CAP88-PC Supplemental Fact Sheet

The following information is provided to describe the intended uses, capabilities, and limitations of the CAP88-PC model. CAP88-PC is the model required for demonstrating compliance with the Agency's radionuclide National Emissions Standard for Hazardous Air Pollutants (NESHAPs) regulation at 40 CFR Part 61 Subpart H. This document provides some clarifications only and does not supersede guidance found in the most recent CAP88-PC User's Guide.

CAP88-PC Description

The CAP88 (which stands for Clean Air Act Assessment Package - 1988) computer model is a computer program for estimation of dose and risk from radionuclide emissions to air. The most current version is CAP88-PC is Version 4.1.1. The original CAP88-PC software package, version 1.0, allowed users to perform full-featured dose assessments in a command line environment **for the purpose of demonstrating compliance with 40 CFR 61.93(a).** CAP88-PC can also be used for non-regulatory purposes provided the user understands the methodologies incorporated into the model. CAP88-PC provides the methodology for assessments of exposures for both populations and the maximally exposed individual. All versions of CAP88-PC use a modified Gaussian plume equation to estimate the average dispersion of radionuclides released from up to six emitting sources. Any version of CAP-88 previously released by EPA may be used to demonstrate compliance with the Subpart H requirements. The sources may be either elevated stacks, such as a smokestack, or uniform area sources (assuming the area source may be represented as a point source relative to the distance to the receptor of interest), such as a pile of uranium mill tailings. Plume rise can be calculated assuming either a fixed, momentum, or buoyant-driven plume. Assessments are done for a circular grid of distances and directions for a radius of up to 80 kilometers (50 miles) around the facility. The Gaussian plume model is simple to use, has been widely tested, and has been shown to give reasonable predictions if a proper selection of model parameters is made.

The Gaussian Plume Model

The Gaussian plume model is the most common air pollution model. It is based on a simple formula that describes the three-dimensional concentration field generated by a point source under steady-state meteorological and emission conditions. The Gaussian plume model makes the following assumptions:

- Continuous emission and negligible diffusion in the direction of travel.
- The material diffused is a stable gas or aerosol, with gases having a zero-deposition rate.
- Mass is conserved.
- Meteorological conditions are steady and constant over the time duration for the analysis.
- Emission rates are constant.

The atmospheric transport model in CAP88-PC is based on a modified Gaussian plume model described in EPA 520/1-79-009, *AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides*. The atmospheric transport model uses time-averaged annual release rates and meteorological data (wind speeds and frequency;

precipitation rate) to estimate the air concentration and deposition rates. The model uses reciprocal averaged windspeeds for dispersion calculations, and the decay in-flight solution uses the arithmetic average wind speed. Since the atmospheric transport model in CAP88-PC uses arithmetic average windspeeds, which can lead to an underestimation of the concentration of particularly short-lived radionuclides (e.g., minutes; relative to flight time), the calculated dose or risk estimates may require additional evaluation of the outputs. Professional judgement should be exercised when using the model to calculate doses for short-lived radionuclides.

A Conservative Model

Several specific 'real world release' situations may not conform to the Gaussian Plume model assumptions from which the CAP88-PC model was developed. However, with a basic understanding of the capabilities of the model and what it was designed to do, the user can better understand what the results represent. Mathematical models for estimating doses or risks to members of the public from radionuclides released to the environment have become increasingly sophisticated. However, when applying these models to assess the radiological impact of potential releases, it is recommended that the simplest model be applied first (NCRP Report No. 123). CAP88-PC is a code made up of conservative models and parameters (i.e., designed so that most applications will overestimate the dose to a member of the public). If compliance with the regulatory limits can be shown using these conservative models, then more sophisticated modeling techniques are not necessary. Because of conservative exposure assumptions in the model (i.e., 100 percent occupancy factor; steady-state continual release; ability to model food grown on site; etc.), the results will usually be a bounding analysis, most useful to demonstrate that radionuclide releases from the facility are below the regulatory limit. When the model is used for non-regulatory purposes, if a dose to a particular individual needs to be calculated, additional parameters (e.g. - occupancy factors) may need to be applied.

