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DESCRIPTION OF THE PERRY NUCLEAR POWER PLANT

EMERGENCY OFFSITE DOSE CALCULATIONS

UNIT NO. 1
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The Cleveland Electric Illuminating Company

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1.0 INTRODUCTION

The Cleveland Electric Illuminating Company (CEI) will adopt for use at the Perry Nuclear Power Plant (PNPP) two methods for determining offsite doses during an emergency: a computerized method and a hand-calculated method. In this document the methods of making these emergency offsite dose calculations will be discussed in the context of the Perry Emergency Response Facilities (ERFs) that are described separately (CEI, 1983). The Emergency Dose Assessment System (EDAS) incorporates a sophisticated dose assessment model (EMERGE) that will run on the Emergency Response Information System (ERIS) computer. EMERGE incorporates a three-dimensional Gaussian, variable trajectory, split-sigma, puff dispersion model that is able to simulate the meteorology of a coastal location.

EDAS is the dose projection methodology of choice because it provides rapid dose assessments based on up-to-the-minute meteorological and radiological data. Provisions, however, are being made for dose projections in the event that EDAS is inoperable or unavailable. The latter situation occurs after accident initiation but prior to activation of the ERFs (CEI, 1983); during that time, dose projections are carried out in the Control Room, in which there is no dose projection terminal. In the event that EDAS is inoperable or unavailable, dose projections will be calculated by hand. Hand calculations do not account for such things as lake breeze effects and time-varying source terms.

This document provides CEI's response on the technical bases of the dose calculational methodology used to assess the impact of an accidental airborne release. While the bases of both the automated and back-up manual methods are generally described in Section 7.3.11 of the Emergency Plan, details are provided here of the assumptions, models, and technical bases used in developing these calculational procedures.

The remainder of this document is organized into five sections that involve the following:

- Hand-calculated emergency offsite doses
- Automated emergency offsite dose calculations
- A summary
- A list of references that were cited in the text
- A cross-reference of sections of this document that respond to NRC Round 1 and Round 2 questions.

2.0 HAND-CALCULATED EMERGENCY OFFSITE DOSES

Dose projections will only be calculated by hand in one or both of the following situations:

- ERIS is non-functional
- The Technical Support Center (TSC) or Emergency Operations Facility (EOF) have not yet been activated.

In the second situation, dose projections are carried out in the Control Room until either the TSC or EOF have been activated (CEI, 1983); there is no dose projection terminal in the Control Room. The hand calculation of offsite doses is therefore a back-up method for use in the event that ERIS cannot be used to generate computerized dose projections.

The method to be selected for hand calculation of offsite doses is based on the availability of data and on the time constraints for performing a dose assessment. These methods are discussed in Section 7.3.11.2 of the Emergency Plan.

This section contains descriptions of the assumptions, methods, and technical bases used in generating the hand-calculated dose projection procedures. The instructions for the hand calculations are contained in the Emergency Plan Implementing Instructions. Each dose projection method is contained in a separate attachment to that instruction; the basis of each attachment is described below.

In the 10 sections that follow, the first three deal with obtaining the atmospheric dispersion parameters that are required for dose calculations. The next five sections use the atmospheric dispersion parameters and available monitoring parameters to calculate offsite dose rates. One section is available as a quick method to determine offsite dose when monitoring data are not available. The last section is used to determine accumulated and projected offsite doses based on dose rates calculated in previous sections and on the estimated duration of the accident.

A number of the dose projection procedures require an identification of accident type before the analysis can proceed. Accident identification provides a source term as the starting input for the dose projection. It is the responsibility of the operator to identify the accident; no technical basis for that decision is provided here.

For all of the dose calculation procedures addressed in the remainder of this chapter, the standard methodology of multiplying a release rate by a dispersion factor and a dose factor is used; this methodology is employed in Regulatory Guide 1.109, Revision 1 (USNRC, 1977b). In all of these methods, the Chi/Q values for the site boundary, two, five, and ten miles are obtained from the more appropriate of the two methods contained in the first three sections. Next, the appropriate dose factor(s) are selected for child thyroid, whole body, or both. Selection is based on the source term that results from each incident, i.e., the amount of noble gas and iodine released. Finally, the main difference from one calculational method to another is the manner in which radioisotope release rate is determined. Using actual grab sample analysis and release flow rates, an actual release rate can be calculated. Otherwise, the release rate must be inferred from available data. Obviously, actual isotopic analysis is the most accurate means of assessing the release. Once the concentration and dose factor have been determined, the difference in dose rate (R/hr) or dose projection (rem) at each of the four above-mentioned down-wind locations is the result of the differing amount of atmospheric dispersion at these locations.

2.1 PRELIMINARY ESTIMATE OF DISPERSION FROM ONSITE DATA

One part of this method describes the automatically determined dispersion information. This information includes normalized concentration (Chi/Q), the direction of plume travel, the speed of plume travel, the travel time, and the plume width. A "Preliminary Estimate" of the information is prepared by each of the independent systems at the Perry meteorological tower. Both the main and backup system have a microprocessor (MDPS, Meteorological Data Processing System) which uses validated, realtime, 15-minute meteorological data to prepare the Preliminary Estimate. (Same-tower substitutions are obtained if data are missing; see Section 7.3.7 of the Emergency Plan for further discussion.) Each MDPS routinely sends the Preliminary Estimate information to the Control Room (as well as ERIS) so it is always immediately available.

The Preliminary Estimate calculations are less sophisticated than those for the Model A' type that are performed in ERIS. The Preliminary Estimate uses the FSAR approach to atmospheric dispersion estimates. A straight-line Gaussian dispersion model, as described in Regulatory Guide 1.145 (USNRC, 1982), is used for consequence assessment; release characteristics are the same. Input meteorological data are wind speed, wind direction, and atmospheric stability class.

2.2 RELATED METEOROLOGY

This part provides the methodology for acquiring the meteorological information needed to obtain an estimate of atmospheric dispersion (Chi/Q) at selected distances from the site. This method is only used when an automated Preliminary Estimate is not available; it is used to generate wind speed, wind direction, and stability. This information is then used with the methodology described in the next section to generate an estimate of atmospheric dispersion.

Of course, onsite data are preferred for this method because the Perry meteorological tower location is representative of the site region. However, provision is made, too, for using offsite sources should they be needed. An extended list of over 20 alternative sources is provided in the implementing instruction. These sources range in distance from 5 to more than 50 miles from the site. The closer high-quality sources are preferred, providing they are available and have the necessary observations to eventually yield wind speed, wind direction, and stability class. Stability classification schemes include delta T (USNRC, 1972), modified sigma theta (Mitchell & Timbre, 1979; USEPA, 1981), and Turner-Pasquill sky conditions (Turner, 1970).

2.3 TABULAR ESTIMATE OF DISPERSION

This method describes the means of generating the preliminary estimate of dispersion from the output of the method described in Section 2.2. Seven tables of dispersion parameters are presented; they are organized by stability class. From each table the normalized concentration (Chi/Q), plume travel time, and plume width can be determined.

These tabular estimates are based on the same technique used for making the preliminary estimate (Section 2.1). Input data required are current wind speed, wind direction, and atmospheric stability class. The straight-line Gaussian model used is in accordance with that described in Regulatory Guide 1.145 (USNRC, 1982). Release characteristics are the same as used in the Perry FSAR. Dispersion values are generated for four down-wind locations: the Exclusion Area Boundary, 2 miles, 5 miles, and 10 miles.

