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ATMOSPHERIC DISPERSION ANALYSIS IN PREPARING PERMIT APPLICATIONS FOR THE NEW NUCLEAR POWER PLANTS IN THE UNITED STATES

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ABSTRACT

Nuclear power generation has become an increasingly attractive alternative in the United States (U.S.) power market due to several factors: growing demand for electric power, increasing global competition for fossil fuels, concern over greenhouse gas emissions and their potential impact on global warming, and the desire for energy independence.

Currently there are more than 19 utilities and nuclear energy groups in the U.S. have announced plans for new plants to submit permit applications of Early Site Permits (ESP) and/or Combined Licenses (COL).

In support of the permit applications, the following assessments are required:

- potential dispersion of radioactive material from, and the radioactive consequences of, design-basis accidents to aid in evaluating the acceptability of a site and the adequacy of engineered safety features for a nuclear power plant;
- maximum potential annual radiation dose to the public resulting from the routine release of radioactive materials in gaseous effluent;
- habitability of the control room during postulated design-basis radiological accidents and hazardous chemical releases;
- near-real-time atmospheric transport and diffusion estimates immediately following an accidental releases of airborne radioactive material to provide input to the evaluation of the consequences of radiological releases to the atmosphere and to aid in the implementation of emergency response decisions;
- the potential dispersion of radioactive materials from, and the radiological consequences of, a spectrum of accidents to aid in evaluating the environmental risk posed by a nuclear power plant; and
- the non-radiological related environmental effects, such as fogging, icing, and salt drift from cooling towers or ponds, to aid in evaluating the environmental impact of a nuclear power plant.

The paper presents an overview of dispersion modeling approaches/techniques. Common regulatory conformance issues, particularly regarding (i) available computer modeling tools (including the USNRC-endorsed dispersion models), model application limitations and model input requirements, and (ii) use of meteorological data collected onsite and/or data collected on regional meteorological network, will be fully discussed. Lessons learned in performing these atmospheric dispersion analyses and practical model user tips are also included.

1. INTRODUCTION

Regulatory processes vary vastly from country to country. However, the types of permits and approvals that must be obtained for an international nuclear power project appear to be similar to those normally encountered in the United States.

In the US, the applicable Federal law that governs any radioactive releases from nuclear power plants is: Title 10 Code of Federal Regulations (CFR). The US Nuclear Regulatory Commission (USNRC) regulates the nuclear power plant activities.

For nuclear power reactor site applications, regulations requires the evaluation of site atmospheric dispersion characteristics and the establishment of dispersion parameters such that (i) radiological effluent release limits associated with normal operation from the type of facility proposed to be located at the site can be met for any individual located off site, and (ii) radiological dose consequences of postulated accidents meet the prescribed regulatory dose limits at the exclusion area boundary (EAB) and low-population zone (LPZ) distances.

The following presents a brief overview on dispersion modeling approaches, techniques and relevant available dispersion models. Model input and limitations, regulatory conformance issues for some of the most commonly used models and model user tips are also discussed.

2. DISPERSION MODELING APPROACHES

2.1 Atmospheric Processes

As effluents are released into atmosphere, they are immediately acted upon by atmospheric processes. Figure 1 below provides a conceptual view of these atmospheric processes.

