will convey specific work-site information regarding where exposures may occur and give instruction on the signal to be used at each job site in the event of an emergency release of NORM in the workplace. Employees will be instructed to immediately evacuate to the safe briefing areas in the event of such a release.

- Safe briefing areas used will have been pre-determined as part of the H_2S emergency evacuation plan.
- All radiation hazard areas in the workplace will be properly designated with the signage specified in §1910.1096 and §1910.97. Specific work-site information on areas where exposure may occur will be supplied by the facility management of each particular job site where Hawk Energy, LLC contracts.
- If the possibility of a radiation hazard exists in any unmarked work area or is suspected, David Slim will be responsible for obtaining the required testing or facility test results from a qualified testing agency to determine that no hazard to unprotected employees exists before authorization to work in those areas.
- David Slim will request information from the required survey of the facility where work is to be performed to include:
  - The magnitude and extent of radiation levels
  - Concentrations or quantities of radioactive material
  - The potential radiological hazards
- In the event the survey determines exposure to radiation hazards is likely, employees will be required to wear individual dosimeters at all times when working in potentially hazardous areas. The occupational dose limits listed below may not be exceeded by any employee:
  - An annual limit, which is the more limiting of:
    - The total effective dose equivalent being equal to five (5) rems (0.05 Sv)
    - The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv)
  - The annual limits to the lens of the eye, to the skin of the whole body, and to the skin of the extremities, which are:
    - A lens dose equivalent of 15 rems (0.15 Sv)
    - A willow-dose equivalent of 50 rems (0.5 Sv) to the skin of the whole body or to the skin of any extremity
- If employees are required to perform work in NORM-contaminated areas, Hawk Energy, LLC will use, to the extent practical, process or other engineering controls (e.g., containment, decontamination or ventilation) to control the concentration of radioactive material in the air. When it is not practical to apply process or other engineering controls to control the concentrations of radioactive material in the air to values below those that define an airborne radioactivity area, David Slim will increase monitoring and limit intakes by one or more of the following means:
  - Control of access
  - Limitation of exposure times
  - Use of respiratory protection equipment conforming to National Institute of Occupational Safety and Health (NIOSH) standards, including HEPA filters or supplied air respirators
  - Respiratory protection will comply with the Company's respiratory protection policy

Testing

Initial tests, inspections and checks of the signal-generating system will be conducted to verify that the fabrication and installation were made in accordance with design plans and specifications and to develop a thorough understanding of the performance of the system and all components under normal and hostile conditions.

Once the system has been placed in service, periodic tests, inspections and checks will be made to minimize the possibility of malfunction.

Following significant alterations or revisions to the system, tests and checks similar to the initial installation tests will be conducted.

Tests will be designed to minimize hazards while conducting the tests.

Before normal operation, the signal-generating system will be physically and functionally checked to ensure reliability and to demonstrate accuracy and performance. Specific tests will include:

- All power sources
- Calibration and calibration stability
- Trip levels and stability
- Continuity of function with loss and return of required services such as AC or DC power, air pressure, etc.
- All indicators
- Trouble indicator circuits and signals, where used
- Air pressure (if used)

Ensure that the sound level of the signal is within the limit of 1910.1096(f)(1)(ii) of this section at all points that require immediate evacuation.

In addition to the initial startup and operating tests, periodic scheduled performance tests and status checks will be conducted to ensure that the system is always operating within design limits and capable of the required response. Specific periodic tests or checks or both will include:

- Adequacy of signal activation device
- All power sources
- Function of all alarm circuits and trouble indicator circuits, including trip levels
- Air pressure (if used)
- Function of entire system, including operation without power where required
- Complete operational tests, including sounding of the signal and determination that sound levels are adequate

Periodic tests will be scheduled on the basis of need, experience, difficulty and disruption of operations. The entire system will be operationally tested at least quarterly.

All employees whose work may necessitate their presence in an area covered by the signal will be made familiar with the actual sound of the signal, preferably as it sounds at their work location. Before placing the system into operation, all employees normally working in the area will be acquainted with the signal by actual demonstration at their work locations.

Hawk Energy, LLC

Employee Instruction and Information for NORM

Naturally Occurring Radioactive Materials

What is NORM?

These are radioactive elements that occur naturally in the earth's rocks, soils and water in varying concentrations. In many industrial operations, including oil and gas extraction and processing, NORM can accumulate at concentrations above normal in by-product waste streams, leading to elevated levels of radioactivity. The presence of elevated NORM concentrations (i.e., above background) in some oil and gas waste streams has been recognized since the early 1930s; however, NORM concentrations have been largely unregulated. Since the mid-1980s, both federal and state regulatory agencies have become increasingly concerned about the presence of NORM.

Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) refer to any NORM not subject to regulation under the Atomic Energy Act whose radionuclide concentrations or potential for human exposure have been increased above natural levels due to human activities. Such activities include mining and milling of ores, extraction of petroleum products, use of groundwater for domestic purposes and living in houses. These activities alter the natural background of radiation either by moving naturally occurring radionuclides from inaccessible locations to locations where humans are present or by concentrating the radionuclides in the exposure environment. Such alterations of the natural environment can increase, sometimes substantially, radiation exposures of the public.

The primary radionuclides of concern in oil and gas NORM are radium-226 and radium-228. These isotopes are the decay products of uranium and thorium isotopes that are present in subsurface formations from which hydrocarbons are produced. While uranium and thorium are largely immobile, radium is slightly more soluble and may become mobilized in the fluid phases of the formation. Other radionuclides of concern, particularly in gas processing equipment, are lead-210 and radon-222, which is sometimes present in natural gas. The amount of radioactivity that accumulates in oil and gas wastes depends on a variety of factors, including the amount of uranium and thorium present in the subsurface formation, the formation fluid chemistry, extraction and treatment processes and the age of the production well.

Both the petroleum industry and regulators are becoming increasingly concerned about the presence of NORM. At present, most existing federal environmental regulations do not address oil and gas NORM, and only a few states have developed regulatory programs. Available data suggest that the occurrence of NORM (and associated health risks) is significant enough to warrant increased regulatory control. However, before these regulations can be developed, additional research is needed to:

- Better characterize the occurrence and distribution of NORM throughout the industry
- Quantify hazards posed by NORM to industry employees and the general public
- Develop effective waste treatment and minimization technologies that will lower the risk associated with NORM and reduce disposal costs

Where NORM might be encountered

Humans can be exposed to NORM radiation through many different pathways. Populations at risk from exposure to NORM radiation include employees at equipment cleaning facilities, oil field employees, employees at facilities where NORM is disposed of, oil and gas refining facilities and the general public. The pathways of concern for occupational exposure include external gamma exposure, dust inhalation, skin beta exposure and radon inhalation.

External gamma exposure can occur when the radioactivity of NORM inside equipment is high enough that gamma rays penetrate the walls, when NORM-contaminated scale builds up on the outside of casing and tubing strings, and when contaminated scale and sludge are removed from equipment, thereby eliminating the shielding factor provided by the equipment walls. Dust inhalation or skin beta exposure can occur whenever contaminated scale and sludge are uncontained, but the risk is particularly great when equipment cleaning processes release airborne particles of NORM. The rsk to employees are increased at disposal facilities where NORM-contaminated wastes and equipment are buried without radiation control features and at smelters where NORM detection systems have not been installed.

Oil and gas extraction and processing operations sometimes accumulate NORM at concentrations above normal in by-product waste streams. Results from NORM surveys indicate that radionuclide concentrations can be quite variable, ranging from undetectable to extremely high levels. To date, efforts to characterize the geographic distribution of NORM have been limited by poor statistical representation. In addition, the fate of NORM in the environment has not been fully defined and few human health risk assessments have been conducted.

The source for most oil and gas NORM is dissolved radium that is transported to the surface in the produced water waste stream. Radium dissolution and precipitation depend on factors such as the formation water salinity, pH, temperature and pressure.

Dissolved radium either remains in solution in the produced water or, under proper conditions, co-precipitates with barium, strontium or calcium to form either hard sulfate scales or more granular silicate and carbonate sludges. Radioactive scale deposits are found in all types of water-handling equipment, such as piping, filters and components of brine disposal/injection wells. Radioactive sludge deposits accumulate inside piping, separators, heater/treaters, storage tanks and other equipment used to handle produced water. Production and processing equipment may be contaminated by deposits of radioactive scale and sludge, which can lead to disposal problems when the equipment is taken offline for repair or replacement.

NORM-contaminated sludge and scale accumulate inside oil production and processing equipment. NORM contamination tends to be greatest in equipment where produced water is handled or stored, such as water lines, flow lines, injection wellheads, vapor recovery units, water storage tank, heater/treaters and separators. When contaminated equipment is taken off-line, the NORM present inside can cause disposal problems. Some types of equipment (e.g., flow lines, storage tanks) can be cleaned to remove the contaminated sludge and scale. Cleaned equipment may be reused if it is in good condition; however, the cleaning process generates radioactive waste that require disposal. Other types of equipment (e.g., wellhead filters, pumps) cannot be cleaned easily and will be disposed of intact.