2.4 DOSE ASSESSMENT BASED ON EFFLUENT MONITOR READING

This method can be used to project offsite dose and release rates when the release is monitored by an effluent monitor, the release flow rate is known or can be estimated, and the accident (incident) that causes the release can be correlated to an accident type analyzed in the FSAR. This method is only used when actual analyses of the release are unavailable. Since actual analyses are not available, the source terms from the FSAR are used. An identification of the accident must, therefore, be made first so that the appropriate source terms can be determined.

In this method, the effluent monitor reading is combined with the effluent release flow rate to obtain a release rate. Before determining the effluent release rate, however, an initial identification of the accident type must be made so that the primary release path can be identified (FSAR). In the event that the flow rate out this path is zero, this method cannot be used because the effluent monitor readings will be invalid. After the release rate is determined it is multiplied by the appropriate dose factors and Chi/Q values as detailed above to obtain dose rates in R/hr at each of the four down-wind locations.

2.5 DOSE ASSESSMENT BASED ON EFFLUENT ANALYSES

This method can be used to determine dose rates at selected downwind locations using a known isotopic release rate. This method is appropriate when sample results provide a radionuclide breakdown for the release.

This method is the most accurate of any of the methods described in this procedure since it is based on:

1. An actual measurement of the radionuclide mix and concentration being released.

2. Actual measurements of the flow rates from the event.

In this method actual concentrations of noble gases and iodines are determined from analyses of effluent samples. The actual concentration is multiplied by the actual release point flow rate, appropriate dose factors for each identified isotope, and Chi/Q to obtain dose rates in R/hr.

2.6 DOSE ASSESSMENT BASED ON CONTAINMENT MONITOR READING

This method can be used to project offsite dose rates and release rates based on the high range containment monitor reading. This method assumes that the containment activity is being released at the design leak rate of 0.2% per day and that 96% is collected and filtered by a 99% efficient iodine filter and 4% is released directly (FSAR source assumptions). This method is used only for accidents inside the containment when effluent monitors are out of service and/or flow indication is zero. Release rates in this method are inferred from the containment release rates described above and the readings of the high range containment monitor.

2.7 DOSE ASSESSMENT BASED ON CONTAINMENT ANALYSIS

This method can be used for projecting offsite dose rates based on a measured isotopic concentration in containment. This method is appropriate when sample results provide a radionuclide inventory that could leak from containment. In the event of a LOCA, this method accounts for child thyroid dose rates due to releases from both direct leakage to the environment and indirectly through a filtered pathway.

Using the containment activity release rate described in Section 2.6, as provided in the FSAR, and the isotopic analyses as actual source terms, the release rate is calculated.

This method would only be used when a LOCA has occurred, effluent monitors are not operating, and/or the vent flow indication is zero.

2.8 DOSE ASSESSMENT BASED ON OFFSITE MEASUREMENTS

This method can be used to project offsite dose rates and release rates from offsite measurements of dose rates or iodine concentrations. An estimate of the atmospheric dispersion factor is required for the sampling location. This method assumes that the offsite isotopic composition for dose rate measurements corresponds to a representative FSAR accident type (for estimates based on external dose rate measurements). For gross iodine measurements this method makes the conservative assumption that all iodine is I-131. This method also assumes that external dose rate at the measurement site is only due to noble gases (semi-infinite cloud).

For the calculation of doses using an offsite dose rate reading, the reading in R/hr is divided by the Chi/Q at that location to obtain a release rate. Calculations for dose rates at each of the four down-wind locations then proceed as described at the beginning of this chapter.

For the calculation of doses using measured offsite iodine concentrations, the measured concentration is divided by the Chi/Q at the sample location to get a release rate. Calculation then proceeds as described at the beginning of this chapter.

2.9 DOSE PROJECTION BASED ON FSAR ANALYSES

This method can be used to project offsite dose when the accident (incident) can be correlated to an accident type which has been analyzed in the FSAR. This method is very approximate and should be used only when parameters are not available to perform other methods or when an offsite estimate is needed very quickly.

After the accident is identified, the FSAR-calculated offsite dose factors are multiplied by the site-related Chi/Qs (atmospheric dispersion factor) to obtain an offsite dose estimate.

2.10 CALCULATION OF ACCUMULATED AND PROJECTED DOSES FROM RELEASES

This method is used to determine accumulated dose and projected dose based on the results of previous methods.

Accumulated dose is simply obtained by multiplying the dose rate obtained from the methods in Sections 2.4 through 2.9 by the elapsed time between monitor readings (previous and present) and summing this product for each subsequent period.

The projected dose is obtained by multiplying the current dose rate by the projected duration of release and adding to it the accumulated dose.

3.0 AUTOMATED EMERGENCY OFFSITE DOSE CALCULATIONS

Methods for obtaining automated estimates of offsite doses during an emergency are covered in the Emergency Plan Implementing Instructions. These methods involve the Emergency Dose Assessment System (EDAS).

The automated emergency dose calculation capability is composed of three integrated software functions:

- The menu-driven, Class A' model, EMERGE, which processes validated and averaged meteorological and radiological monitor data, and outputs dosimetric assessment data for display to the user.

- The model's data base, which serves as a repository of site and plant parametric table data for model reference during processing; and dynamic data resulting from model and DAS output processing and operator inputs.

- The user terminal interface software (TIS), which generates tabular and graphic displays of data and enables a user to control displays, review and/or update data base values, and produce reports. The terminal interface software is menu-driven.

These software functions are discussed separately below after a discussion of input data acquisition.

3.1 DATA ACQUISITION FUNCTIONS

The data acquisition of radiological and plant parameters will be done to a large extent by ERIS (CEI, 1983). The remainder will be performed by A^2RGUS through the function of RADCAPT.

The meteorological data are largely pre-processed to 15-minute values by MDPS before transmission to ERIS. The remainder of the processing is done through the A^2RGUS function of METCAPT.

In the following subsections, these are discussed in order: RADCAPT, MDPS, and METCAPT.

3.1.1 RADCAPT

The EMERGE calculational model requires 15-minute average data. RADCAPT will take the five-second averaged radiation and process monitor data from ERIS, that has already been electrically validated, perform further Boolean logic validation as appropriate, and then process it into the format required by EMERGE.

3.1.2 MDPS

The MDPS is the microprocessor Meteorological Data Processing System, which is located at the meteorological tower. As described in Section 7.3.7 of the Emergency Plan, meteorological data are processed and validated, using statistical and Boolean logic, to yield 15-minute values. Each of the two independent systems, both the main and backup, has an MDPS. Data are sent every 15 minutes to ERIS and other onsite locations.

3.1.3 METCAPT

The meteorological data from each MDPS are received in ERIS every 15 minutes. METCAPT receives and inspects the data. Those meteorological parameters that are potentially needed in EMERGE (dispersion-related parameters) are checked for availability. If any needed data are missing, METCAPT proceeds through a sequence of alternatives from the onsite meteorological tower. An example of automated backup sequences is presented in Section 7.3.7 of the Emergency Plan.

3.2 EMERGE

The purpose of EMERGE is to provide a rapid dose assessment of a nuclear power plant accidental atmospheric release, which could directly affect the general population via plume exposure in an area of approximately 10 miles radius around the power plant site. This area is generally known as the plume exposure Emergency Planning Zone (EPZ). To simulate the coastal meteorology of the Perry Nuclear Power Plant, EMERGE incorporates a three-dimensional, Gaussian, split-sigma, variable trajectory, puff dispersion model.

The dose assessment function is performed in the EMERGE model, which includes the capability to:

- Assess the wind flow field in which the plume will be transported
- Characterize the effluents contained in the plume
- Model the transport and diffusion of the plume
- Calculate the doses resulting from exposure to the plume.