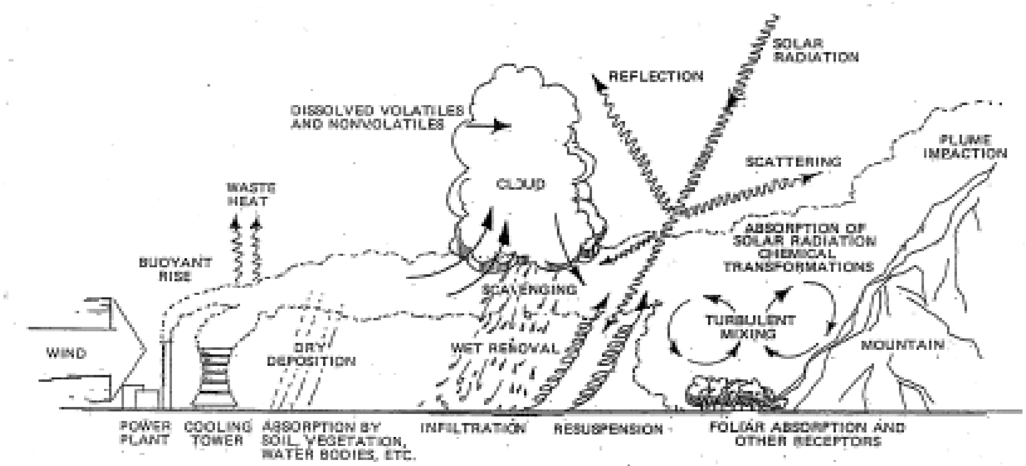

Figure 1 A Conceptual View of Atmospheric Processes

Given some particular source of material, the questions of primary interest are where does it go; how rapidly does it dilute in getting there; and how rapidly and by what mechanism is it removed from the atmosphere. The answers to these questions are extremely complex and depend on the interacting factors of source effects, atmospheric structure, and elements of the underlying terrain.

2.2 Dispersion Modeling Concepts

Dispersion modeling concepts include Gaussian plume, statistical theory of diffusion (e.g., Monte Carlo Particle Trajectory Models of diffusion), Similarity Theory (dimensional analysis), and Gradient Transport (K) Theory (numerical solutions and higher order closure methods).

The most frequently used dispersion modeling concept for practical applications is the Gaussian plume and it has served as vehicle for many useful and innovative studies. The choice is by no means arbitrary but has a basis in classical diffusion theory and statistics. It produces results that agree with experimental data as well as any model, consistent with the random nature of turbulence.

The atmospheric transport, diffusion and deposition of effluents have been widely studied theoretically and experimentally.

The adequacy of the existing dispersion models for certain problems depends largely on the application.

2.3 Modeling Frame of Reference

As an atmospheric process, diffusion represents the spreading of gaseous caused by turbulence motion in the atmosphere. When effluents are released into the atmosphere, their concentration patterns are controlled to a large extent by turbulence diffusion. This process depends on how turbulence the atmosphere is at a given time and place.

Eulerian turbulence is traditionally measured at a fixed point, such as on a meteorological tower. The wind and turbulence are measured by an anemometer as the air flows past. Measurements of an air molecule that has been tagged and followed as it moves through the turbulence field are called Lagrangian measurements. Figure 2 illustrates the two measurement systems.

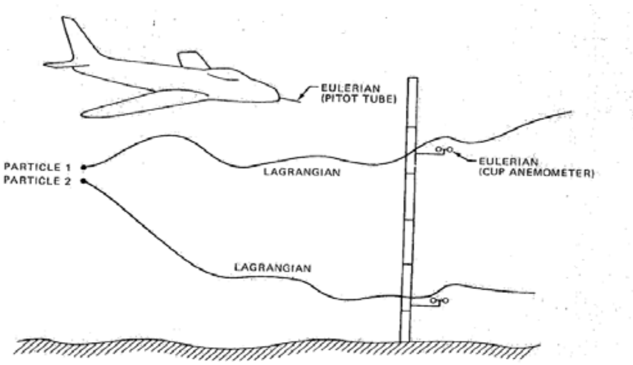

Figure 2 Eulerian and Lagrangian Wind-measuring System

The statistical theories of diffusion are based on the evolving time history of maker particles in turbulence flows and therefore reflect a fundamentally Lagrangian variable. Clearly the diffusion of pollutants is a Largrangian process, which unfortunately must usually be estimated by using Eulerian measurements. A relationship between the two systems has been established by Gifford (1955) and others. The results indicate that the turbulence spectra are similar in structure and differ only by a ratio of their time scale. Thus, this finding allows relating atmospheric turbulence to routine meteorological measurements. In particular, many attempts have been made to link boundary-layer turbulence to the vertical gradients of temperature and wind, to the average temperature, and to the horizontal wind. However, the relation between these quantities and diffusion is not well understood. Therefore it has been necessary to develop empirical connections between the meteorological quantities and atmospheric diffusion. These empirically based procedures are known as turbulence typing schemes.

