United States
Environmental Protection
Agency

National Risk Management Research
Research Laboratory
Research Triangle Park, NC 27711

Research and Development

EPA/600/SR-96/037 May 1996

EPA

Project Summary

IAQ Model for Windows, RISK Version 1.0: User Manual

Leslie E. Sparks

A computer model, called RISK, for calculating individual exposure to indoor air pollutants from sources is presented. The model is designed to calculate exposure due to individual, as opposed to population, activity patterns and source use. The model also provides the capability to calculate risk due to the calculated exposure. RISK is the third in a series of indoor air quality (IAQ) models developed by the Indoor Air/Radon Mitigation Branches of U. S. EPA's National Risk Management Research Laboratory. The model uses data on source emissions, room-to-room air flows, air exchange with the outdoors, and indoor sinks to predict concentration-time profiles for all rooms. The concentration-time profiles are then combined with individual activity patterns to estimate exposure. Risk is calculated using a risk calculation framework. The model allows analysis of the effects of air cleaners located in either/or both the central air circulating system and individual rooms on IAQ and exposure. The model allows simulation of a wide range of sources including long-term steady state sources, on/off sources, and decaying sources. Several sources are allowed in each room. The model allows the analysis of the effects of sinks and sink re-emissions on IAQ. The results of test house experiments are compared with model predictions. The agreement between predicted concentration-time profiles and the test house data is good. The model is designed to run in the Windows operating environment.

This Project Summary was developed by EPA's National Risk Management Research Laboratory's Pollution Prevention and Control Division, Research Triangle Park, NC, 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

RISK is the third in a series of indoor air quality (IAQ) models developed by the Indoor Air/Radon Mitigation Branches of U. S. EPA's National Risk Management Research Laboratory. The first model, INDOOR, was designed to calculate the indoor pollutant concentrations from indoor sources. The second model, EXPOSURE, extended INDOOR to allow calculation of individual exposure. **RISK** extends EXPOSURE to allow analysis of individual risk to indoor pollutant sources. Note that risk estimates based on currently available data are projections containing a great deal of uncertainty. This is particularly true when using a model such as this one to calculate risk estimates for individuals, because such numbers as carcinogenic potency, upon which the model depends for calculating individual and population cancer risk, are projections of population risks based upon a variety of extrapolations and assumptions. Risk estimates generated by models such as this one are useful mainly for the purpose of comparing scenarios rather than for determining absolute risks to individuals or populations. The three models were all developed as tools to carry out the mission of the engineering portion of the EPA's indoor air research program “To provide tools necessary to reduce individual exposure and risk to indoor air pollutants.”

The three models reflect the status of EPA source and sink characterization research at the time the models were written. **RISK** includes new empirical source models and mass-transfer-based source models in addition to the common first order decay source models used in previous models. The mass-transfer-based source models are particularly useful for gas-phase-limited mass-transfer situations.

RISK is the first version of the IAQ model designed for the Windows operating environment. Most of the material in the full manual is contained in the on-line help file provided with **RISK**.

Purpose of IAQ Engineering Modeling Research Program

The modeling component of the IAQ engineering research program is designed to support the overall mission of IAQ engineering research. In meeting this mission the IAQ modeling program:

- Provides tools to integrate the results of IAQ research.
- Provides tools for analysis of the effects of IAQ control options on individual exposure.
- Provides tools for improving understanding of interactions of sources, sinks, ventilation, building parameters, air cleaners, and individual activity patterns on individual exposure to indoor air pollutants.

Relationship Between Modeling and Source Characterization

The role of the model relative to source characterization can be seen from Figure 1.

Data related to source characterization are developed as part of EPA’s indoor air source characterization program. These data are used to develop source emission models that are used in this IAQ model. The source models are updated whenever new information is developed by the source characterization research program.

Model Overview

RISK is designed using the concepts of buildings and scenarios. The fixed information about a building (the number of rooms, the room dimensions, and the arrangement of the rooms) is contained in a building file. The changing information (sources, sinks, air exchange, room-to-room flows, etc.) is contained in scenario files. The steps in using the model are: define the building, save the building information to a file, define the scenario, save the scenario to disk, and run the model. Repeat the scenario definition model execution process for each scenario of interest.

RISK provides a wide range of graphical and tabular outputs of the results of the calculations. Summary outputs of risk and exposure are provided in tabular form. Full risk, exposure, and concentration output are also provided in tabular form. The tabular outputs are supplemented by graphs of concentration and exposure versus time. The calculated results can also be saved to disk for later analysis.

Building

In model terms a building is a collection of rooms and their interconnections. Room dimensions and room-to-room interconnections, but not room-to-room air flows, are fixed for a given building. The actual values of room-to-room air flow and air flow between the building and the outdoors can be changed for the various scenarios. A building may have an unlimited number of scenarios associated with it.