The functional requirements for the dose assessment model are:

- Upon activation of model execution (if within approximately two hours of the beginning of the accident), the dose assessment model shall be capable of providing current dose estimates and projections within 15 minutes for all areas within 10 miles of the plant.
- After initial execution, updates of dose estimates and projections shall be available every 15 minutes on a near-real-time basis for the duration of the accident.

- After user identification of the accident, the dose assessment model shall execute during the course of an accident without user input.

- The model will provide prediction of doses for 1- and 2-hour time periods without user intervention.

- The model shall be able to accept user changes of input data during execution. These changes could consist of inputting meteorological forecast data and/or spectral analysis of grab samples.

- The dose assessment model shall use actual 15-minute average meteorological measurements. The selected data shall be indicative of the conditions within the plume exposure EPZ.

- Atmospheric diffusion rates shall be based on atmospheric stability as a function of site-specific terrain conditions.

- Local climatological effects on the trajectories, such as seasonal, diurnal, and terrain-induced flows, shall be included.

- The lake breeze phenomenon, part of the terrain-induced flows, will be based on the literature and regional Great Lakes data.

- Source characterization (release mode and building complex influence) shall be incorporated.

- The model will process up to three simultaneous representative release points. (One or more physical release points may be included in a single modeled release point.)

- The model shall produce an analysis of plume location as it varies in trajectory with time and space.

- The model shall provide ground-level doses along the plume exposure track.

- Dose estimates shall include whole-body external exposure to the plume and thyroid exposure from inhalation of the plume.

- The model shall include a capability to assess the consequences of a broad range of accident scenarios representative of the spectrum of potential accidental releases at the nuclear plant.

- The model will be table driven.

- The model will allow for accident reanalysis upon user request.

- The model shall provide analyses of planned releases on an interactive basis.

- The model will have the capability to allow generation of results so that verification of correct execution of the software is possible.

The dose assessment model, EMERGE, calculates the plume behavior within the plume exposure EPZ. EMERGE details the plume dimensions and provides ground-level doses along the plume path for the duration of an accident. EMERGE provides these estimates within 15 minutes of initiation. Real-time meteorological data and radiological data are used to provide calculations of dose rates and cumulative doses. Site-specific meteorological and radiological information, such as building wake effects, terrain effects, lake breeze, and accident behavior, have been incorporated. EMERGE provides dose rates and cumulative doses for whole-body exposure to the plume and thyroid exposures due to inhalation of the plume.

EMERGE accounts for the following factors:

- Temporal meteorological variability
- Spatial meteorological variability
- Temporal and spatial radiological source term variability
- Plume rise
- Plume trapping (mixing heights and elevated inversions)
- Lake/land breeze recirculation.

EMERGE is composed of the following four major calculational modules and an operations control module:

- WEST' assesses the three-dimensional wind flow field in which the plume will be transported

- ASTP characterizes the effluents contained in the plume and calculates initial plume growth during plume rise

- ACPUFF models the transport and diffusion of the plume within the WEST'-derived wind flow field and calculates doses

- ACDOSE uses isotopic spectral data generated by ASTP to calculate decay and dose factors used by ACPUFF

- SUPER provides interface with other EDAS system functions and controls the operations of EMERGE.

These modules work together to give an accurate and timely indication of radiological dose assessment. Figure 3.2-1 indicates the relationship of the EMERGE modules. Each of these modules is discussed below.

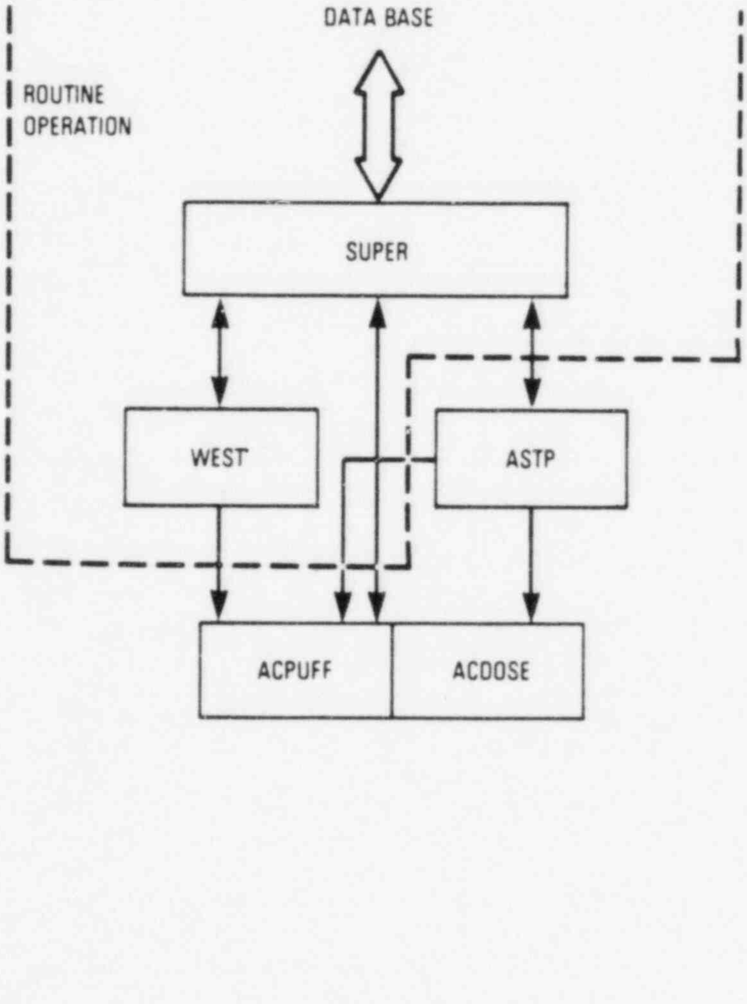


Figure 3.2-1. Relationship of EMERGE Modules

3.2.1 WEST' MODULE

The WEST' module produces a three-dimensional wind flow field on the basis of real-time meteorological data. Its early development and recent assessment were discussed in Fabrick et al., (1978) and Baskett and Asoian (1982), respectively. The wind flow field is a set of three-dimensional wind vectors that govern the transport of atmospheric effluent released into that field.

Of particular interest at Perry is the effect of the lake/land breeze on the three-dimensional meteorological field. These mesoscale circulations, the lake breeze or the land breeze, can greatly influence the coastal meteorology. These breezes are most important because of their spatially variant winds. The low-level wind flow will tend to change direction at the frontal zone (convergence zone) associated with the lake/land breeze, and there will tend to be a recirculation aloft of air back toward the coastline and an eventual return to the low-level flow. The lake/land breezes are also important because of the spatially varying stability associated with them. WEST' is designed to represent these lake/land breeze circulations at Perry.

The WEST' module is exercised in two operational modes. The first mode is exercised every 15 minutes to provide preparatory data for development of a complete wind flow field. These data are used to determine the location of the front or convergence zone associated with the lake/land breeze on a near-real-time basis. The second mode is the generation of the complete wind flow field. The second mode is exercised during the dose assessment function and performs the evaluation of the consequences of accidents, planned releases, as well as the evaluation of model output using standard meteorological and radiological input files (quality control and quality assurance of model operation).

3.2.1.1 Location of Lake/Land Breeze Front

The WEST' module updates, on a real-time basis, the location of the lake/land breeze front every 15 minutes. To determine this location, it is first necessary to estimate the gradient wind and to identify the existence of conditions favorable for the formation of a TIBL (thermal internal boundary layer) and a lake/land breeze.