3. MODELING TECHNIQUES AND AVAILABLE TOOLS

What models and/or assumptions to be used in an application depend on the released effluent characteristics and their quantities, distances from the releases location to the receptors of interest, nature of the underlying terrain within the modeling domain, length of time required to be model and the amount of available meteorological data are available.

A sample list of commonly used atmospheric dispersion modeling techniques / tools is briefly discussed below.

3.1 Routine and Accidental Radiological Releases

- XOQDOQ (for simple terrain) – R.G. 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors."

  It is an atmospheric dispersion program for evaluation of routine releases at nuclear power stations. The model is a straight-line Gaussian distribution program designed to calculate X/Q (relative concentration) values. A combined thermal and mechanical turbulent effect is calculated via vertical and lateral diffusion coefficients as determined by atmospheric stability conditions. Model source characteristics include: topography, radioactive decay, plume depletion through dry deposition, local air recirculation and stagnation. Releases from a single source may be at ground level, elevated, or mixed mode. X/Q and D/Q (deposition) calculations are made at the site boundary and at the closest vegetable garden, residence and cow/goat.

  Meteorological input includes 1-3 years composite joint frequency distribution of wind speed, wind direction and stability class.

  MESODIF (for complex terrain) Plume Segmented Trajectory model in conjunction with XOQDOQ has been used to determine terrain re-circulation factors.

- PAVAN – R.G. 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants."

  It is an atmospheric dispersion program for evaluating design basis accidental releases of radioactive materials from nuclear power stations. PAVAN is a straight-line Gaussian distribution program designed to calculate X/Q (relative concentration) values. A combined thermal and mechanical turbulent effect is calculated via vertical and lateral diffusion coefficients as determined by atmospheric stability conditions. Model source characteristics include: Wake effects due to nearby buildings, plume meandering due to low wind speeds, and adjustments due to non-straight plume trajectories. Releases from a single source may be at ground level or elevated. X/Q values (up to 30-day averaging period) are calculated at the exclusion area boundary (EAB) and at the outer boundary of the low population zone (LPZ).

  Meteorological input includes 1-3 years of composite joint frequency distribution of wind speed, wind direction and stability class.

3.2 Control Room Habitability Evaluation (for radiological and chemical releases)

- ARCON96 – R.G. 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants."

  The program was developed for use in control room habitability assessments following accidental releases of radioactive and/or chemical material from sources such as steam pipe, containment building, vent stack, water tank, equipment hatch door, atmospheric dump valve, etc. The model has also been used in the existing nuclear power plants for re-design purposes. Model descriptions can be found in NUREG/CR-6331. Unlike the XOQDOQ and PAVAN, the program uses an entire year or a multiple years (1 to 5 years) of hourly meteorological data as input to estimate short-term (1 to 2 hours) and long-term (up to 30 days) X/Qs.

- R.G. 1.78, Rev. 1, "Evaluating the Habitability of a Nuclear Power Plant Control Room during a Postulated Hazardous Chemical Release", USNRC 2001

- NUREG-0570, "Toxic Vapor Concentration in the Control Room Following a Postulated Accidental Release", USNRC, Wing, J., 1979.

- HABIT (NUREG/CR-6210) is a Pacific Northwest Laboratory developed and NRC-sponsored code for estimating concentrations of toxic substances at control room air intakes.

3.3 Radiological Consequences Evaluation of a Spectrum of Severe Accidents

MELCOR Accident Consequence Code System, Version 2 (MACCS2)

It is a statistical stochastic diffusion model. The plume is modeled by an ensemble of fluid particles that have trajectories described in stepwise fashion according to a particular stochastic formulation. One of the simple steps is the random walk where each new step of a particle trajectory is randomly chosen from a distribution of possible steps independently of the previous history of particle motion, or following a "Monte Carlo" path. The model also accounts for the efficient removal of particulate radio-nuclides from the plume by wet deposition.

Meteorological input includes multiple years of sequential hourly wind speed, wind direction, stability class and precipitation data.

A Code Manual for MACCS2 (NUREG/CR-6613) was developed by Sandia National Laboratories (SANS97-0954) and published by the USNRC, May 1998.

