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OAK RIDGE NATIONAL LABORATORY

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Moore, et al., 1979

RSIC COMPUTER CODE COLLECTION

AIRDOS-EPA

ESTIMATION OF RADIATION DOSES CAUSED BY AIRBORNE RADIONUCLIDES IN AREAS SURROUNDING NUCLEAR FACILITIES

NRC reg guide 1.109

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AIRDOS-EPA: A COMPUTERIZED METHODOLOGY FOR ESTIMATING ENVIRONMENTAL CONCENTRATIONS AND DOSE TO MAN FROM AIRBORNE RELEASES OF RADIONUCLIDES

R. E. Moore – 576-2130
C. F. Baes III 574-7302
Min Lora L. M. McDowell-Boyer – 576-2125
Min ___ A. P. Watson – 576-2126
F. O. Hoffman – 576-2118
J. C. Pleasant
C. W. Miller – 576-2136
P.C. Nelson

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OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

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ABSTRACT

The AIRDOS-EPA computer code is a methodology, designed for use on IBM-360 computers, that estimates radionuclide concentrations in air; rates of deposition on ground surfaces; ground surface concentrations; intake rates via inhalation of air and ingestion of meat, milk, and fresh vegetables; and radiation doses to man from airborne releases of radionuclides. This report describes the atmospheric and terrestrial transport models used in the code, their computer implementation, and the applicability of the code to the assessment of radiological impacts. A listing of the code and a demonstration run of the code are presented in the appendices.

A modified Gaussian plume equation is used to estimate both horizontal and vertical dispersion of as many as 36 radionuclides released from one to six stacks or area sources. Radionuclide concentrations in meat, milk, and fresh produce consumed by man are estimated by coupling the output of the atmospheric transport models with the U.S. Nuclear Regulatory Commission, Regulatory Guide 1.109 terrestrial food chain models. Dose conversion factors are input to the code, and doses to man at each distance and direction specified are estimated for total body, red marrow, lungs, endosteal cells, stomach wall, lower large intestine wall, thyroid, liver, kidneys, testes, and ovaries through the following exposure modes: (1) immersion in air containing radionuclides, (2) exposure to ground surfaces contaminated by deposited radionuclides, (3) immersion in contaminated water, (4) inhalation of radionuclides in air, and (5) ingestion of food produced in the area.

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The code may be run to estimate highest annual individual dose in the area or annual population dose. For either option, output tables summarize doses by nuclide, exposure mode, and organ. Also, for either a square or circular grid option, ground concentrations of radionuclides and intake rates by man are tabulated for each environmental location. Working level exposures are also calculated and tabulated for inhalation of ^{222}Rn short-lived progeny. Run time is less than 5 min on the IBM 360/91, and the core requirement is 650 K (kilocore).

1. INTRODUCTION

The AIRDOS-EPA computer code was developed at Oak Ridge National Laboratory (ORNL) to be used by the U.S. Environmental Protection Agency (EPA) as part of a methodology to evaluate health risks to man from atmospheric radionuclide releases. This report describes the final version of an interim methodology outlined under Task I of Interagency Agreement No. EPA-78-D-X0394 between ORNL and the EPA. The models and parameters described in AIRDOS-EPA will be reviewed and reevaluated under Task II of this interagency agreement.

The code is a modified version of AIRDOS-II (Moore, 1977), which has been used by the Environmental Sciences Division (ESD) and the Health and Safety Research Division (HASRD) of ORNL for several years to assess radiological impacts of routine operations of nuclear facilities. Both point sources and uniform area sources of atmospheric releases of radionuclides can be evaluated by AIRDOS-EPA, which estimates (1) concentrations in air, (2) rates of deposition on ground surfaces, (3) ground surface concentrations, (4) intake rates by man via food ingestion and air inhalation, and (5) radiation doses received by man.

As many as 36 radionuclides released from one to six stacks or area sources can be handled in a single computer run. Annual-average meteorological data for the area surrounding a nuclear facility may be supplied as input to the code, which then estimates air and ground concentrations and intake rates by man for each radionuclide at various distances and directions from the release point or the center of an area source. From these values, doses to man at each distance and direction specified are

estimated for total body, red marrow, lungs, endosteal cells, stomach wall, lower large intestine wall, thyroid, liver, kidneys, testes, and ovaries through each of five exposure modes. These modes are (1) immersion in air containing radionuclides, (2) exposure to ground surfaces contaminated by deposited radionuclides, (3) immersion in contaminated water, (4) inhalation of radionuclides in air, and (5) ingestion of food produced in the area. The dose calculations are made with the use of dose conversion factors supplied as input data for each radionuclide, exposure mode, and reference organ or tissue.

At the option of the user, the area surrounding the source may be subdivided either with a circular or a square grid. For the circular option, as many as 20 distances may be specified for each of 16 compass directions. Each distance represents the midpoint of a sector. The square option employs a 20 by 20 grid with the source at the center. The grid size is specified by the user.

The code may be run to estimate either the highest annual individual dose in the area or the annual population dose. For either of these options, tables are provided as output which summarize doses in several ways — by nuclide, exposure mode, and organ. Also, for either option selected, ground concentrations of radionuclides and intake rates by man are tabulated for each specified environmental location. In addition, working level exposures are calculated and tabulated for inhalation of ^{222}Rn and its short-lived progeny. daughters.

Section 2 of this report discusses the atmospheric and terrestrial transport of released radionuclides and the methods used for calculating the resultant dose to man from these radionuclides. Section 3 details

the atmospheric and terrestrial transport models used in the code. Section 4 describes the input data requirements for the various user options. Section 5 lists terrestrial transport input parameters used in a demonstration run of the code. The methods used to determine the values presented are briefly discussed, and special problems in the determination of parameter values are identified. A listing of the code and a demonstration run of the code are presented in Appendix A and B, respectively.

2. APPLICABILITY OF THE COMPUTER CODE FOR ATMOSPHERIC DISPERSION CALCULATIONS AND RADIOLOGICAL ASSESSMENTS

Release rates (in curies per year) to the atmosphere from each point or area source are known collectively as the source term. The plume containing radionuclides is dispersed both horizontally and vertically as it is blown downwind. The code estimates the annual-average concentration (picocuries per cubic centimeter) of each radionuclide in the source term in air at ground level as a function of direction and distance from the source; annual-average frequencies of wind direction, wind speed, and atmospheric stability category are employed as input data.

Radionuclides in the form of particulates or reactive gases deposit on ground or water surfaces through scavenging processes, which primarily consist of washout by rainfall, and through dry deposition processes. The code estimates the deposition rate for each radionuclide in units of picocuries per square centimeter per second for each location for which estimated air concentrations are calculated.