The estimated gradient wind is determined twice daily at approximately sunrise and sunset. The gradient wind is estimated on the basis of winds measured at the top of the meteorological tower during those morning and evening periods when mesoscale forces are least effective. TIBL conditions are identified on the basis of the time of day, Lake Erie water temperature-air temperature differential, tower temperature lapse rate, absence of rain, and wind direction (Burda et al., 1982; Atkinson, 1981). The occurrence of a lake/land breeze recirculation cell requires the presence of a TIBL and the wind speed measured at the top of the tower to be within site-specific limits for a site-specific time cycle.

The lake/land breeze convergence zone (front) location is dependent on frontal velocity and the time of onset of the lake/land breeze. The frontal velocity is a function of the gradient wind (Biggs and Graves, 1962). The determination of the site-specific relationship of the lake/land breeze frontal velocity and the gradient wind is based on the literature and regional Great Lakes field studies (Lyons, 1975; Bennet and List, 1975; Guski and Miller, 1980). Also the generic techniques to represent the TIBL and sea breeze have been implemented based on the consultation with Dr. Walter Lyons. After these routine calculations are performed, the results are written to a file contained in the data base for use during evaluation of the front location in the next 15-minute time period and for use during dose assessment.

Lake/land breeze parameters are updated every 15 minutes and stored in the data base regardless of whether the full model is being exercised.

3.2.1.2 Wind Flow Field Generation

The generation of the wind flow field is necessary during execution of dose assessment to accurately model the transport of atmospheric effluent. The wind flow field is a set of three-dimensional vectors. This operational regime of the WEST' module utilizes a three-dimensional Cartesian network of cells that completely fills the region to be simulated. For the Perry EMERGE system, each horizontal cell layer is composed of approximately 21 cells by 21 cells. There are five such layers.

Input wind data from the onsite meteorological measurement system are assigned to the cell(s) representing the geographical location and elevation of the meteorological sensors. These values are extrapolated upwards by use of a stability-dependent wind power law procedure to derive initial wind vectors for each cell in the column directly above the measurement location. These vectors are resolved into U and V components, and a weighted $1/R^2$ interpolation could be applied for each horizontal plane to derive initial vectors for each cell in the 21 x 21 x 5 cell array. Thus, a complete initial wind flow field is calculated.

The further development of the wind flow field requires an atmospheric stability array distributed over the cell network. The stability array is developed from measured values of horizontal and vertical stability and is structured on the basis of the presence of either a TIBL, a surface or elevated (non-TIBL) inversion, or the absence of any of these phenomena.

If a TIBL is determined to be present, its spatially variable height is calculated as a site-specific function of distance from shore, wind speed and direction, and climatological values of solar flux. Site-specific values are based on the literature and on Great Lakes studies. For daytime onshore flow, stability below the TIBL is measured directly from the onsite tower. The 60-m tower, approximately 1.8 km inland, is sufficiently far inland to ensure that it is almost always within the TIBL. A conservative typical height of the TIBL at the tower for a direct onshore wind would be nearly 100m. Thus, conditions at the tower are representative of the overland air. A stable atmosphere is assumed above the TIBL. For nighttime offshore flow, stability above the TIBL is measured directly from the tower, while below the TIBL, a neutral atmosphere is assumed.

Depths of surface inversions and mixing heights are based on seasonal and diurnal climatological data. Meteorological data to represent limited mixing conditions may be input by user adjustments of the mixing height file.

The stability array is used to adjust the initial wind flow field for the effects of terrain. This is accomplished by varying the relative transparencies (measure of flow resistance) of the horizontal and vertical cell faces as a function of atmospheric stability.

The assignment of transparency, T, is as follows:

	Stability Category						
Transparency	A	B	C	D	E	F	G
Horizontal (Tx,Ty)	1.	1.	1.	1.	200.	500.	100.
Vertical (Tz)	1.6	1.4	1.2	1.	0.8	0.6	0.4

Terrain cells are assigned zero transparency, that is, infinite flow resistance.

This operation results in a redistributed wind flow field that includes vertical motion. The nondivergence of the wind field is imposed by an iterative solution based on calculating the divergence ϕ such that:

$$\nabla \cdot \vec{U} = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = \phi$$

and readjusting the velocity to minimize the divergence.

$$u = u + \alpha\phi(Tx/\Delta x)$$
$$v = v + \alpha\phi(Ty/\Delta y)$$
$$w = w + \alpha\phi(Tz/\Delta z)$$

In finite difference, these expressions are written as:

$$\frac{u_{ijk} - u_{(i-1)jk}}{\Delta x} + \frac{v_{ijk} - v_{(i-1)jk}}{\Delta y} + \frac{w_{ijk} - w_{(i-1)jk}}{\Delta z} = \phi_{ijk}$$

$$u_{ijk} = u_{ijk} - \frac{\alpha}{\Delta x} \phi_{ijk} Tx_{ijk}$$

$$v_{ijk} = v_{ijk} - \frac{\alpha}{\Delta y} \phi_{ijk} Ty_{ijk}$$

$$w_{ijk} = w_{ijk} - \frac{\alpha}{\Delta z} \phi_{ijk} Tz_{ijk}$$

where

$$\alpha = \beta / \left\{ \left(Tx_{ijk} + Tx_{(i+1)jk}\right) / \Delta x^2 + \left(Ty_{ijk} + Ty_{i(j+1)k}\right) / \Delta Y^2 + \left(Tz_{ijk} + Tz_{ij(k+1)}\right) / \Delta Z^2 \right\}$$

where β is an overrelaxation factor ($1.0 < \beta < 2.0$) and is set equal to 1.25.

The resulting set of three-dimensional wind vectors agrees with input wind measurements and reflects the influence of both terrain features and spatially varying stability.

At this point, if no land or lake breeze recirculation is in effect, the wind flow field is complete. If lake/land breeze recirculation does exist, the wind field is divided into eight regimes, illustrated for a lake breeze in weak gradient flow in Figure 3.2-2. These are:

- Surface layer flow field in front of the convergence zone (A)
- Surface layer flow field in back of the convergence zone (B)
- Return flow aloft behind the convergence zone (C)
- Return flow aloft in front of the convergence zone (D)
- Upwelling flow on front side of convergence zone (E)
- Upwelling flow on backside of convergence zone (F)
- Transition cells at top of upwelling flow behind convergence zone (G)
- Transition cells at top of upwelling flow in front of convergence zone (H).

The airflows shown in Figure 3.2-2 are perpendicular to the coastline. In practice, they would be combined with along-shore wind components of the gradient wind.