Reported Risk and Dose Levels

40 CFR Part 61 Subpart H requires that "Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public (i.e., – the MEI) to receive in any year an effective dose equivalent of [0.1 mSv] 10 mrem/yr." (Sec 61.92) "The method for calculating effective dose equivalent and the definition of reference man are outlined in the International Commission on Radiological Protection's Publication No. 26" (Sec 61.91, Definitions). The most recent versions of the code use dose coefficients developed using the recommendations in International Commission on Radiological Protection's Publication No. 60.

CAP88-PC calculates the equivalent dose to individual tissues and organs and the effective dose to the reference person. The user can select one of six ages for the age of the reference person. The doses are based on age-specific human utilization factors (e.g., breathing rates, food consumption rates) and age-specific dose coefficients.

The requirements specifically state that "To determine compliance with the standard, radionuclide emissions shall be determined and effective dose equivalent values to members of the public calculated using EPA approved sampling procedures, computer models CAP-88 or AIRDOS-PC, or other procedures for which EPA has granted prior approval."

Exposure pathways

CAP88-PC includes the exposure pathways of ingestion and inhalation intake, and direct exposure from ground surface and air immersion. Additionally, ingestion of food (leafy vegetables, milk, and meat (per NRC Reg Guide 1.109) produced in the assessment area) is included to estimate uptake of emitted radionuclides into the food chain. Regarding groundwater uptake, the model assumes that transport, and incorporation into an aquifer would be unlikely over the timeframe of the model's consideration, therefore drinking water from a groundwater aquifer is not included as a potential pathway.

Applications for Emergency Responses

CAP88-PC is not designed for use in emergency response or preparedness. Other tools are more appropriate for use in radiological emergencies (TurboFRMAC, HotSpot, RESRAD-RDD, HYSPLIT). There is also a national capability that supports local, state, tribal, territorial and federal government response agencies. The Interagency Modeling and Atmospheric Assessment Center (IMAAC) is led by the Federal Emergency Management Agency. IMAAC can be called upon to answer questions about potential emergency releases of radioactivity (as well as other types of hazardous materials).

Short-term/Temporary Releases

CAP88-PC is designed for demonstrating compliance on an annual basis. If the user knows the atmospheric conditions over a short-term release (and these are fairly constant over the release period), then the code can be used for short-term releases. Note that the dose is reported for both ingestion and inhalation, so if ingestion is not considered to be a contributor for very short periods, the user can select "Imported" as the food scenario. The inhalation dose, air immersion and external dose pathways all have a fixed calculation time of 1 year (365 days) so if the exposure period to the plume is less, the user can 'ratio' the exposure time. For the external exposure pathway, the assessment buildup time is set as a default at 100 years, however the user can set the assessment buildup time to other timeframes.

Radionuclides not Included in Inventory

There are occasions when a facility will emit a radionuclide that is not included in the current suite of radionuclides in CAP88-PC. When this situation is encountered, a surrogate radionuclide can be identified. EPA understands the choice of surrogates to be based on similarities in biological, chemical, and radiological properties to those radionuclides for which a surrogate is sought. Any use of surrogate radionuclides for NESHAPs compliance requires official approval from the appropriate EPA Region, or EPA headquarters.

Location of Maximally-Exposed Individual

Doses for the maximally-exposed individual are estimated by CAP88-PC for the location, or sector-segment in the radial assessment grid, of highest risk where at least one individual actually resides. All annual equivalent and effective doses are based on a one-year exposure. Annual internal equivalent and effective doses are committed doses at the age of intake to an age of 70 years. Ground surface concentrations used for dose calculations are based on 100 years of build-up (including decay and ingrowth of decay products).

Limitations Inherent to Model

The following are limitations of many Gaussian plume models, including the current version of CAP88-PC.

a. Wind conditions – very turbulent wind conditions (lots of gusts) fall outside of the design of the Gaussian plume model.
b. Geographical conditions – mountainous or very hilly terrain or river canyons can cause fluctuations in wind speeds and/or temperature variations.
c. Emissions from an area source that is non-uniform – area sources are modeled as though they are uniform. If there exists significant variation in the concentration of the source radionuclide, then assumptions must be made to accommodate this in the source term.
d. Complex terrain issues and/or local building wakes (high terrain and/or structures near the source of the emissions which cause wind speed and direction not to be uniform). These issues impact the accuracy of the Gaussian plume model and cause problems with the results.
e. Close proximity receptors – cause assumptions for Gaussian plume model to be less accurate (distances < 2 stack heights represent close proximity).