CONTROL TECHNOLOGY ALTERNATIVES AND COSTS FOR COMPLIANCE - ELEMENTAL PHOSPHORUS PLANTS

FINAL REPORT TO THE
ENVIRONMENTAL PROTECTION AGENCY

R. T. Stula
B. E. Kirstein
R. T. Redding
D. L. deLesdernier
W. F. Horton
P. H. Hunter
R. F. May
R. E. Belanger

R. Kirby, Contracting Officer
J. M. Gruhlke, Project Officer

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ENERGY SYSTEMS GROUP
SCIENCE APPLICATIONS, INC.

P.O. Box 2351, 1200 Prospect Street, La Jolla, California 92038

3.0 BACKGROUND

3.1 RADIONUCLIDES IN PHOSPHATE ORES

Phosphate ore deposits are located in three principal regions of the United States:

- Southeastern region (mainly Florida, but also South Carolina, North Carolina, and Georgia)
- Northern Rocky Mountain region of eastern Idaho, western Wyoming, northern Utah, and southwestern Montana
- Middle Tennessee

Most of this country's marketable phosphate rock is produced in Florida, but most of the ore used in elemental phosphorus production is from the other regions. The phosphate ores from the three principal regions are distinct in their radiological characteristics. Generally, ores from the southeastern region have the highest radionuclide concentrations, followed respectively by those from the northern Rocky Mountain region and those from middle Tennessee. The radioactivity content of phosphate rocks from different deposits within the same general region, however, may vary widely. Most of the natural radioactivity present is represented by the uranium series radionuclides (Figure 3-1), although some phosphate rocks also contain elevated levels of thorium and its daughter products. Uranium-238 is a primordial radionuclide that heads a series of heavy radioactive atoms. If a phosphate deposit is sufficently old and has not been subjected to physical or chemical separation processes, the radionuclides present should be in a state of radioactive equilibrium, wherein the rate of decay of each radionuclide is very nearly equal to that of the parent U-238. Table 3-1 gives radionuclide concentration data for phosphate rocks of various geographic