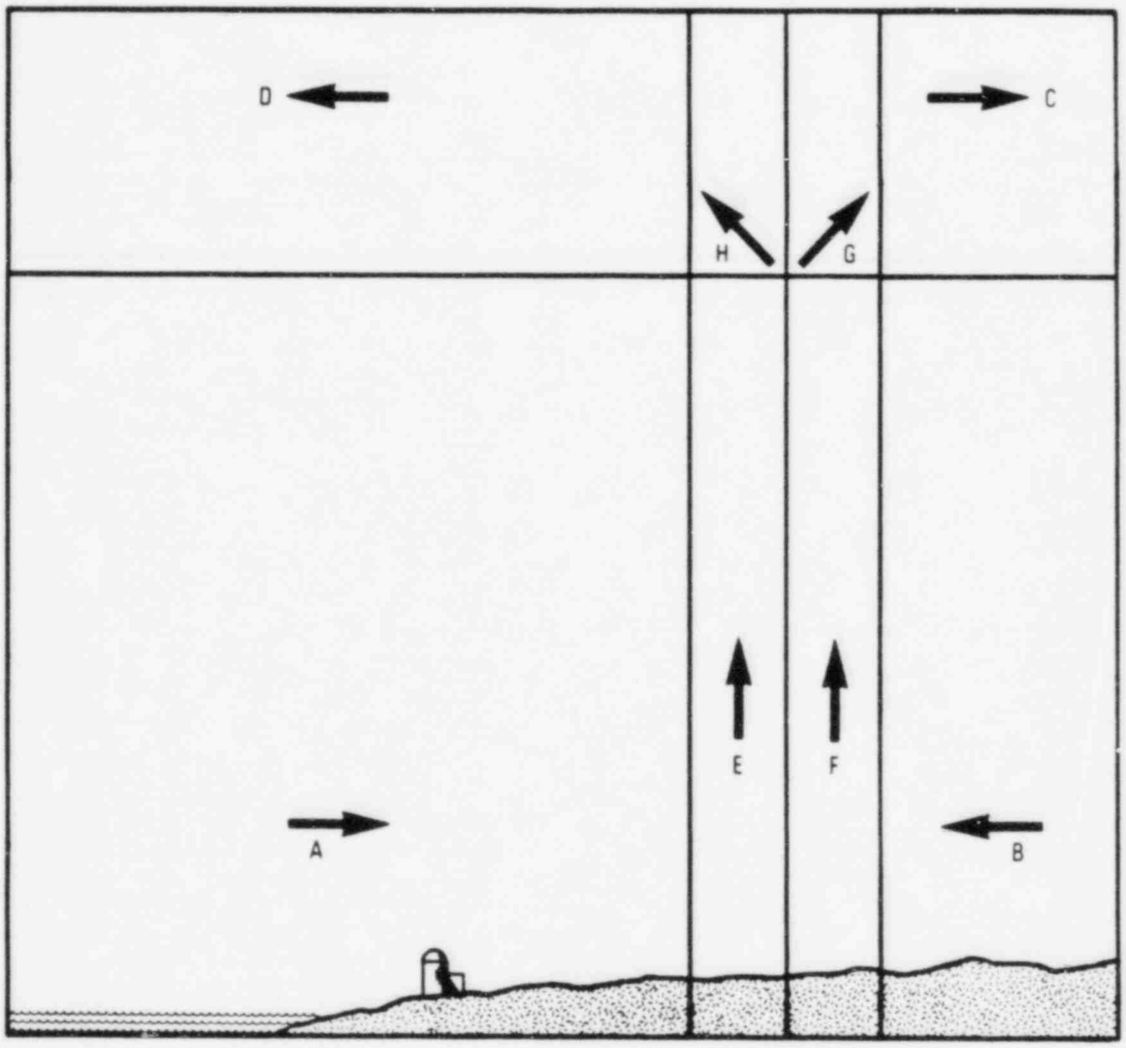


Figure 3.2-2. WEST' Wind Field Regimes for Lake Breeze Pattern with Weak Gradient Flow

Regime A is the onshore flow before the air reaches the lake breeze front. The winds in this regime are assumed by WEST' to be largely unaffected by the presence at the convergence zone.

The wind flow field in Regime B is adjusted by means of a gradient wind-dependent factor.

The wind flow field in Regime C is uniform and is a function of the wind speed measured at the top of the tower and the gradient wind. This wind field includes a weak negative vertical velocity to simulate subsidence of the return flow.

The wind flow field in Regime D is similar to Regime C with the exception that a different function of the gradient wind is applied.

The wind flow field in Regimes E and F are characterized by strong upward velocities with weak horizontal components towards the center of the convergence zone.

The wind flow fields for Regimes G and H are a function of the gradient wind and are used to approximate the time of vertical transport of the plume from the top of the surface layers to the appropriate level for return flow.

The result of these regimes is that air flowing in over the coastal plant (Regime A) may eventually return over the lake (Regime D). Subsequently, as described in Section 3.2.3.2, the return air will eventually subside toward the lake until the air may be re-entrained into the in-flow (usually at some distance up or down the coast from its original point over the plant).

3.2.1.3 Uncertainty Conditions

Every 15 minutes, when WEST' updates the flow field, it will inspect its meteorological data for uncertainty conditions.

Uncertainty conditions are identified to be relayed to the operator. These conditions may significantly increase the uncertainty of the model results or the interpretation of its output. The following are uncertainty conditions for which messages will be provided:

- Calms
- Variable wind directions
- Very stable conditions
- Lake breeze circulation (and location of frontal zone)
- Land breeze circulation (and location of frontal zone)
- Use of offsite data in place of onsite data.

Guidance will be provided in the Emergency Plan Implementing Instructions for compensatory actions to be taken during these uncertainty conditions.

3.2.2 ASTP MODULE

After user identification of the accident to be modeled by EMERGE, the Automated Source Term Processor (ASTP) module generates the atmospheric effluent source term every 15 minutes.

The source term consists of the total radioactivity release rate, the isotopic spectrum of the release, and initial plume configuration. Values for these variables are provided by ASTP for the current 15-minute period and 1- and 2-hour projections.

Approximately ten default accidents will be modeled in EMERGE, ranging from incidents with minimal offsite doses up to the Maximum Hypothetical Accident (MHA). After user identification of one of the modeled accidents, ASTP will select the appropriate files from the data base for source inventory isotopic spectrum; time-dependent total radioactivity release rates; source release point characteristics, including exit height, diameter, velocity, and building wake factor; the identification of each radiological monitor for each possible release point; and the response characteristics of each monitor. ASTP will next calculate the release point concentration and crosscheck the appropriate release point monitor(s) for reasonability with respect to the calculated concentration.

If unreasonable (but valid) monitor values are observed, ASTP will check all other possible release monitors and inform the user that a monitor not normally associated with the selected accident is detecting high concentrations. The user may then re-evaluate his accident selection and via menu-prompted selection (1) direct the model to continue processing based on the unmonitored release, (2) direct processing based on the monitor values, or (3) reinitiate the system with a different accident selection. If the user takes no action within 2 minutes, ASTP will continue processing, assuming an unmonitored release. If reasonable and valid monitor values are observed, ASTP will adjust the current total radioactivity release concentration to the monitored value.

For monitored releases, both the total and isotopic release rates are then calculated based on plant flow rate monitor values, if available, or default values. The release rate for unmonitored releases is a default value.

ASTP then calculates initial plume height and growth. For monitored releases, initial plume rise and growth are calculated, based on the methodology of Briggs, as discussed in NRC Regulatory Guide 1.111 (USNRC, 1977a).

Two plume rise calculations are performed for each release point. The two calculations differ depending upon the stability class (based on delta T or an equivalent).

For a neutral or unstable atmosphere the two calculations are:

$$H_1 = 1.44\ (V/U)^{2/3}\ (500/D)^{1/3}\ (D)$$
$$H_2 = 3.0\ (V/U)\ (D)$$

where

H_1, H_2 = plume rise in meters
V = exit velocity in meters/second
U = wind speed in meters/second
D = exit diameter in meters.

For a stable atmosphere the two calculations are:

$$H_3 = 4.0\ (F/S)^{1/4}$$
$$H_4 = 1.5\ (F/U)^{1/3}\ S^{-1/6}$$

where

H_3, H_4 = plume rise in meters
$F = V^2D^2$
S = stability parameter = 8.75×10^{-4} for E stability
= 1.75×10^{-3} for F stability
= 2.45×10^{-3} for G stability

Of the calculated plume rises, the minimum value, h, calculated for the appropriate stability class, is selected as the actual plume rise.