3.4 Real-time Dispersion Modeling (Emergency Planning)

- MESODIF-II, "A Variable Trajectory Plume Segment Model to Assess Ground-Level Air Concentrations and Deposition of Effluent Releases from Nuclear Power Facilities"

In the model, calculated particle trajectories vary as synoptic scale wind varies. At all sampling times the particles are connected to form a segmented plume centerline and the lateral and vertical dimensions of the plume are determined by a parameterization of turbulence scale diffusion. The emissions are simulated by discrete particle emissions are a user-specified time interval (e.g., 1-hour, 15-minutes and etc.). The model assumptions are outlined in R.G. 1.111. Sequential meteorological data at user specified time interval are used.

- CALPUFF Model

It is a non-steady-state air dispersion model which will be implemented by the EPA for assessing air quality impacts involving complex terrain, light and calm wind conditions, long range transport, visibility assessments, etc. The model has 3 main components: CALMET (a diagnostic 3-D meteorological model), CALPUFF (the transport and dispersion model), and CALPOST (a post processing package). There are other processors that are used to prepare geophysical (land use and terrain) data in many standard formats, meteorological data (surface, upper air, precipitation, and buoy data), and interfaces to other models. Hourly meteorological data includes data from a single meteorological station or a network of stations.

CALPUFF has been formally proposed by the EPA for inclusion in Appendix A of the Guideline on Air Quality Models as a preferred model. Both the EPA and the U.S. Park Service have indicated that this model will be mandatory for air permit applications involving complex terrain, national parks, and other pristine areas.

3.5 Heat Dissipation System Impact Analysis

SACTI (EPRI) - The Seasonal/Annual Cooling Tower Impact Model consists of three programs: PREP (data pre-processor), PLUME (plume program), and TABLES (table generation). The pre-processor determines plume categories and generates representative cases for each category based on meteorological data (hourly surface and twice-daily mixing height). The plume program determines plume drift predictions for each plume category. The generation program for tables uses the enhanced database to produce tables of predicted impact by distance and wind directions for user-specified season(s). SACTI can also calculate rates of salt deposition based on user-specified drift size distributions (drop size distributions for natural daft cooling towers are provided as default values in the SACTI model).

Note that the model applies to the conventional cooling towers, but not the plume abated towers.

4. MODELING CONFORMANCE CHALLENGES

Majority of the submitted and planned ESP/COL applications for new nuclear power plants in the United

States are with proposed facilities located at existing nuclear plant sites.

The following addresses some conformance challenges that have recently been encountered in preparing the ESP and COL licensing documents.

4.1 Length and Currentness of Meteorological Records Required

Submittal Requirements

For an ESP application, at least one annual cycle of onsite meteorological data should be provided at docketing (RS-002, Attachment 2; Section 2.3.3). Meteorological data required should be provided in the form of joint frequency distribution of wind speed and wind direction by atmospheric stability class as described in R.G. 1.23, and an electronic listing of each hour of the hourly-averaged data should also be submitted.

For a COL application, at least two consecutive annual cycles (and preferably three or more whole years), including the most recent 1-year period, should be provided at docketing. The data reporting format is identical to that required for the ESP application.

Conformance Issues

Although the regulatory guidance provided in Draft DG-1145 and DG-1164 and the recently updated Draft Standard Review Plan (SRP) Rev.3 (NUREG-0800) stipulates that data for “the most recent 1-year period” is to be used, the NRC has indicated a willingness to be flexible on this point in order to assure that the data used is defendable, representative and complete.

In general, the use of 3 to 5 years of data is considered to be sufficient to ensure that meteorological conditions have been adequately represented for use in dispersion calculations and the most recent 1-year period could be relaxed provided that there are no significant man-made obstructions and/or moisture sources additions in the surrounding environment that could caused any weather modifications.