Scenario

In model terms a scenario is a collection of data for a given building that can change from model run to model run. All information on sources, sinks, air flow rates, individual activity patterns, type of

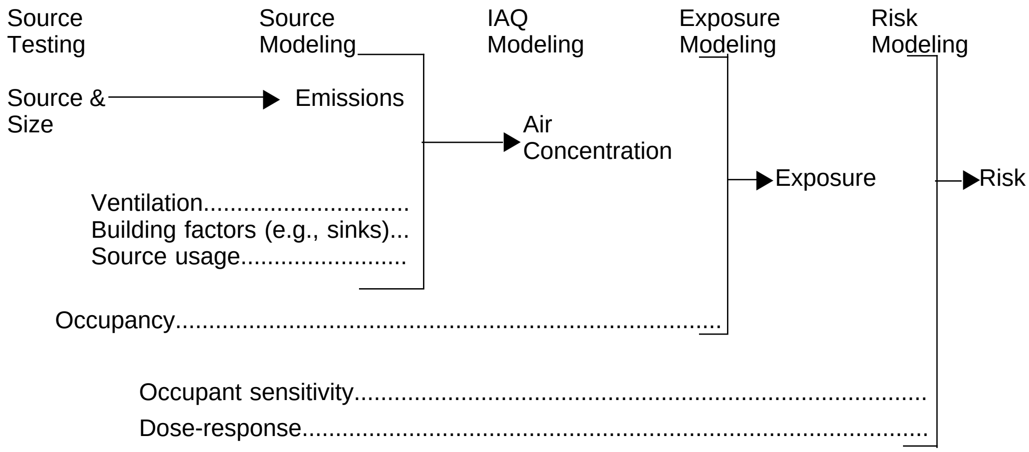

Figure 1. Risk analysis process.

pollutant, and risk factors is included in the scenario.

Data input

Data are entered into the model using a “fill in the form” interface. The data in the form are not available for use by the program until they are “transferred” from the data entry form to the model. Data are transferred from the data entry form to the model by selecting the transfer command from the file sub-menu, or by clicking on the transfer button provided with the various data entry screens.

Model output

Graphs

The model can display the results of the various calculations in several graphs:

- Concentration versus time.
- Instantaneous exposure versus time.
- Cumulative exposure versus time.
- Total exposure for each activity pattern.
- Time exposed to irritant concentration for each activity pattern.

Most of the graphs can be displayed in the following formats:

- Linear x linear y.
- Log x linear y.
- Linear x log y.
- Log x log y.

All graphs can be printed.

Tables

In addition to the graphs, the model provides numerous tables displaying the results of the calculations, including:

- Summary, showing time exposed to irritant concentration, total exposure, and risk.
- Concentration versus time.
- Exposure versus time.
- Concentration and exposure versus time.
- Summary risk.
- Risk analysis.

Data in the output tables may be copied to the Windows clipboard and pasted into other Windows applications. This is a convenient way to enter data into a graphics package for plotting.

Files

The results of the calculations can be saved to a disk file. This file is a Tab delimited file that can be read by many spreadsheet and graphics packages.

Model Assumptions

The model is based on two assumptions:

1. All rooms in a building are well mixed.
2. Mass is conserved.

Assumption 1 means that the concentration leaving the room through all exits is the same as the concentration in the room. Numerous experiments in EPA's IAQ test house show that this assumption is valid.

The assumption that the rooms in a building are well mixed does not mean that the building is well mixed. Individual rooms in a building may have different concentrations.

A room in the model does not always equal a room in the physical building. For example, a single large room may need to be divided into two or more model rooms to meet the well mixed assumption, and several physical rooms may be treated as a single room in the model.

Assumption 2 means that the amount of air entering a room must equal the amount of air leaving the room. This assumption also means that the amount of outdoor air entering the building as a whole must equal the amount of air leaving the building for the outdoors. The model will warn the user if the mass balances are incorrect. However, the model will not balance the flows for the user. The user is responsible for ensuring that the flows balance.

Modeling decisions

Several decisions were made in designing the model. Some of the major decisions were:

- The emphasis of the effort was on model ease of use.
- The data requirements were minimized as much as possible.
- Data defaults would be provided as much as possible.
- Results of ongoing source and sink research would be incorporated into the model as soon as possible.
- User would be responsible for balancing flows.
- Room-to-room flows and ventilation rates were model inputs and would not be calculated from pressure/temperature data.

Most of these decisions were made to make the model easier to use. Having the user balance the flows will help the user understand the input data. The computer will determine if the flows balance, but it will not actually balance them. The purpose of this decision is to reinforce the idea that mass must be conserved. The user must determine where air is coming from and where it goes.

Model limitations

There are two types of limitations on the model:

- Data limitations.
- User limitations.

Data limitations

Data limitations are limitations about our understanding of the processes occurring and imperfect scientific knowledge. The major data limitations are:

- Limited data on source emission rates.
- Limited understanding of sinks and inadequate models for sinks.
- Limited risk information.
- Limited library of default data for room-to-room flows, ventilation rates, etc.

Research is underway to correct each of these data limitations. The results of the research will be incorporated into the model as soon as they are ready.

User limitations

User limitations fall into four broad categories:

- User does not understand what the model can do.
- User does not understand or know what question the model should address.
- The user does not fully understand the input data requirements.
- The user does not understand the model output.

Often these limitations interact with each other and result in failure of the model to meet the user’s needs.

These limitations often reinforce limitations caused by data gaps.

*Author **Leslie E. Sparks** is also the EPA Project Officer (see below).*

The complete report, entitled "IAQ Model for Windows, RISK Version 1.0: User Manual," (Order No. PB96-501 929; Cost: $38.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Air Pollution Prevention and Control Division
National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection Agency
National Risk Management Research Laboratory (G-72)
Cincinnati, OH 45268

Official Business
Penalty for Private Use $300

EPA/600/SR-96/037

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35