Responding to Wildland Fires in or near Abandoned Uranium Mines

Background

Abandoned uranium mines exist on both BLM and Forest Service lands and interagency Wildland Firefighters maybe required to fight fires in these areas. General knowledge and understanding of potential radiation exposure on these sites is necessary for the fire community to make valid risk assessments during fire activities.

Most uranium ore is mined in either open pit or underground mines[1]. In the early years of the atomic era, up until the 1960's, uranium was predominantly mined in open pit mines from ore deposits located near the surface. The uranium content of the ore is often between only 0.1% and 0.2%, and consequently, large amounts of ore have to be mined to get at the uranium. High walls, exposed radioactive lignite beds and mine spoils were left exposed after the open pit mining activity was done, and open pit mining operations produced great amounts of waste rock (tailings) from overburden. These tailing piles often contain elevated concentrations of “Naturally Occurring Radioactive Material” (NORM) in comparison to normal rock. However, radioactivity from these sites is considered to be low.

Exposure limits for radioactive sources and nuclear devices have been identified by the Nuclear Regulatory Commission (NRC) under 10 CFR 20 for both the general public and occupational populations. The maximum allowable occupational exposure is 5000mrem/yr and this limit applies to persons working in the nuclear field, such as reactor workers. The exposure limit is reduced to just 100 mrem/yr for the general public.[1] The general public exposure limit applies to employees in academic, university, industrial, and medical facilities that use radioactive material, as well as employees such as BLM/US Forest Service Wildland Firefighters. Additionally, the dose rates established by the NRC for both occupational and public populations are significantly lower than the levels that have been demonstrated to cause health effects (cancer, genetic abnormalities). Public health data have not established the occurrence of these health risks following exposure to low doses and low-dose rates — below about 10,000 millirem (mrem)[2].

The regulatory community, including the Environmental Protection Agency (EPA) and the NRC has always promoted the concept of “As Low As Reasonably Achievable” (ALARA) for radiation exposure. ALARA is the concept that exposure to radiation should be minimized to the extent practical and should not be based on dose limits alone. A fundamental tenet of ALARA is that radiation program managers must use sound judgment in protecting individuals to keep exposures below the acceptable limits.[3] Risk must be balanced against acceptable benefit and is taken into account when establishing exposure limits. The risks of not fighting the fire because of some potential radiation NORM exposure may be much higher than fighting the fire. The economic and environmental benefits warrant action. Fighting wildland fires in or around uranium mine areas should be limited to operational purposes and it is advised that sleeping and eating areas be located away from these sites.

Radiation Risk in Perspective

In order assess the risk that fire fighters may have at these sites we can compare the expected dose rates from various known sources.

Source/Activity	***Average Dose/year(or as noted)***
5 hour jet plane ride	***3 mrem/5 hours***
Building material	***4 mrem***
Chest X-ray	***8 mrem***
Cosmic	***30 mrem***
Soil	***35 mrem***
Internal to our body	***40 mrem***
Per Mammogram	***138 mrem***
Radon gas	***200 mrem***
Per CT Scan	***2500 mrem***
Smoking 20 Cigarettes/day	***5300 mrem to the lung***
Per Cancer treatment	***5,000,000 mrem to the tumor***

For the general public, the exposure limit is 0.001 Sv/year (100 mrem/year).[4] The public dose limit is set at least 50 times lower than the occupational limit to give the public an extra margin of safety. According to American Cancer Society, in the US, the chance of an individual contracting a fatal cancer from all causes (smoking, drugs, alcohol, and pollution) is approximately 25 percent.

The maximum allowable exposure from an external source to the general population has been determined by the NRC to be 2 mrem/hr.[5] Wildland firefighters should not be classified as radiation workers and therefore are not covered by the occupational dose limit. A prudent conservative standard to apply to the firefighting community would be the use of the 100 mrem/yr allowable for the general public, in conjunction with the 2 mrem/hr as the maximum exposure rate.

An exposure assessment model based on conservative values (attachment 1) conducted by Dr. John Cardarelli CHP, CIH, P.E. indicates that " Even with extremely conservative assumptions about duration of exposure, breathing rates, etc., the potential radiation exposures for Wildland Firefighters are not likely to approach 100 mrem per yr."

Assessment Strategies

If there is a concern about fighting fire at a specific abandoned uranium mine, the following modeling strategies can be used to assess exposure. A trained resource advisor with calibrated radiation detection equipment should be ordered up to take measurements of the radiation. The results can be put into the formulas below to assess exposure:

Example:

You are at an abandoned uranium mine preparing to fight a fire and measuring .04 mrem/hr on a Geiger Muller Tube Radiation Counter. Your maximum yearly allowable exposure is 100 mrem/yr, so how many 12 hour work days can you work at the site?

