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# Project Summary

# User's Guide for the Automated Inhalation Exposure Methodology (IEM)

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**The Inhalation Exposure Methodology (IEM) is a system of computer programs that estimates atmospheric transport and population exposure to air pollutants. This summary describes the components of the IEM system and the types of modeling output it can generate.**

***This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Introduction

The Inhalation Exposure Methodology (IEM) is a system of computer programs used to estimate atmospheric transport of, and population exposure to, airborne pollutants. IEM was developed to provide automatic access to population and meteorological data employed in a sophisticated but user-friendly atmospheric dispersion modeling methodology. Although results of IEM can be applied to a number of different problems, its principle use is estimating air pollution concentrations and human inhalation exposures in the vicinity of hazardous waste incineration facilities. IEM has been particularly effective in comparing different pollution control techniques and the relative importance of several sources of facility emissions. IEM employs current models chosen to balance rigorous estimation techniques with use of readily available data. IEM can produce tables of annual average ground-level air concentrations, population distributions, and population exposures via inhalation for pollutants emitted from industrial sources.

The IEM system installed on the IBM computer at EPA's National Computer Center, Research Triangle Park, North Carolina, is accessible from any terminal (remote or on-site) which can access the system.

IEM consists of four groups of computer programs (Figure 1) and several permanently stored files of meteorological and population data. The meteorological data group (MET) selects a meteorological data set from permanently stored files containing National Oceanic and Atmospheric Administration Stability Array (STAR) data, and formats the data for use in the atmospheric dispersion program, which is a slightly modified version of the long-term Industrial Source Complex Dispersion Model (ISCLTM).* ISCLTM uses the meteorological data and other input to calculate average ground-level air concentrations of pollutants emitted from sources located at the site of interest. The population data group (POP) selects a site-specific population distribution from permanently stored 1980 Census population data and formats it for use in a concentration-exposure program (CONEX). CONEX takes the concentration estimates from ISCLTM and the population distribution from POP group and prepares tables that describe the pollutant concentrations and population exposures around the site. Each of these steps is described in greater detail below.

*The ISCLT is one of the EPA's recommended air quality models

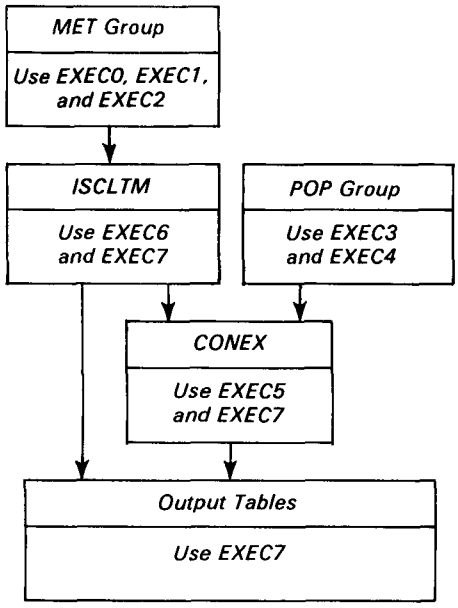


*Figure 1. Schematic of program group interactions in IEM.*

The flow of program execution and data input in IEM are controlled by eight interactive executive (EXEC) routines run in proper sequence. Each EXEC routine contains appropriate job-control program statements which access system-stored data files and programs, direct the user in preparation of a problem-specific input data file, run the program, and process program outputs. The language used to control an IEM session is INTERACT WYLBUR 6.0. Because some of these programs must be run sequentially (as described below) and have more than an eight-hour turnaround time, four days are usually required to run the complete system.

## Coordinate Systems

IEM uses two polar coordinate systems: the "grid" system and the "centroid" system. Each system is characterized by a set of radial distances to rings circumscribed about the origin and a common set of angles representing sixteen different vectors. The coordinate systems have a common origin. The relative orientation of the coordinate systems, as built into IEM, is shown in Figure 2.

