CRIS: A Computerized Radiological Risk-Investigation System*

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The U. S. Environmental Protection Agency (EPA) is responsible for regulating radioactive airborne effluents in the U. S. A comprehensive, integrated Computerized Radiological Risk Investigation System (CRRIS) is being developed to support EPA's radiation standards development. This modular system consists primarily of five computer codes and their supporting data bases for estimating environmental transport and radiation doses and risks. Health effects are estimated on the basis of a life-table methodology developed by EPA. CRRIS is designed to provide EPA with a reasonable and flexible way of assessing the risk to man associated with radionuclide releases to the atmosphere.
SUMMARY

Introduction

Authority to regulate radioactive airborne effluents was given to the U. S. Environmental Protection Agency (EPA) by the 1977 amendments to the Clean Air Act. A computerized methodology for performing an interim assessment of airborne radionuclide releases as the basis for regulatory action has been supplied to EPA. Efforts are now underway to develop a more comprehensive methodology that can be the continuing basis for EPA assessments and radiation standards development. The purpose of this paper is to describe this integrated Computerized Radiological Risk Investigation System (CRRIS).

The CRRIS System

The CRRIS system is a modular system of computer codes. This design allows for maximum flexibility in the use of CRRIS and for changing the individual codes. The five computer codes currently comprising CRRIS and their possible interactions are shown in Figure 1. The individual codes are discussed in more detail below.

PRIMUS

The PRIMUS code will generally be the first code run each time a new set of released radionuclides (source term) is evaluated using CRRIS. This is a program for the Preparation of Radionuclide Ingrowth Matrices from User-specified Sources. These matrices are output by PRIMUS and may serve as part of the input for any or all of the other codes in CRRIS.
Based on the radionuclides in the source term supplied as input by
the user, the PRIMUS code sets up matrices of decay constants for the cal-
culation of daughter ingrowth by accessing a documented radionuclide decay
data base. \(^2\) PRIMUS then creates arrays of released radionuclides and their
associated daughter products for later use by other codes in CARRIS to calcu-
late resulting doses and risks.

**ANEMOS**

Discharges of radionuclides to the atmosphere result in doses to man
from inhalation of and immersion in contaminated air, exposure to contami-
nated ground surfaces, and ingestion of food-stuffs contaminated by
deposited radionuclides. The purpose of the ANEMOS code is to estimate
concentrations in air and ground deposition rates for Atmospheric Nuclides
Emitted from Multiple Operating Sources. These concentrations and deposi-
tion rates are used in subsequent portions of CARRIS for estimating doses
and risks to man.

The calculations made in ANEMOS are based on the use of a straight-
line Gaussian plume atmospheric dispersion model with both dry and wet
deposition parameter options. \(^3\) The code will accommodate ground level or
elevated multiple point and area sources. Adjustments may be made during
the calculations for surface roughness, building wake effects, terrain
height, wind speed at the height of release, the variation in plume rise
as a function of downwind distance, and the build-up and decay of daughter
products.

The output of this code is presented for a 16 sector polar grid with
nuclide-specific air concentrations and ground deposition rates. While
ANEMOS is most appropriate for continuous, routine radionuclide releases,
this basic methodology has been applied to longer-term acute releases as well.\(^4\)

**RETADD-II**

ANEMOS is most appropriately applied within 80 km of the point of radionuclide release. For downwind distances on a regional or continental scale, a **REgional Trajectory And Diffusion-Deposition model (RETADD-II)** has been incorporated into CRRIS. This code represents a revision of the original RETADD code.\(^5\)

RETADD-II considers a source as emitting a puff every six hours and follows the puff trajectories at three-hour intervals. Monthly, seasonal, or yearly average trajectories may be constructed using upper air wind data collected over the continental U.S.

The radionuclide concentration in the puff is diffused around the centroid both in the vertical and the horizontal directions. Both wet and dry plume depletion effects may be considered. Radioactive daughter product ingrowth and decay matrices for up to eight exposure nuclides are generated through access to PRIMUS. The source may be either at ground level or elevated. Ground-level air concentrations and deposition rates for each exposure nuclide are output on a rectangular grid for use by TERRA and/or ANDROS.

**TERRA**

The computer code TERRA is used to calculate the **Transport of Environmentally-Released Radionuclides through Agriculture**. TERRA calculates radionuclide concentrations on ground surface and in vegetables, meat, and milk. The code does not, however, calculate human intakes or exposures.
Ground deposition rates may be input directly into TERRA or they may be obtained from ANEMOS or RETADD-II. Using input from PRIMUS, radionuclide parent decay and daughter build-up are explicitly calculated during biological transport. Site-specific default parameters may be incorporated into the concentration calculations in lieu of user-input parameters. A site-specific calculation of radionuclide removal from the soil root zone via leaching is also included. The concentration estimates made by TERRA may be used as input to ANDROS to calculate the resulting dose and risk to man.

ANDROS

The ANDROS computer code is used for the Assessment of Nuclide Doses and Risks with Option Selection. ANDROS takes output information generated by the other codes in CRKIS in the form of radionuclide concentrations in air, crops, milk, soil, etc., and, using human intake factors, couples these concentrations with dose and risk factors to arrive at individual and collective doses and risks.

Doses and risks may be calculated for the released radionuclides and/or their daughter products. Intake rates of these radionuclides may be calculated for both individuals and populations. Doses and risks for external pathways may be corrected for the time the exposed persons spend indoors. The dosimetric and health effects data base used in ANDROS was developed using the RADRISK computer code. The basic life-table methodology used to derive the health effects data in RADRISK was developed by EPA's Office of Radiation Programs.
Supporting Data Bases

The environmental transport codes used in CRRIS rely heavily on a variety of transfer factors for estimating the movement of radionuclides between various environmental compartments. It is preferable to have site-specific empirical data for these parameters, but it is realized that this will seldom be possible. As a result, a major effort is being made to acquire data for agricultural production across the country and to develop default values for various pathway factors, e.g., atmospheric deposition fraction on crops, that may be readily used by the codes in CRRIS.

Data files are being developed for various agricultural, meteorological, geographical, and population input parameters. For example, these data files include vegetable production and productivity estimates, morning and afternoon mixing height estimates, information on dominant land features, and population distribution based on the 1970 Census, respectively. All of these site-specific parameters will be determined with a resolution of 1/2 x 1/2 degree longitude-latitude for the Continental U. S. Also, element-specific transport parameters describing soil-to-plant, ingestion-to-beef, and ingestion-to-milk are being developed based on reviews of available literature and empirical relationships between parameters.

Conclusions

The doses and risks calculated by the CRRIS system of computer codes will be used by EPA to set standards relative to the release of radionuclides to the atmosphere. The features of CRRIS discussed above, as well as other aspects of this risk investigation procedure, encompass more details than are often used in radiological assessment activities today. However, in our
judgment, these methods represent improvements in assessment methodology based on the best scientific evidence available. As a result, we believe this implementation should provide EPA with a reasonable methodology for its regulatory needs to assess the risk to man as the result of the release of various radionuclides to the atmosphere.
REFERENCES


LIST OF FIGURES

Figure 1. Flow diagram for the Computerized Radiological Risk Investigation System (CRRIS)
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