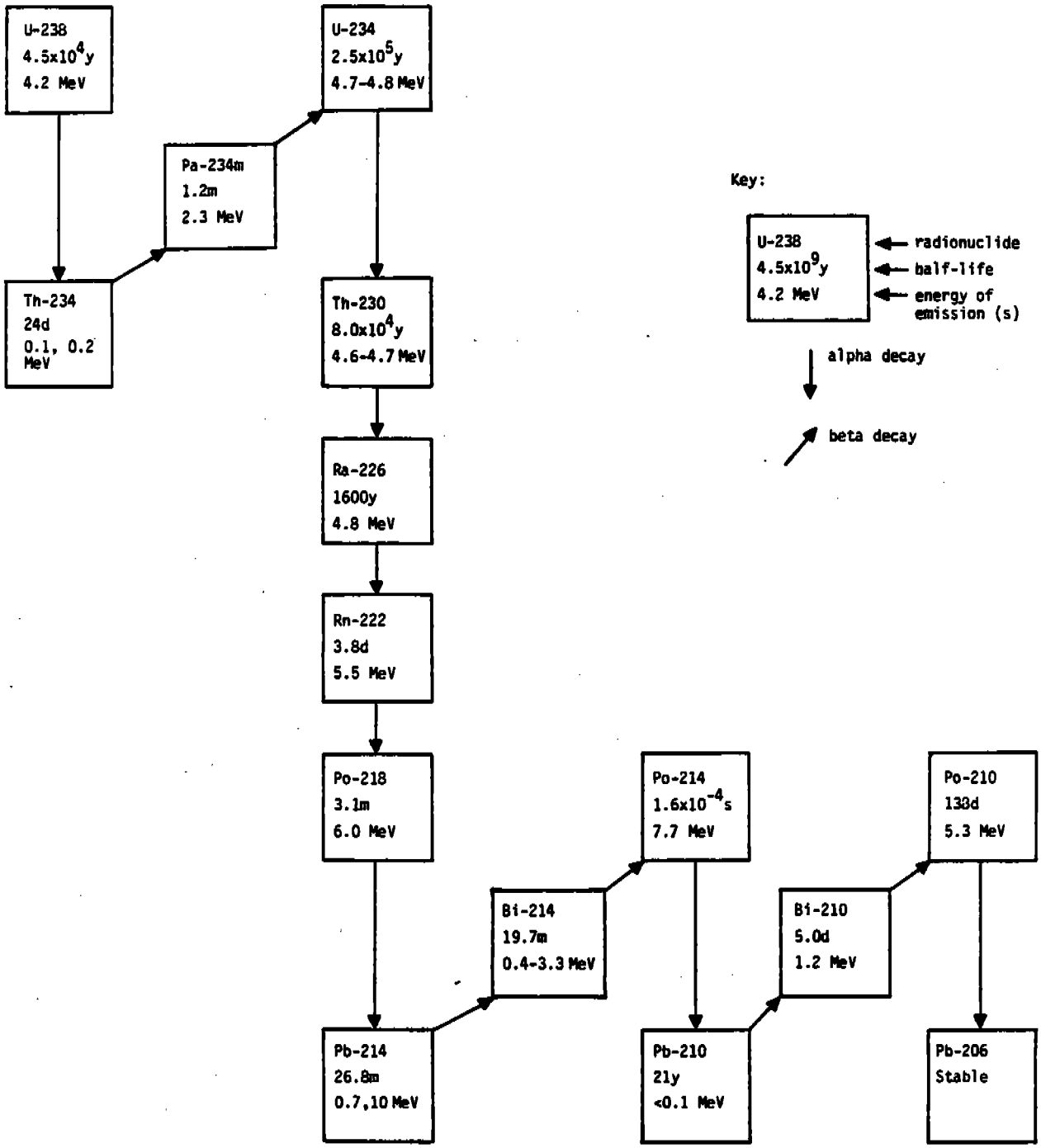

Figure 3-1. The Uranium Decay Series.

Table 3-1. Radionuclide Concentrations in Phosphate Rocks of Various Origins.

Origin	Type of Material	No. Samples	Radionuclide Concentration (pCi/g)			Remarks
			U-238	Ra-226	Th-232	
Florida	Pebble	11	69	73	1.5	Data are from Ref. [2]; concentration data are median values and are converted to pCi/g from reported units of ng/kg or mg/kg
		4	73	74	1.2	
		14	49	53	1.4	
	Soft phosphate	12	42	43	1.9	
	Miscellaneous phosphate	7	34	31	2.1	
		9	25	21	1.9	
North Florida	Mining land matrix	4	NS(1)	8.6	NS	Data are from Ref. [3]; concentration data are mean values and are reported on dry weight basis
	Pebble	1	NS	26	NS	
	Rock concentrate	4	NS	17	NS	
Central Florida	Mining land matrix	6	NS	38	NS	
	Pebble	13	NS	57	NS	
	Rock concentrate	12	NS	35	NS	
North Florida	Mining land matrix	NS	7.6	8.6	NS	Data are from Ref. [4]; concentration data are mean values of composite samples
Central Florida	Mining land matrix	NS	20	18	NS	
Florida	Marketable phosphate rock	NS	41	42	0.5	Data are from Ref. [5]
Tennessee	Brown rock	17	3.6	4	0.7	Data are from Ref. [2] and are median values converted to pCi/g from reported units of ng/kg or mg/kg
		8	4.3	4	0.6	
		3	3.3	4	0.7	
Tennessee	Blue rock	3	5.3	7	0.3	
	White rock	4	3.3	5	0.2	
	Phosphatic limestone	3	2.6	3	0.2	
South Carolina	Phosphate	11	132	133	2.1	
North Carolina	Phosphate	3	25	18	1.0	
Arkansas	Phosphate	13	9.9	11	1.4	
Oklahoma	Phosphate	5	8.3	10	0.9	
Montana	Phosphate	10	38	41	0.8	
Idaho	Phosphate	5	50	49	0.9	
Wyoming	Phosphate	4	60	62	1.3	
Utah	Phosphate	9	42	50	0.8	

(1) NS = Not specified

origins. The table indicates that the uranium series radionuclides in phosphate ores are in equilibrium.

3.2 RADIONUCLIDES IN PLANT MATERIALS

The major products of the elemental phosphorus industry are elemental phosphorus and the by-products associated with its production. The major by-products are calcium silicate slag produced at rates of 8 to 9 tons per ton of phosphorus produced [6] and ferrophosphorus. Other significant by-products include processed dust removed from furnace offgases and furnace offgas condenser exhaust (CO).

Radionuclide concentrations in elemental phosphorus are very low because of numerous plant production isolation and purification steps. Elevated concentrations of uranium series radionuclides, however, are found in the slag, processed dust, and to a much lesser extent, the ferrophosphorus. An activity balance of the nonvolatile radionuclides entering the production process indicates that most of output activity can be accounted for in the slag.

The elemental phosphorus production process results in the release of fugitive dust and particulate emissions containing uranium series radionuclides. In addition, two long-lived radon daughters, Po-210 and Pb-210, have boiling points low enough to be vaporized by the process, and may be released to the atmosphere. In general, the air pollution control equipment in phosphorus plants is installed to reduce particulate and fluoride emissions. While such equipment is also effective in reducing emissions of radioactive particulate material, it is much less effective at removing radionuclides present as fumes or vapors. Polonium-210, for example, is volatilized during phosphate ore calcining, and significant quantities can be released through particulate emission control equipment during calcining.

3.3 GENERAL INDUSTRY DESCRIPTION

3.3.1 Plants

Table 3-2 lists each plant examined in this study, its location, and its design capacity.

9.0 REFERENCES

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