4.2 Meteorological Model Input Requirements

- Wind Speed, Wind direction and Ambient Temperature Difference (Delta-T)

  Regulatory Requirements

  On the primary tower, wind speed and wind direction should be monitored at approximately 10 and 60 meters and at a representative higher level for stack releases. The 60-meter level generally coincides with the routine release level for LWRs. Ambient temperature differences are measured between 10 and 60 meters, and between 10 meters and the stack release height. (R.G. 1.23, C. Regulatory Position 2)

  Conformance Issue

  R.G. 1.23 and Draft DG-1164 require at least two levels of wind measurements and the upper level measurement level is implicitly indicated to be at the level of the routine releases. Guidance from ANS/ANSI 3.11 states that additional wind measurements should be made at the level representative of the most probable atmospheric release height applicable to radiological activities.

  It is conceivable that accident releases from some of the new reactor designs (e.g., AP1000), which are being considered in the ESP/COL Applications, are at a level higher than the implied routine releases height. Caution must be exercised to ensure that representative data has been captured by the existing data collection system in order to perform the required X/Q estimates.

  On the other hand, radioactive releases from certain new reactor designs (e.g., ABWR) can be relatively low when compared to the typical 60-meter routine release level for LWRs. Nevertheless, actions must be taken to ensure that the separation of the temperature difference between the 10 meter and the release height should be no less than 30 meters.

- Dew Point

  Regulatory Requirements

  Ambient moisture should be monitored at approximately 10 meters and at a height where the measurement will represent the resultant atmospheric moisture content if cooling towers are to be used for heat dissipation. (R.G. 1.23, C. Regulatory Position 2)

  Conformance Issue

  In recent ESP reviews, additional onsite data (i.e., dew point measurements at two levels) have been requested by NRC in support of their review of cooling system impact analyses. However, Draft DG-1164 does not require dew point temperature measurements made at 10-meter level, instead, the measurement requirement is to be at height representative of water-vapor release.

  In general, onsite dew point measurements are made at the 10-meter level at existing nuclear power plants. Measurement at the height where the cooling tower plume exits the tower presents significant technical challenges, especially for natural-draft cooling towers which are typically in a range of 400 to 500 feet tall. Requirements for measurements at these levels are impractical.

Regulatory guidance on vertical extrapolation of dew point data, as well as agency explanation on exactly how the data will be used, and how the agency has approached this in the past without such data being available would be very helpful.

In addition, it is commonly known from operating experience that dew point sensors are difficult to maintain. The availability of acceptable dew point data onsite may be low. Therefore, early consideration by ESP and COL applicants for implementation of reliable and acceptable moisture sensors onsite and/or to raise data requirements early with the agency is advisable.

4.3 Thermal Internal Boundary Layer Effects

When cooler air over a large body of water (e.g., ocean, bay, natural or man-made lake) moves inland during onshore flow conditions, a thermal internal boundary layer (TIBL) begins to develop due to mechanical and thermal effects at the land-water interface. The properties and growth of a TIBL will depend upon a number of factors, such as the land-water temperature difference, depth of the water body, strength and direction of the geostrophic wind, time of day (i.e., this is a daytime, rather than nighttime phenomenon), roughness of the terrain, curvature of the coast- or shore-line relative to the site, and moisture conditions over land.

The diffusion characteristics within a TIBL are noticeably different than those above the TIBL. Thus, the consequence of the TIBL would be its effect upon a change in stability of the atmosphere and diffusion characteristics. Figure 3 illustrates a typical shape for a TIBL in relation to the land-water interface and how the representativeness of the meteorological data measured during the influence of a TIBL can be affected by location of the tower.

