Division of Biological and Medical Research

Argonne National Laboratory

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Trip Report of A. M. Brues and M. W. Rosenthal

Informal Meeting on "Plutonium Contamination in Man" at Rocky Flats, Colorado, July 25-26, 1966

This meeting was held at the Rocky Flats plant of the Dow Chemical Company, near Boulder, Colorado. The work at that plant which is germane to the subject of the meeting is chemical engineering and metallurgical in nature and consists in the recovery of plutonium from various materials and in fabrication of plutonium metal. The work is carried out by dry box techniques, and occasional exposures have occurred through inhalation of radioactive aerosols or through introduction of material into accidental wounds. Industrial health representatives of some other laboratories handling this sort of material were present at the meeting and there was an exchange of information about the management of accidental contamination. DTPA is generally used, locally in the course of decontaminating wounds, and parenterally to increase the excretion of circulating material; there is evidence also that some deposited Pu may be released by such treatment.

Bioassay is carried out by the usual evaluation of excreta levels. Whole body counting takes advantage of the presence in plutonium of amounts of americium-241 (daughter of Pu^{241}) which are measurable by weak-gamma-counting techniques. This was discussed at some length, both as to counting techniques and with regard to whether the metabolisms of Pu and Am are enough alike to make the latter a suitable tracer for the former. The consensus was, that for practical purposes, i.e. well within a factor of two in body counts, they are. However, further work seems to be indicated, bearing on the case where vigorous DTPA therapy has been used, in view of some evidence that it removes Am more efficiently than Pu.

Data on actual occupational exposures were given by E. A. Putzier (Rocky Flats), W. D. Norwood (Richland) and Phil Dean (Los Alamos). In all, there may be three dozen personnel retaining the maximum permissible body burden (0.04 μCi, or 2/3 microgram plutonium-239), not more than 3 of whom have 10 times that amount. These are divided about equally between the inhalation and wound modes of introduction. Inasmuch as some dogs in the Utah experiment have developed bone tumors after ten years' exposure to skeletal dose rates corresponding to 18 times the human permissible burden, it seems that under the best circumstances, a few industrial exposures can occur which are not very far below demonstrably toxic levels.

Since evaluation of local and general contamination is facilitated by external counting of very soft gamma radiations, there were discussions of methodology in this area. Hodge Wasson (AEC Headquarters) described some very promising developments in solid state counting which get around the problems of detector and amplifier noise and of window thickness, even when photons below 20 KeV are being measured. One has been developed by General Electric, covered by AEC patent, which is not much larger than a thumbnail. Box and screws occupy 95% of that volume and 5% contains a specially prepared boron-silicon crystal and a tunnel diode. The crystal has been treated with phosphorus on one side and gallium on the other and then shaped and etched to gain maximum efficiency. It measures the 5.5 KeV iron-55 gamma very nicely and the output can be fed directly into a scaler. There is no noise, even when it is warmed up to 75°C. In addition to all this it is adaptable to very wide dose rate and energy ranges, is cheap, and so can be used in arrays and combinations ad libitum. Wasson is anxious for people to suggest or develop uses for it and we are planning to do business with him (the Bioassay group here is already doing so). He is going to send some reports which will give an idea of the scope of its potentialities.

Roy Thompson (Richland) mentioned the much greater gastrointestinal absorption by new-born than by adult animals (this is very well known but not very well understood). Polymeric or monomeric Pu given to pregnant rats show much less deposition in the fetus than in the dam. The monomeric material, however, deposits much less heavily in the fetal liver and much more heavily in the fetal skeleton than in the corresponding maternal organs, indicating that it gets into the fetus in a "super-ionic" form.

Pigs have been injected intradermally in 20-30 sites: maximum single-site injection 5 μCi (cf. HW-76000). When given as the nitrate 5-10 percent is deposited in the skeleton and liver within a few days; after a few weeks the injection site sloughs off leaving 1-2% at the site after 2 years. Given as the oxide, one-third remains at the site after a year, up to 10% is found in regional lymph nodes, and less than 1% in internal organs. No tumors have developed 5 years after injections were made.

D. Atherton (Utah) reported gel-filtration chromatographic studies of protein binding of plutonium in the plasma following intravenous injection (Rad. Res. 26:114, 1965). It is bound so strongly to plasma protein that even after a day the plasma contains one-fourth or more of the injected amount. The largest fraction of the protein-bound Pu is associated with transferrin. A recent similar study on americium-241 has shown that it disappears from plasma much more rapidly than plutonium and that its binding with plasma proteins is more labile.

C. Mays (Utah) described the beagle toxicity data and discussed them along the lines of his Argonne seminar last year. Some preliminary work

on americium deposition was mentioned.

W. J. Bair (Richland) prepared oxide aerosols by various methods and got somewhat different retention values after inhalation. All but the most recent work appears in HW-6700 and AFWL-TR-65-214 (March 1966). Of that initially deposited in the lung alveoli, the half-time of retention in lung is between 600-1000 days (300-400 with one preparation). In a long-term experiment begun 6-1/2 years ago, 40 dogs were exposed so that they retained various amounts up to about 10 μCi; 20 of them have died, 12 with pulmonary tumors (the first at 38 months) and 8 others with pulmonary fibrosis and insufficiency. One tumor occurred at 67 months in a lung containing 0.3 μCi (see Health Physics 12:609, 1966).

L. Casarett (Rochester) presented material on lung deposition and transport, mostly based on work by P. Morrow and included in the ICRP task group report on the lung model (Health Physics 12:173, 1966).

Some more or less informal discussion seemed to reveal (1) that while subcutaneous plutonium tends to be translocated to internal organs as if monomeric, that which is deposited in lung tends to be translocated as if polymeric; (2) this may be because there is a good deal of phagocytosis going on in the lung, so that the translocation may be by cellular mechanisms (endocytosis)*; (3) everybody uses the terms "monomeric" or "ionic" but nobody takes them too literally, as they are generally based on ultrafilterability of solutions or on track counts in autoradiographs; (4) the "solubilization" for transport of deposited "insoluble" material, for instance fragments of plutonium metal, may take place through complexing by protein; (5) it is possible that in a long-lived animal with appreciable amounts of Pu in the liver, that organ, rather than bone, may become the "critical organ."

W. Langham discussed the handling of the Spanish plutonium contamination from the accidental dropping of weapons last January. Although a great deal of Spanish soil has been translocated to the southern U. S. for burial, there does not appear to have been a significant amount of human contamination. Some rumors to the contrary have been generated by lay sources and there is a suspicion of ulterior motives for this, since land values in the developing Spanish Riviera are due to improve considerably in the next few years.

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*Casarett thinks that alveolar lining cells become phagocytes and wander off to the lymphatics with ingested material.