The "grid" system is represented by the solid rings in Figure 2. Intersections of the rings and the direction vectors (D1-D16) mark the points at which ISCLTM calculates ground-level air concentrations (e.g., points G1 and G2). The "centroid" system is represented by the broken rings. Intersections of these rings

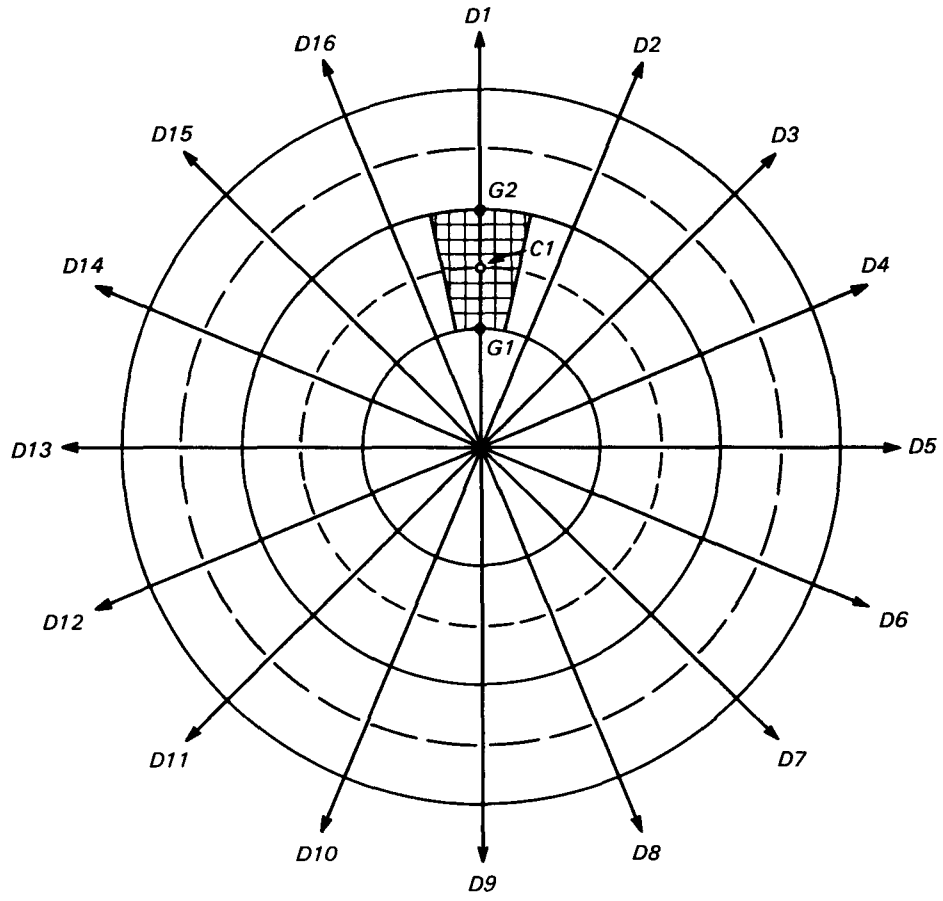


*Figure 2. The coordinate systems used in IEM.*

and the direction vectors (e.g., point C1) locate the centers of sector segments (represented by the hatched area). The POP program group assigns an appropriate number of persons to each sector segment and the CONEX program calculates an average air concentration over each sector segment using the adjacent "grid" concentrations. CONEX then combines the population and average concentration values to calculate exposures in each sector segment.

## Program Groups

### *The MET (Meteorological Data) Group*

The MET group consists of three sequentially executed computer programs, each controlled by its own EXEC routine. These routines provide step-by-step guidance for preparing a meteorological data set for use by ISCLTM.

The first program, SERCH (controlled by EXEC0), locates and identifies meteorological weather stations near the site being considered. Stations may be located by state or by latitude-longitude window. Output from SERCH consists of the five-digit station number, name and location (city, state, and latitude and longitude), and the Federal Information Processing Standards (FIPS) state code of each station located in the search area. The number of stations located in the area is also indicated. The user notes the station numbers of all potentially useful weather stations.

Using the selected station numbers, the second program, DIREC (controlled by EXEC1), supplies a description of the available STAR data sets for each potentially useful weather station. In addition to the information supplied by SERCH, DIREC lists each data set's header number, tape location information (i.e., starting record number, number of records, and tape number), and a description of the data contained (e.g., time period covered, seasons or months included, etc.). From this information, the user can select a data set for use by ISCLTM.

The user then chooses the meteorological data set he will use and supplies the information obtained from DIREC to the next program, STAR (controlled by EXEC2), which formats the chosen data set for use by ISCLTM. This reformatted data set is stored in a semi-permanent data file.

### *The POP (Population Data) Group*

The POP group consists of two sequentially executed computer programs, each controlled by its own EXEC routine. These routines provide step-by-step instructions for transforming 1980 Census population data into a site-specific population distribution for use by CONEX.