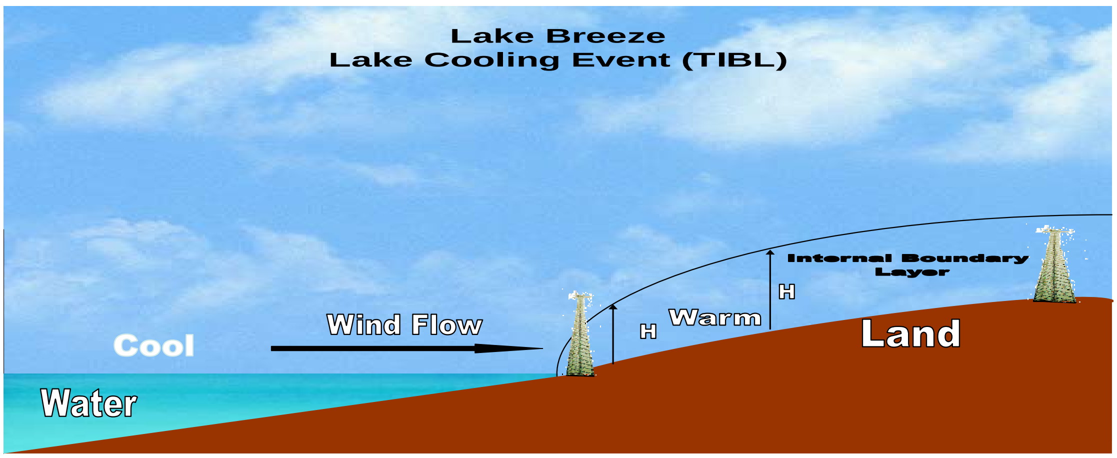

Figure 3 Thermal Internal Boundary Layer Effects

Regulatory Requirements

At coastal sites, the primary meteorological tower should be in such a location that the upper measurement level is within the TIBL during onshore flow conditions. Heights of the TIBL should be confirmed experimentally before the tower is chosen. (R.G. 1.23, C. Regulatory Position 2)

Conformance Issue

When meteorological data collected from an existing tower, that is located near a large body of water, are used to support a new nuclear plant permit application, the X/Q estimates for the new unit(s) based on the existing data could be under-predicted, over-predicted or unaffected depending on the relative locations of the tower to the growing TIBL and to the proposed unit(s). Therefore, it is essential that the representativeness of the existing data be fully analyzed. The impacts from under-predictions will need to be accurately quantified and considered in making the site specific X/Q estimates. The potential implications of over-predictions need to be evaluated as well.

4.4 Meteorological Data Substitution

When meteorological data from an existing primary tower are not available, values may be substituted from an alternative source where it can be demonstrated that the alternative data are representative of conditions at the proposed site.

Industry Guidance

If it becomes necessary to replace onsite data, one of the following methods should be used (in the order shown) as recommended by (ANS/ANSI 3.11, 2005).

- If the site location has a multiple-level meteorological tower or a back-up tower, valid measurements from a redundant sensor at the same level (if installed) or measurements from another level should be used. If the measurement height is significantly different, adjustments should be made based on vertical profiles of the parameter of concern. Site- specific profiles based on 3 years of onsite data should be used, if possible.

- If the missing data period is short (i.e., up to two hours), the missing data might be resolved using linear interpolation. If the data missing period occurs during the day-night transition period or during a weather event such as a thunderstorm, linear interpolation may not be appropriate.

- When there are nearby monitoring sites, such as National Weather Service (NWS) stations or military bases where monitoring programs are operated under a well-documented quality assurance program, it may be possible to substitute these data for missing periods. These data substation techniques should only be used when previous studies have confirmed that data for parameters from both sites compare favorably. Differences in instrument thresholds or data collection procedures could make some data from two stations incompatible.

Conformance Issue

The majority of the existing nuclear plants in the U.S. have a 10-meter back-up tower located onsite, measuring wind speed, wind direction, and wind direction fluctuation While substitution of stability class data is allowed, replacement of a large amount of missing temperature difference data from the primary tower with the sigma-theta collected from the backup tower should be avoided. Results have suggested that the atmospheric stability class determinations based on these two types of data do not compare well.

4.5 Use of Nearby Existing or Regional Data

A comparison or confirmatory study is required to be made when nearby existing or regional data are used to demonstrate their repersentativeness of conditions at the proposed site. However, regulatory guidance regarding the methodologies that should be used for such comparisons or confirmation studies is unclear.

Conformance Issue

In Draft D.G. 11-45, Sections C.I.2.3.3, C.I.2.3.4, and C.I. 2.3.5, USNRC has indirectly suggested the following approaches:

- Wind Rose comparisons (both seasonal and yearly)
- X/Q calculations based on the XOQDOQ, PAVAN, and/or ARCON96 models

The ESP and/or COL applicants may consider using the Design Control Document (DCD) limitation values for their technology design of choice in lieu of making direct comparisons of the X/Q values calculated by these two sets of data. However, one could lose the design margin that use of onsite meteorological data potentially affords by taking the DCD limitation values approach.