Downwash is assumed to occur if the exit velocity, V, is less than 1.5 times the wind speed, U, at the exit height. If downwash occurs, a correction to the plume rise is calculated:

$$C = 3D\ (1.5-V/U).$$

This correction is applied to the plume rise, h, such that

$$H_F = h - C$$

where H_F = effective plume height

Initial plume dispersion parameters are set equal to the stack diameter. In the absence of an elevated release (e.g., unmonitored releases), the plume is assumed to be entrained in the wake of the adjacent buildings with the initial dispersion parameters set proportional to the building height. The release height is set equal to the maximum of 10 meters or 1/3 the building height above ground level. For either ground level or elevated releases, the initial plume dispersion parameters are checked to ensure that they are greater than or equal to 1 meter.

ASTP provides initial plume height and growth information and total radioactivity release rate to ACPUFF. The isotopic release rates are provided to ACDOSE.

3.2.3 ACPUFF MODULE

The ACPUFF module is a three-dimensional, variable trajectory, split-sigma, Gaussian, puff dispersion model. The Pasquill-Gifford diffusion parameters are used in the diffusion equation to model the contribution of each puff to concentrations at each of an array of receptors. ACPUFF requires the three-dimensional atmospheric stability and wind arrays as developed by the WEST' module.

ACPUFF is a descendent from NUSPUF (Chandler et al., 1976), which was accepted for application at Perry in 1977 (Markee, 1977).

ACPUFF computes doses/dose rates at approximately 2200 receptor locations. Two types of receptor locations are used. The first type are fixed locations, which are distributed throughout the plume EPZ on a polar grid array. There are 13 radial distances with 160 evenly spaced (2-1/4°) locations at each distance. The spacing of 2-1/4° between locations was chosen as one half of the plume width of a G stability plume. The second type of receptor locations are user-specified points, which can be placed throughout the plume EPZ. For display purposes, the first of these locations is placed at the center of the grid, while the next 16 locations are placed around the site boundary. There are a total of 160 user-specified locations available for use.

Using the methodology of Regulatory Guide 1.111, Revision 1 (USNRC, 1977a), each release point can be classified as either ground level, elevated, or mixed mode. Release points with similar characteristics may then be combined for modeling purposes. ACPUFF can simultaneously model up to three different time-varying release points. Each release point modeled may be a composite of several actual release points. The source term for each release point is calculated in the ASTP model and can be varied as a function of time to represent the behavior of continuous releases. After release, the contents of a puff are varied in accordance with the decay schemes of the radioisotopes in the ACDOSE module as the material advects through the spatial and temporal varying fields developed by the WEST' model.

ACPUFF is based on the concept that a continuous plume can be represented as the limiting behavior of a puff model as the time between puff releases becomes infinitesimally small. The instantaneous concentration from a single puff at a fixed receptor point can be expressed as

$$\chi(x,y,t,z) = \underbrace{\frac{M(t-\tau)}{(2\pi)^{3/2}\sigma_y^{\,2}\sigma_z} \exp\left[-\frac{1}{2}\left(\frac{x-x'}{\sigma_y}\right)^2\right]}_{A} \underbrace{\exp\left[-\frac{1}{2}\left(\frac{y-y'}{\sigma_y}\right)^2\right]}_{B} \underbrace{F(H,\sigma_z,G)}_{C}$$

where

$R(x,y)$ = coordinates of the fixed receptor
$P(x',y',H)$ = coordinates of the puff
$M(t-\tau)$ = mass of material in puff released at time τ (curies)
t = time (sec)
σ_y = horizontal dispersion parameter (m)
σ_z = vertical dispersion parameter (m)
F = multiple reflection function (dimensionless)
G = stability class

Expression A in this equation gives the concentration along the direction of travel (centerline) determined by the wind field. Expression B evaluates the concentration at distances normal to the direction of travel. Expression C is the correction to the concentration that results from reflecting boundaries (ground plane, inversion lids, and TIBLs). The average concentration or doses at fixed receptors involves an analytical integration algorithm that permits the simulation of a plume by the tracking of multiple puffs from each continuous release point. This integration algorithm calculates the dose in a time step Δt

$$\bar{\chi}(x,y,t) = \frac{1}{\Delta t} \int_{t-\Delta t}^{t} \int_{-\infty}^{t} \chi(x,y,t,\tau)\,d\tau\,dt$$

from the source emission and the meteorological field histories for a release point. The contribution Ψ_{ijk} for the ith puff from the jth release point in the kth time step is calculated from:

$$\Psi_{ijk}(x,y) = \left\{ \frac{Q}{4\pi\sigma_y\sigma_z u} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2 \right] F(H,\sigma_z,G) \times \left[\operatorname{erf}\left(\frac{x}{\sqrt{2}\sigma_y}\right) + \operatorname{erf}\left(\frac{u\Delta t-x}{\sqrt{2}\sigma_y}\right) \right] \right\}_{ij}$$

where

x,y = coordinates of the receptor relative to the coordinates of the puff at $t-\Delta t$

$Q = Q(k\Delta t-\tau)$ = emission rate at time τ (curies/sec)

u = wind speed (m/sec)

and

erf $(\cdot)$ = error function.

The dose at a fixed receptor is then calculated by

$$D_k(x,y) = \sum_j \sum_i \Psi_{ijk}(x,y) DF_{ij}$$

where

DF_{ij} = dose factor calculated in ACDOSE.

3.2.3.1 Advection

Each puff must be advected in the correct direction with the correct distance in order to render meaningful the calculated dose patterns. ACPUFF moves each puff from cell to cell using wind vector components unique to each cell. The analytic vector expression of this process is:

$$\bar{R} = \bar{R}_o + \sum_{i=1}^{N} \bar{v}_i \Delta t_i$$

where

$\bar{R}_o$ = puff position at the start

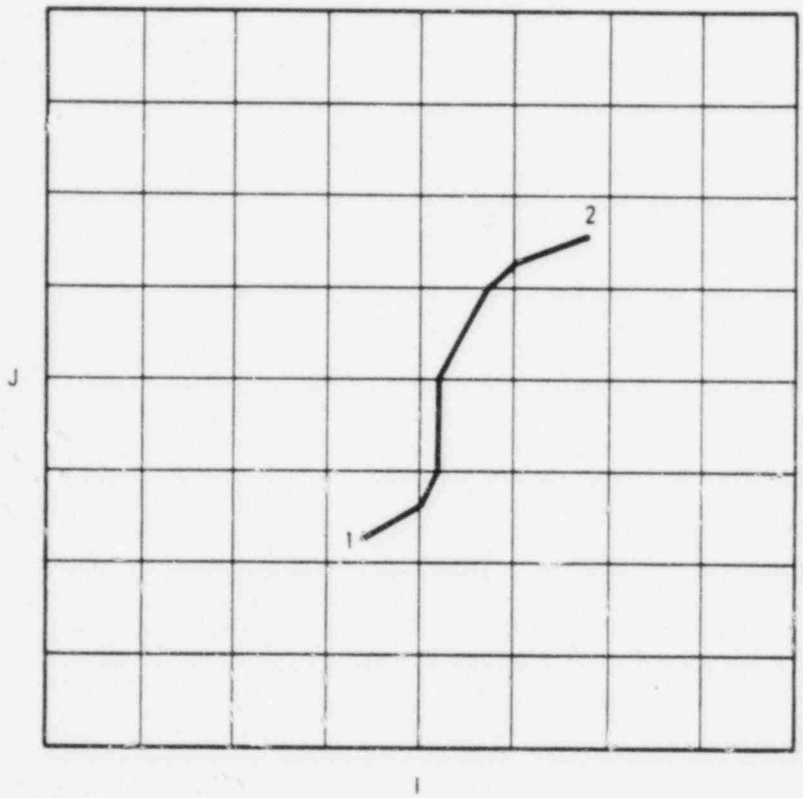
$\bar{R}$ = puff position at the end

$\bar{v}_i$ = velocity vector in the ith cell

t_i = increment of time the puff spends in the ith cell, and

N = number of cells traversed.