The first program, RD80 (controlled by EXEC3), reads grid-recorded 1980 Census population data for the region surrounding the site and transforms it into a format suitable for use by the second program. Two types of data sets are available as permanently stored files. A coarse grid (6'-latitude x 6'-longitude rectangular matrix) data set contains estimates of the number of persons contained in each rectangle. Sets of fine grid (2'-latitude x 2'-longitude rectangular matrix) data contain estimates of the number of persons living in each rectangle. Fine-grid data sets are available for 54 high-population areas. To run EXEC3, the user must supply the latitute and longitude of the site (the origin of the coordinate systems), the radial distance to the outermost "grid" ring, and, if applicable, the code name of the fine-grid data set (listed in the user's guide). Output from RD80 is stored as a semi-permanent data file.

The second program, APORT (controlled by EXEC4), is an adaptation of a computer code written by Fields and Little.[1] After the user supplies, through EXEC4, the number of "grid" rings, the distance of each ring, and the latitude and longitude of the origin, APORT uses the data file created by RD80 to produce the population data file needed as input by CONEX. This semi-permanently stored data file contains the number of persons located in each sector segment of the "centroid" system.

### *The Atmospheric Dispersion Program (ISCLTM)*

The atmospheric dispersion program, ISCLTM, is a slighly modified version of the Industrial Source Complex Dispersion Model—Long Term.[2] This program estimates the average ground-level air-concentrations of a pollutant at the "grid" points around a site (one or more sources) which emits the pollutant. Input to ISCLTM is supplied by the semi-permanent meteorological data file produced by the MET group and an interactively created data file that is prepared using EXEC6. The program is run using EXEC7, which also controls program outputs.

The ISCLTM is a steady-state Gaussian plume model which can account for settling and dry deposition of particles, downwash, and plume rise as a function of downwind distance. ISCLTM can be used to simulate the dispersion of non-reactive gases or of those reactive gases which can be accounted for by an exponential decay term. It is limited to flat or gently rolling terrain; receptors are at ground level at elevations not exceeding source stack height, as discussed in the final report.

EXEC6 directs the user in the preparation of a permanently stored input data file for use by ISCLTM.[2] To coordinate ISCLTM with the other IEM programs and to reduce the quantity of interactively input data, many of the input variables have been assigned preselected values. Most pre-evaluated variables pertain to the meteorological data descriptors. Source, site, and pollutant variables must be entered by the user.

Outputs from ISCLTM include the standard ISCLT line printer output and the temporary file used by CONEX. The line printer output lists the input data and gives tables of ground-level air concentrations for each source individually and for all sources combined. The temporary file contains the "grid" system coordinates and the source-specific concentration arrays.

### *The Concentration-Exposure Program (CONEX)*

CONEX rewrites the source-specific concentration estimates from ISCLTM into a variety of tables, including tables of concentrations for selectable source combinations; converts concentrations at "grid" points (from ISCLTM) into average concentrations over the sector segments defined by the "centroid" coordinates; prepares tables of sector segment concentrations; multiplies the sector segment concentrations by the number of persons in the corresponding sector segments (from APORT) to estimate sector-segment exposures; prepares tables of sector-segment exposures, and calculates and tabulates various combinations of the sector-segment exposures. Input data are supplied to CONEX from ISCLTM, APORT, and a user prepared input data file that is created interactively using EXEC5. Program execution and output is controlled by EXEC7.

EXEC5 asks the user to select the desired output tables. Available output tables include a matrix of the number of persons assigned to each sector segment; three sets of five tables, one set describing pollutant concentrations at the "grid" points, one set describing average pollutant concentrations over each sector segment, and one set describing exposures in each sector segment; and four tables that summarize exposures by source, by sector and source, by radial band and source, and by concentration level and source.

### *Sample Calculations*

Besides describing how each program of IEM is accessed and the types and formats of the data which they produce, the project report provides an example of calculation for a hypothetical incinerator facility. All computer interface statements are shown, along with the data tables which are generated for this particular example.

## References


1. Fields, D. C., and C. A. Little. 1978. APORT — A Program for the Area-Based Apportionment of County Variables to Cells of a Polar Grid ORNL/TM-6418. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

2. Bowers, J. F., J. R. Byorklund, and C. S. Cheney. 1979. Industrial Source Complex (ISC) Dispersion Model User's Guide (Volume 1). EPA-450/4-79-030. U.S. Environmental Protection Agency, Research Triangle Park, NC.

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*The complete report, entitled "User's Guide for the Automated Inhalation Exposure Methodology (IEM)," (Order No. PB 83-187 468; Cost: $13.00, subject to change) will be available only from:*
*National Technical Information Service*
*5285 Port Royal Road*
*Springfield, VA 22161*
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