4.6 Climatic Representativeness

Regulatory Requirements

Evidence should be provided to show how well the existing data to be used in preparing the permitting applications, represent long-term conditions at the proposed unit(s) site. (Draft D.G. 11-45, Sections C.I.2.3.3)

Conformance Issue

The climatic representativeness of the onsite joint frequency distribution of wind speed, wind direction and atmospheric stability class and other data used in the permit application should be checked by comparison with nearby stations with similar geographical locations and topographical settings and have collected reliable long-term (i.e., 30 years) meteorological data.

Alternatively, a demonstration of the climatic representativeness of the joint frequency distribution and data used can be made using the onsite data because most of the existing nuclear power plants would have collected more than 20 years of onsite meteorological data. However, caution must be exercised to ensure the quality of the data used as it will be scrutinized by the regulators and the public once included in the application and submitted for review.

In some cases, there may be sufficient coverage of offsite first-order NWS stations and cooperative network observing stations to adequately characterize non-dispersion related conditions representative of a proposed site (e.g., normals, means and extremes of temperature, rainfall and snowfall).

4.7 Issuance of Draft Regulatory Guide and Review Guidance

- Draft DG-1164 (Third Proposed Revision to R.G. 1.23)

Safety Guide 23 (February 12, 1972), the predecessor to R.G. 1.23, still has regulatory standing although in practice the requirements in Proposed Revision 1 to R.G. 1.23 (September 1980) are expected to be implemented by the regulatory community. Draft DG-1164 was issued in October 2006. With respect to RG 1.23, the NRC plans to have a third proposed Revision 1 issued in the near future, which could be as soon as by spring of 2007.

Conformance Issue

USNRC understands that the guidance for onsite meteorological programs in support of nuclear power plants will be coming late for those applicants who plan to submit their applications during 2007 and 2008. Its Staff also indicated that there are no major changes expected in the proposed Revision 1 from the Draft DG-1164. However, the Staff has suggested that applicants should be prepared to address any changes in the revised Regulatory Guide., if any are made.

Close coordination and cooperation between the regulatory agency and permit applicants is highly desirable during the licensing process.

- Draft Standard Review Plan (SRP), Section 2.3.3, Revision 3

Draft SRP Section 2.3.3, Revision 3 was recently updated and issued for pubic comments. In particular, the Draft added special considerations for meteorological instrumentation at complex terrain sites, review interfaces, measurements of precipitation to the set of basic meteorological parameters, additional guidance on instrumentation surveillance and procedures for the identification and handling suspect data, a finer category breakdown for high occurrence of low wind speed site and data quality check using the NUREG-0917 for computer spreadsheet.

The USNRC plans to issues the SRP Section 2.3.3, Revision 3 in the near future. However, its Staff has suggested that applicants should be prepared to address any changes in the SRP, Revision 3, if any are made.

Similar to Draft DG-1164, close coordination and cooperation between the regulatory agency and permit applicants is highly desirable during the licensing process.

5. PRACTICAL MODEL USER TIPS

Practical modeling tips for the commonly used USNRC-sponsored models are provided below:

5.1 XOQDOQ

Mode of releases

- Elevated release is a release at a height equal or greater than 2.0 times the adjacent tallest solid structure
- Ground-level releases are for effluents released from points < the height of the adjacent structures, and
- Mixed-mode releases are for vents or other points at height > adjacent structures
- elevated, if $w_0/u \geq 5.0$,
  where: w_0 = effluent exit velocity and u = wind velocity at the exit
- mixed-mode, if $1.0 \leq w_0/u \geq 5.0$
- ground-level, if $w_0/u \leq 1.0$

Model Input

- For a "north" wind, the affected receptors are directly downwind to the south
- Changes in terrain height translated into changes in the effective plume height
- A ground release is specified by setting the stack exit velocity and diameter to zero and wind height at 10 meters
- A re-circulation factor may need to be applied to the model results for sites located in complex terrain.