The highest concentrations of radium typically are found in scale deposits that form when dissolved radium co-precipitates with barium, strontium or calcium sulfates. These sulfates form hard, insoluble deposits on the inside of piping, filters, brine disposal/injection wells and other water handling equipment. In Michigan, radioactive scale deposits have also been detected on exterior surfaces of downhole casing and tubing. Scale deposits can thicken and may need to be removed by cleaning processes to ensure that equipment will operate.

In general, radium concentrations are highest in wellhead piping and in production piping near the wellhead (EPA 1991). Radium content in most scale ranges from background levels to several thousand picocuries per gram. However, much higher concentrations have been measured in Michigan (i.e., from 76,000 to 159,000 pCi/g of Ra-226, suggesting that the range of NORM concentration is much greater.

Radon emanation rates (the fraction of radon released) from scale typically are around 5%, primarily because the hard, solid structure of the scale inhibits the release of radon as gaseous progeny.

Natural gas production and processing equipment may be contaminated with a thin film of Pb-210 plated onto interior surfaces. Lead-210 is a long-lived daughter product of Rn-222, which sometimes is produced along with natural gas and partitioned mainly between the propane and ethane fractions. If allowed to accumulate for a sufficient time, Pb-210 will decay to produce bismuth-210 and polomum-210, relatively short-lived isotopes that decay to stable lead-206. Gas plant equipment with the highest levels of Pb-210 includes reflux pumps, propane pumps and tanks, other pumps and production lines. Lead-210 decays by beta emission, emitting only low-energy gamma rays and poses less disposal hazard and reduced exposure threat to humans than other forms of radiation. However, because it is difficult to measure radiation levels inside equipment and because employee awareness is low, Pb-210 plating still may pose a significant operational hazard.

Health Risk Assessments

The hazards associated with human radiation exposure from any source depend on a variety of factors, including the type of radioactive emission, activity level, exposure pathway and environmental setting.

Types of Radioactive Emissions

Three (3) types of radioactive emissions occur: alpha, gamma and beta. Alpha radiation is particulate, depositing its energy within a small volume but with limited penetrating power. Although alpha radiation can result in more concentrated doses, minimal shielding can provide protection. The greatest exposure pathway of concern related to alpha radiation usually is through inhalation or ingestion. Gamma radiation is electromagnetic, capable of penetrating deeply into materials but with a more diffuse distribution. Although the diffuse distribution results in a lower dose, the penetrating power of gamma radiation can result in exposures over great distances if the source is not adequately shielded. Therefore, in addition to inhalation and ingestion, external exposure to gamma radiation is a critical pathway. Beta radiation is somewhat intermediate to alpha and gamma radiation in terms of penetrating power; exposure pathways of concern related to beta radiation include inhalation, ingestion and dermal contact.

Radiation Exposure Limits

Conceptually, there are acceptable levels of radiation exposure below which there are no undue human health risks. Radiation exposure limits established by federal regulations and guidelines for other waste types will be applicable to NORM-contaminated oil and gas wastes. Limits have been established or recommended for radionuclide concentrations in drinking water, radon concentrations in indoor air and total external exposure.

Radium concentrations in drinking water are limited to five (5) pCi/L (40 CFR 141). A proposed rulemaking would raise the radium standard to 20 pCi/L and establish a drinking water standard of 300 pCi/L for radon.

Average indoor radon concentrations are approximately two (2) pCi/L. The EPA recommends additional testing and, possibly, remediation efforts when indoor radon concentrations are greater than four (4) pCi/L. By deducting the average background radon concentrations from the EPA's recommended action level, the exposure limit attributable to radon release from oil and gas NORM (or any other radon source) will be approximately two (2) pCi/L. The CRCPD recommends limiting radon emanation rates from the surface to two (2) pCi/m2/s. At licensed NORM waste disposal sites, operated in accordance with the EPA's regulations for uranium mill tailings disposal sites as specified in 40 CFR 192, surface radon flux to the atmosphere will be limited to 20 pCi/m2/s, averaged over the disposal site over any one (1)-year period.

In accordance with 40 CFR 190.10, Environmental Standards for the Uranium Fuel Cycle, annual dose equivalents for whole-body radiation will not exceed 25 mrem/yr. for any member of the general public. OSHA standards, which apply to oil and gas industry operations, limit employee exposure.

Exposure rates for NORM

Median exposure levels for oil production equipment range from two (2) to 42 urem/h above background; median exposure levels for gas processing equipment range from two (2) to 76 urem/h above background, where median background level = seven (7) urem/h.

