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Deposition Velocity of Iodine-131 Over Desert Terrain and Foliage

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The evaluation of the effect of nuclear reactor operations to the environment requires a knowledge of the deposition of biologically-significant radioactive isotopes upon the surface. Foremost in importance among these isotopes is Iodine-131, which can give biologically significant radioactive doses when inhaled or consumed. It is the purpose of this note to review some of the Iodine-131 deposition measurements made at the National Reactor Testing Station (NRTS) in southeastern Idaho and elsewhere for use by meteorologists and health physicists at other sites with similar terrain.

The recent nuclear incident at the Stationary Low Power Reactor No 1 (SL-1) on Jan. 3, 1961 resulted in the slow but steady emission of Iodine-131 for several weeks afterwards [1]. Measurements of air concentration and deposition on the desert-type foliage, sagebrush elements some 50 cm high covering about 20 per cent of the desert floor, were made in great quantity by health physicists and ecologists of the Health and Safety Division, Idaho Operations Office, Atomic Energy Commission. The major isotope in the radiation samples was identified

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by spectroscopic means as Iodine-131. The deposition velocity, V_g, defined as the ratio of the rate of the surface deposition, D, to volumetric air concentration near the ground, χ, by

$$V_g = \frac{D(\text{curies}/m^2/\text{sec})}{\chi\ (\text{curie}/m^3)}$$

is the essential parameter needed for computations of surface deposition from dispersion-deposition models [2]. The deposition in the mathematical model is computed in terms of curies/m^2/sec but the radiation on the vegetation is measured in terms of radioactivity per unit mass, μcuries/gm, so that the density of vegetation is required. From ecological studies, a vegetation density factor of 50 gm m^{-2} was found appropriate for converting the deposition per unit mass measurements into units of deposition per unit area. The deposition velocity for Iodine-131 computed from the air concentration and deposition measurements at several distances from the SL-1 are shown in table 1.

Table 1. Deposition velocities of Iodine-131 from the SL-1 Incident

Distance (Kilometers)	Date	χ (curies m^{-3})	D (micro curies m^{-2} day^{-1})	V_g (cm sec^{-1})
1	Jan. 24	6.0×10^{-11}	1.3×10^{-2}	0.25
8.5	Jan. 4	3.6×10^{-11}	6.7×10^{-3}	0.21
67	Jan. 9	4.0×10^{-12}	7.8×10^{-4}	0.23

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There appears to be little variation of V_g with distance, although the samples were not collected on the same days at the various distances. The deposition velocities in table 1 are probably most appropriate for stable atmospheres since, there were about 17 hrs. of strong inversion in the day during the period of the measurements. The air concentration filters, consisting of a pre-filter to collect particulate Iodine-131 and a charcoal cartridge to collect the gaseous material, were changed at daily or weekly intervals. [About half of the Iodine-131 was collected on the pre-filter, indicating that there was virtually an even division of the effluent into particulate and gaseous form.] There is some evidence [3] that the deposition of molecular Iodine-131 is considerably greater than that of the particulate form.

NOT TRUE THAT I^{131} IN PREFILTER MUST BE PARTICULATE GAS [illegible] RATE GOVE[illegible] EFFICIENC[illegible]

A number of planned releases of Iodine-131 have been performed at the National Reactor Testing Station, Idaho and Dugway Proving Grounds, Utah in which reactor fuel elements were melted down and the radioactive materials were released over a densely-sampled grid. Comparisons of many samples of vegetation and air concentration-measurements from one such test, conducted by General Electric Company during nearly neutral temperature lapse conditions [4], gave V_g-values of about 0.15 cm sec^{-1} with little variation with distance out to the end of the grid, some 4 mi. distant. The sagebrush density in this area appeared to be somewhat less than in the region downwind of the SL-1. A number of similar experiments were performed at the NRTS and the Dugway Proving Grounds,

Utah [5]. Most of the Iodine-131 from these releases was found to be sub-micronic in size, with nearly half in the molecular form. The deposition velocities are shown for various types of collection media in table 2, none of which were natural vegetation or surfaces. It appears that deposition velocities from gummed paper samples in stable atmospheres

Table 2. Deposition velocities (cm-sec^{-1}) for various collection media. (courtesy of R. E. Field).

Meteorological Conditions	Gummed Paper	Grass Trays	Water	Sand
Lapse or Weak Inversion (NRTS)	1.1	——	1.6	0.7
Strong Inversion (Dugway, Utah)	0.2	1.5	——	——

are quite similar to that obtained over desert-type foliage, whereas the other collection media require some simultaneous measurements of deposition on natural surfaces to interpret their meaning.

The nuclear accident at Windscale, England on Oct. 10-11, 1957 resulted in the release of large amounts of Iodine-131 from which Chamberlain [6] computed deposition velocities over the downland of 0.1 cm sec^{-1} at Harwell and 0.3 to 0.4 cm sec^{-1} at the Lancashire/Yorkshire region. These are quite similar to the values in table 1, despite differences in terrain and atmospheric diffusion conditions. The meteorological conditions following the Windscale accident were mostly

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mild to strong temperature lapse compared to the more stable atmosphere for the SL-1 incident.

Recently the Weather Bureau Research Station at the NRTS has conducted a series of dispersion-deposition measurements utilizing a fluorescent tracer, uranine dye, which has a median particle size of less than 1 micron [7]. The total amount of tracer deposited between the release point and 400 m downwind was computed from the vertically-integrated air concentrations measured on 30-m sampling towers at that distance. With the use of Chamberlain's dispersion-deposition model [2] and the measured air concentration, deposition velocities can be computed for comparison to the direct measurements discussed above. During very stable atmospheric conditions, deposition velocities of 0.2 cm-sec^{-1} were computed from the tracer-balance measurements. These are in remarkable agreement with the various measurements of deposition velocity of Iodine-131 made at the NRTS.

It appears from the measurements discussed in the previous paragraphs, that a deposition velocity of 0.2 cm sec^{-1} for Iodine-131 is the best value to use for health and safety type calculations over desert type terrain such as at the NRTS. Variations of deposition velocity with atmospheric stability, if any, seem to be as yet not understood and require more study.

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