At the conclusion of a full advection step (15 minutes), the age of each puff is increased by the time allocated to that step. This age is then used in dose calculations to decay the various nuclides in the puff. Figure 3.2-3 illustrates a multicell horizontal translation. Puffs may also concurrently move through



Notes:

1 and 2 are the starting and ending locations of the puff during a single time step.

I and J are cell numbers in the x and y direction, respectively.

Figure 3.2-3. Intercellular Puff Advection vertical cells. Figure 3.2-4 depicts the three-dimensional aspects of movement through one cell during which the puff started on a y-z face and ended on an x-z face. Several aspects of cellular advection require special attention.

3.2.3.2 External Puffs

For the Perry EDAS, ACPUFF can track up to 15 puffs per source including puffs which exit the wind flow field. Since wind vectors are undefined outside the wind flow field, special treatment is necessitated. Puffs which have left the grid during previous time steps are treated during the current step as follows:

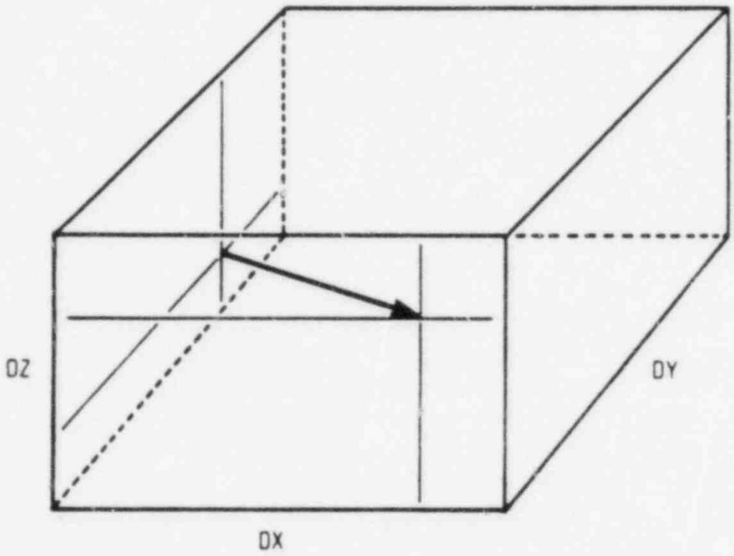
- Puffs which originate within the grid during the current time step and leave during this same time step are propagated outside the grid during the calculation for the time-step in which they leave the grid and using the last valid grid-defined u, v, and w components of the puff.

- Puffs having previously left the top of the wind flow field are assumed to have the wind vector components of the center cell of the top layer.

- Puffs having previously left the sides of the grid use vector components taken at puff height and averaged over cells comprising the face nearest the puff. Terrain cells are ignored in the averaging process.

- Puffs are permitted to re-enter the grid. They are examined to see if by chance they re-entered below terrain and if so, are set 10 meters above terrain.

With this function of the treatment of external puffs, the recirculation of lake/land breezes is completed. (See Section 3.2.1.2 of WEST'.)



Notes:

DX, DY, and DZ are the dimensions of a single cell in the x, y, and z directions, respectively.

The arrow depicts a three-dimensional trajectory of a puff through a cell.

Figure 3.2-4. Intracellular Translation

3.2.3.3 Terrain

In general, divergent-free winds prevent puffs from impacting terrain cells but on occasion, under conditions of strong trapping with flow directed at steep terrain, puffs can directly encounter terrain cells. The velocity component that would cause impaction on terrain is reversed and diminished by a factor of 10, while momentum is conserved by distributing nine-tenths of the component to the remaining two components. For cases in which puffs are found less than 10 meters above a terrain cell, they are reset to 10 meters above that cell.

3.2.3.4 Dispersion

Both y and z components of puff dispersion (σ_y, σ_z) are permitted to grow independently during inter-cellular translation. This is achieved by associating with each puff a virtual downwind distance. The standard Pasquill-Gifford (P-G) curves provide current values of puff dispersion parameters. Virtual distance is repeatedly incremented by actual distance traversed in each cell. If stability should change from one cell to the next, a new value of virtual distance is calculated appropriate to the stability of the cell into which the puff is moving. At this point the new virtual distance is incremented by the actual distance traveled.

In the EMERGE model horizontal and vertical stabilities are not necessarily equal. Thus, the above process of virtual distance assignment is carried out independently for the horizontal and vertical directions.

3.2.3.5 Height Above Ground

The value of puff height above ground at the end of an inter-cellular movement is determined by two different methods. If the accumulated change in vertical position of the puff is less than

10 percent of cell layer depth and the terrain heights at the beginning and end of travel are equal, then puff height above ground is set to the calculated vertical position minus the present cell's value of terrain height. If these conditions are not satisfied, the implication is that the puff is moving over changing terrain. In this case, step-like values of local terrain are inappropriate indicators of terrain height giving rise to discontinuous changes in computed puff height as a puff drifts across cell boundaries. Therefore the value of local terrain is smoothed through interpolation of the four nearest terrain cell heights. The resulting interpolated terrain value is subtracted from the vertical value of puff position to yield a continuous measure of puff height above ground.

If the original two conditions are satisfied, non-interpolated terrain is employed to create a more realistic measure of puff height above ground when a puff is near terrain and is moving parallel to it. In this case, the puff's elevation will not change appreciably during horizontal movement and the use of interpolated terrain could thereby yield puff heights above ground that are too low. An example of this is puff motion in a steep-walled canyon where the puff is close to one of the walls but moving parallel to the canyon walls. The non-interpolation method of height determination provides a better measure because discrete terrain steps are analogous to steep canyon walls.

Puff advection results in the movement and growth of the puff. The concentration at a receptor must account for modification due to reflections from ground plane, inversion lids, or TIBL. The following describes the modification of concentration through the use of a reflection factor.

3.2.3.6 Vertical Boundary Reflections

ACPUFF incorporates reflection due to the effect of plume trapping or presence of the ground.

In the absence of a lid or TIBL, ground plane effects are calculated as a single reflection. In the presence of a lid or TIBL, three different forms for the reflection factor are used. When the puff's vertical diffusion is less than one-half of the height of the lid, the puff is not significantly influenced by the lid and reflection is calculated as follows:

$$F(H,\sigma_z) = 2 \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]$$

where

H = height of plume (m)
σ_z = vertical standard deviation (m)

When the puff's vertical diffusion is greater than the lid height, the puff is strongly modified by the lid and uniform mixing is assumed as follows:

$$F(H,\sigma_z) = \frac{\sigma_z \sqrt{2}\pi}{H}$$

Between these limits the lid's influence is approximated with two reflections as follows:

$$F(H,L,\sigma_z) = 2\left\{\exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2 + \exp\left[-\frac{1}{2}\left(\frac{H+2L}{\sigma_z}\right)^2\right]\right.\right. \\ \left.\left. + \exp\left[-\frac{1}{2}\left(\frac{H-2L}{\sigma_z}\right)^2\right]\right]\right\}$$

where

L = height of lid (m)

For two special conditions the reflection factor is set to zero. The first case is when the puff is below the lid, in neutral or unstable air, and the receptor is above the lid (on nearby high terrain) in stable air. The second is when the puff is above a ground-based inversion, that is, where it is in neutral or unstable air, while the receptor is below the interface in stable air.