According to API, gamma-ray measurements on NORM-contaminated equipment usually indicate levels of radiation below levels considered to be of concern, although survey results from Michigan included exposure rates as high as 5,300 uR/h. Despite Michigan's elevated readings, the primary threat associated with contaminated equipment is ingestion or inhalation of NORM when the equipment is opened for inspection or repair. It is difficult to predict the activity level of the NORM from external measurements because some radiation is absorbed by the metal wall and distribution of the NORM may vary.

NORM concentrations in oil and gas wastes vary considerably, both geographically and with respect to specific waste streams. Concentrations can range from undetectable levels to 40,000 pCi/g of radium-226 (Ra-226), the primary isotope of concern. The EPA estimates an average total radium concentration in oil and gas NORM of 210 pCi/g (155 pCi/g of Ra-226 and 55 pCi/g of radium-228 (Ra-2281). Radium is considered to be the most hazardous radionuclide in the natural environment and average radium concentrations in soil range from one half (1/2) to several picocuries per gram according to the American Petroleum Institute. NORM concentrations in some oil and gas wastes are similar to those found in uranium mill tailings, which are heavily regulated by the Atomic Energy Act (AEA). The petroleum industry has stated that most NORM occurs in small quantities and at low levels of radioactivity; however, highly elevated radionuclide concentrations do occur and warrant attention.

Radiation Exposure Pathways

Radiation exposure from oil and gas NORM can occur from seven (7) environmental pathways: radon inhalation, external gamma exposure, groundwater ingestion, surface-water ingestion, dust inhalation, food ingestion and skin beta exposure. Populations at risk from exposure to NORM radiation include employees at equipment cleaning facilities, oilfield employees, employees at NORM disposal facilities and the general public.

Employees in equipment designing facilities are considered to be at the greatest risk for exposure to NORM. Exposure pathways of concern are external gamma exposure, dust inhalation and skin beta exposure. External exposure occurs when:

11. The concentration of NORM inside equipment is high enough that gamma rays penetrate the equipment walls.
12. Contaminated scale and sludge are removed from the equipment, thereby eliminating the shielding factor provided by the equipment walls. Dust inhalation is possible when dry cleaning processes are used without adequate controls. Direct contact with contaminated scale and sludge can result in skin beta exposures.

The pathway of greatest concern for oilfield employees is external gamma exposure. External exposure can occur when:

- The concentration of NORM inside equipment is high enough that gamma rays penetrate the equipment walls.
- NORM-contaminated scale accumulates on the outside of casing and tubing strings.

More concentrated external gamma exposure and dust inhalation may occur when contaminated scale or sludge is cleaned from the inside surfaces of equipment during well workover operations.

Employees at NORM disposal facilities risk exposure via radon inhalation, external gamma exposure, dust inhalation and skin beta exposure pathways. Risk is increased at facilities where NORM-contaminated waste and equipment are buried without control features (i.e., not at licensed NORM or LLW facilities) and at smelter facilities where NORM detection systems have not been installed.

The general population may risk exposure to NORM via radon inhalation, groundwater ingestion, surface-water ingestion and food ingestion. Improper disposal of NORM-contaminated scale and sludge may lead to soil and water contamination and to higher indoor radon levels in nearby buildings. Ingestion of food grown in contaminated soils or seafood harvested in areas contaminated by produced water outfalls may result in radiation exposure. A recent risk assessment for radium discharged in produced waters indicated a potential risk of exposure exists for an individual who ingests large amounts of seafood harvested near a produced water discharge point over a lifetime.

Federal Regulations

The Occupational Safety and Health Administration (OSHA) has developed safety regulations to limit employee radiation exposure. The oil and gas industry are required to comply with all OSHA regulations or approved equivalent state regulations. The OSHA regulations require employers to evaluate radiation hazards in the workplace and to limit employee exposure to ionizing radiation. In a 40-hour work week, no employee will be exposed to airborne radioactive material in an average concentration of three (3) uCi/mL of Ra-226 and seven (7) uCi/mL of Ra-228 (29 CFR 1910.97). General labeling and posting requirements for the use, storage and transport of radioactive material are also established in 29 CFR 1910.97.

Neither the EPA nor the U.S. Nuclear Regulatory Commission (NRC) has established federal regulations that directly govern NORM wastes from the oil and gas industry, although a number of environmental legislative acts will be amended to encompass these wastes. The NORM Task Group on Regulatory Analysis thoroughly discusses the applicability of federal regulations to oil and gas NORM in an API Training Record

Trainer:	
Signature:	
Date:	
Content of Training	
Attendees	
Print Name:	**Signature:**