12hr/day x .04 mrem/hr = 0.48 mrem/day 100 mrem/year ÷ 0.48 mrem/day = 208.3 days/yr

General Guidelines

If monitoring equipment is to be used the use of passive environmental integrating devices as area monitors or air sampling can be performed. Individual dose can then be estimated by how much time was spent in the area and assumed breathing rates.

Radiation measuring equipment must be maintained, stored correctly and calibrated according to the manufacturer's specifications. Employees using this equipment will be thoroughly trained and understand the limitations of the equipment and interpretation of the exposure limits associated with the use of this equipment. Training will be documented.

Awareness training with good risk communication strategy is very effective in allaying concerns that firefighters may experience while fighting a fire in an elevated NORM environment. Firefighters must be sufficiently knowledgeable so that they understand that radiation exposure to "NORM" is of little concern relative to the routine dangers they face in their job.

References

1. 10 CFR part 20 Standards for Protection against Radiation Section.1201

2. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/tritium-radiation-fs.html

3. The National Council on Radiation Protection and Measurements (NCRP), in Reports No. 116 and No. 127 (NCRP, 1993; 1998),

4. http://www.atsdr.cdc.gov/toxprofiles/phs149.html#bookmark09

5. 10 CFR Subpart D--Radiation Dose Limits for Individual Members of the Public 20.1301

Attachment 1

Occupational Exposure Assessment Modeling

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Uranium-238 and Thorium-232 radioactive decay series are the naturally occurring radioactive materials (NORM) of concern in the uranium mining industry. The abundance of these uranium and thorium varies widely over geographic areas, ranging from 0.5 to 5 mg per kg of uranium and 2 to 20 mg per kg of thorium.[1] These correspond to concentrations of about 6 to 60 Bq per kg of ^{238}U and 8 to 80 Bq per kg of ^{232}Th. This is the uranium ore concentrations, not the overburden waste materials that firefighters are likely to be exposed to. Typical soil in the United States, for comparison, contains about 0.04 Bq each of ^{226}Ra, ^{238}U, and ^{232}Th per g, and the US EPA surface soil standard for remedial actions at inactive uranium processing sites is 0.185 Bq ^{226}Ra per g.

The sources of radiation exposures to fire fighters working in a technologically enhanced NORM (TENORM) may include external gamma radiation, airborne radon, radon-decay products and ore dust containing radionuclides. Radon and radon-decay products are not expected to be of any significance in the fire-fighting scenario due to the extreme dilution and turbulent environmental conditions during a large fire. Inhalation of the long-lived alpha-emitting materials in the ore dust and overburden mining waste and exposure to external gamma radiation may warrant consideration but generally is not significant relative to the other acute hazards present during firefighting (e.g., fire, smoke inhalation, heat stress).

External exposures will vary significantly based on the uranium, thorium, and radium concentrations in the material, how close the firefighters are to the surface, and how long they are in the area. In mines, the gamma exposure rate varies from less than 0.1 mrad per h in shafts and tunnels to 0.5 to 1.5 mrad per h near ore faces or ores of 0.2 percent uranium oxide. You can speculate that firefighters are not likely to be near (within 12 inches of) the surfaces for long periods of time (>24 hours) during firefighting activities to warrant protective actions from external radiation exposures.

Ore dust containing uranium and uranium-decay products may be suspended in the air due to fire and wind. The concentrations of the radionuclides will vary with time, location and local conditions of the fire and wind. In ordinary mining activities, the average concentration of radionuclides is below 0.3 Bq per cubic m of air and this is below the limiting airborne concentrations. The dose rate factor for immersion in contaminated air (Gy/y per Bq/m^3) for ^{238}U is 1.39E-10[2]. This equates to a dose of about 4.17E-11 Gy per y (4.17E-9 rad per y). If the air concentration during firefighting is equivalent to ordinary mining activities, then the inhalation dose component is likely to be insignificant as well.

These examples are provided to demonstrate how low the radiation exposure potentials are while fighting a fire in an area containing NORM materials. Even with extremely conservative assumptions about duration of exposure, breathing rates, etc., the potential radiation exposures are not likely to approach 100 mrem per yr.

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[1] NCRP 117. Radiation Protection in the Mineral Extraction Industry, 1993.

[2] The Health Physics and Radiological Health Handbook, Revised Edition 1992