3.2.3.7 Doses

Once the integrated concentration at a receptor is determined, the concentration is multiplied by the dose factors provided by ACDOSE to yield doses. This product is the dose received during the 15-minute time period. The cumulative dose is calculated by adding the current dose to the previous accumulation of dose rates. ACPUFF can process two sets of doses/dose rates.

These are whole-body plume exposure and child thyroid inhalation. In addition to the two sets for the current time period, ACPUFF presents similar information for the 1-hour and 2-hour forecast periods.

3.2.4 ACDOSE MODULE

The ACcident DOSE (ACDOSE) module processes the isotopic spectral release rate information provided by ASTP to calculate the dose factors required by ACPUFF. A dose factor is a variable which when multiplied by concentration yields a dose. Dose factors are developed for whole-body dose from plume submersion and for child thyroid dose from inhalation of the plume. The dose factors are based on the isotopic, age, organ and pathway-dependent dose conversion factors and age-dependent breathing rates contained in NRC Regulatory Guide 1.109, Revision 1 (USNRC, 1977a). ACDOSE can use up to 50 isotopes and can include the effect of decay during the plume transport.

3.2.5 SUPER MODULE

The EMERGE module SUPERvisor (SUPER) provides overall control of the EMERGE model. The OIF (Operator Interface File) provides the control flags which SUPER interprets for determination of the operational sequences of EMERGE. The control flags are set depending on the operational mode specified by the user. Based on these flags, SUPER determines which of the various modes of operation will be used by EMERGE during the current 15-minute time period along with necessary input and output. SUPER provides all the controls for EMERGE I/O either by providing the reads and writes or by controlling access to files (opening and closing) processed in the other four EMERGE modules of WEST', ASTP, ACPUFF, and ACDOSE.

3.3 DATA BASE

The model's data base consists of two types of files: parametric data (or table-lookup) files and dynamic data files.

The parametric data, supporting the table-driven aspect of the model, are user adjustable/updatable. This approach provides the model with the most current and accurate definition and specifications of plant and site characteristics. (This precludes the need to substantially re-code the model to accommodate any plant and site changes.)

Included in the parametric data files are: locations of special receptors and meteorological and radiological monitors; parameters defining lake breeze and terrain; local maps; site-specific reference environmental data (water temperature, solar flux, mixing heights, stability classes); source spectral characteristics of default accident scenarios; and accident scenario descriptions.

The dynamic files contain time-tagged data resulting from regular software runs (e.g., from DAS) to be input to the model for processing, and output from the model for dosimetric and time history data display generation. All collected dynamic data are maintained in historical archive files and are retrievable.

3.4 TERMINAL INTERFACE SOFTWARE

The terminal interface software (TIS) operates under a menu-driven regime that includes various dosimetric displays. In the event of an accident, the accident start time is specified to the system by the user. The user also selects the appropriate accident type (from a display menu).

Upon accident identification, the EMERGE model accesses the appropriate data base record from the accident scenario description file (for that selected accident) that identifies the list of appropriate radiological sensors and their default values for that accident type. EMERGE then accesses the real-time meteorological and radiological data files from its data base.

The EMERGE model will process the monitor averages and produce the dosimetric and isopleth displays for the first phase of the accident. The model will subsequently run every 15 minutes upon receipt of current validated meteorological and radiological monitor averages; it will run without user intervention and will produce dosimetric displays.

Each time that the EMERGE dispersion model completes the calculation of data concerning plume dispersion, consequent dose and dose rates, it provides dose output files to the data base. The TIS accesses the data base dose output files and applies a graphics/contouring routine to generate the isopleths of the display. Displays are presented with user-selectable overlay maps of the 10-mile EPZ.

The following types of displays are available for viewing:

1. Display of dose isopleths or lines of constant dose. The dose isopleth groups are divided as follows: four current update isopleths, four 1-hour-forecast isopleths, and four 2-hour-forecast isopleths.

   Four dose isopleths for each of the time periods above will be designated as follows:

   a. Thyroid dose rate
   b. Whole-body dose rate
   c. Thyroid cumulative dose
   d. Whole-body cumulative dose

2. In addition to the isopleth display, a selection menu will provide the maximum dose/dose rate direction and distance for thyroid and whole body pathways, as well as

a display of plume centerlines or center of mass movement for the past 1 hour, the current time, and 1-hour-forecast data.

3. Display of dose time histories. The base time histories will give the dose history (for thyroid or whole body pathways) for a specific user-selectable point(s), up to 160 points.

In addition to directing the selection of displays, the user can respond to changing conditions through the TIS. By calling up menus, the user can interactively direct the following:

- Add new release locations (actual or "what if")
- Adjust release rates (actual or "what if")
- Adjust isotopic spectrum of releases (actual or "what if")

  [In the "what if" mode the user-entered data do not effect actual measured or calculated values in the data base.]

- Determine possible effect of an updated weather forecast
- Adjust any measured or calculated variable in the data base
- Update any site-specific and plant parameter data in the data base.

4.0 SUMMARY

The methods and technical bases have been presented for making emergency offsite dose calculations at the Perry Nuclear Power Plant. Both a hand-calculated and a compatible automated method will be adopted.

The automated method is the more sophisticated one. It uses real-time source term and release characteristics information, as well as real-time meteorology that takes into account the coastal location of the PNPP. The system is menu driven to enhance the man-machine interface. The system will provide for rapid dose assessment for the Perry EPZ in the event of an accidental atmospheric release.

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6.0 CROSS-REFERENCE TO NRC QUESTIONS

This chapter lists the sections of this document in which NRC Round 1 and Round 2 questions on the Perry Emergency Plan are addressed. Only questions directly relating to emergency offsite dose calculations are cross-referenced. References to Chapter 2 concern the hand-calculated method; Chapter 3 contains the automated methodology.

6.1 ROUND 1 QUESTIONS

Question	Location(s) Addressed	Comments
I.3	Sections 2.0, 2.4-2.10 Section 3.2.2	Identification of the accident, and therefore, the source terms, is the responsibility of the operator. Once the accident is identified, the source terms and release magnitude can be "fine-tuned" using results of effluent analyses.
I.4	Sections 2.4, 2.5, 2.8 Section 3.2	Section 3.2 includes an incorporation of the lake/land breeze.
I.6	Sections 2.9, 3.2, 3.4	If the ERIS computer is inoperable, use entire Chapter 2.
I.10	Sections 2.8, 2.10 Sections 3.2.3.7, 3.2.4, 3.4	Integrated doses are addressed in Sections 2.10 and 3.2.3.7.

6.2 ROUND 2 QUESTIONS

Question	Location(s) Addressed	Comments
H.5	Sections 2.1, 2.2, 2.3 Sections 3.1.2, 3.1.3, 3.2.1, 3.2.2, 3.2.3	Sections 2.2 and 2.3 contain back-up methods for estimating dispersion parameters based on visual observation.
H.6	Sections 3.1, 3.2	Actual dose calculation methods are in Section 3.2. Section 3.1 discusses data validation requirements for input into the dose calculations.
H.7	Sections 2.1, 2.2, 2.3 Sections 3.1.2, 3.1.3, 3.2.1, 3.2.2, 3.2.3	Sections in Chapter 2 contain back-up methods for obtaining dispersion estimates.
I.3	Sections 2.4, 2.5 Section 3.2	Back-up methods are in Sections 2.4 and 2.5.
I.4	Chapter 2, Chapter 3	Chapter 2 addresses hand-calculated methods; Chapter 3 discusses automated methods.
I.5	Sections 2.9, 3.2, 3.4	If the ERIS computer is inoperable, use entire Chapter 2.