Other Modeling Tips

- Multiple previous versions of the model existed (old output files may produce different results.)

5.2 PAVAN

Model Input

- On an annual basis, both the 5% (overall site or direction-independent) and the 0.5% (sector dependant or direction-dependant) determination are based on the total number of hours in the annual data set.
- For low wind sites, more wind category breakdown at the lower end of the wind speed spectrum may be required in order to pinpoint the 0.5% X/Q value.
- Delta-T is the preferred method for determining stability classes at nuclear power plants because PAVAN (and ARCON96) are based on empirically derived plume meander factors from field tracer studies that used Delta-T to classify atmospheric stability.

Model Output

The enveloped frequency distributions generated in subroutine ENVLOP may not always be reasonable. These should always be checked and the values listed by ONEOUT be adjusted accordingly.

5.3 ARCON96

Model Input

- ARCON96 calculates a "midpoint height" between the lower and upper wind instrument heights. The "midpoint height" is used to determine which level of the wind data are to be used in calculating X/Qs.
- Both RG 1.194 and Users Guide (NUREG/CR-6331) do not discuss the use of the "midpoint height" approach.
- Enter actual above grade heights for the vent release height and receptor height in modeling, instead of entering absolute heights (see Figure 4).

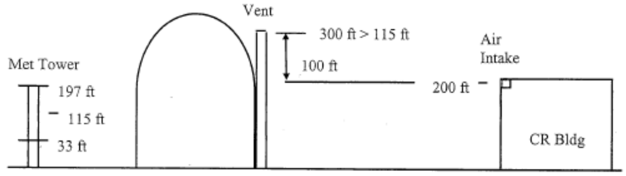

Figure 4 Actual Vent Height > Tower Midpoint Height

- Do not enter absolute heights even if you have treated a vent release as a ground-level release; the "midpoint height" approach could cause unexpected error as shown in figure below.

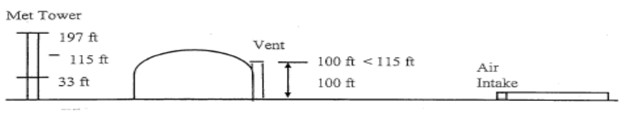

Figure 5 Absolute Vent Height < Tower Midpoint Height

- Always treat vent releases as ground-level releases, unless sound justification can be made.
- Make sure north winds are recorded as 360 degrees, instead of 0 degree in the input meteorological data set.

Model Output

- The worst case ARCON96 calculated X/Qs usually occur under 3 to 4 meter/sec winds.
- ARCON96 is not sensitive to the building area when the wind speeds are low.

6. CONCLUSIONS

It is essential for all model users to acquire relevant and adequate modeling training prior to performing any dispersion calculations and analyses.

Ensure that the meteorological input data to the model is consistent with the meteorological basis used in the model development.

When a nearby meteorological data collection system is used in the licensing application for a new nuclear plant, a thorough examination of the data from this collection system by a professional meteorologist regarding the quality, adequacy and representativeness of the data against the regulatory requirements is highly recommended.

In support of an ESP or a COL application, it is vitally important that the applicant has a valid, accurate, adequate and representative meteorological data base or has implemented a meteorological data collection system that is capable of generating such information.

Currently, available guidance from both the USNRC and nuclear industry in the United States for an ESP and/or a COL application is not comprehensive and precise. When room is left for interpretation, the opportunity exists for creating confusion.

Furthermore, the issuance of the 3rd Proposed Revision 1 of R.G. 1.23 is expected by spring of 2007 and other relevant regulatory requirements and guidance documents shortly after. Therefore, close coordination and co-operation between the regulatory agencies and the permit applicants is highly desirable in order to streamline the licensing process.

REFERENCES

Regulatory Guide 1.23, "Onsite Meteorological Programs," Rev. 0, dated February 1972, and Proposed Revision 1 to R.G. 1.23, USNRC, September 1980

Draft Regulatory Guide, DG-1164, "Meteorological Monitoring Programs for Nuclear Power Plants", USNRC, October 2006

NUREG-0800, Draft Revision 3 to Standard Review Plan (SRP), Section 2.3.3, "Onsite Meteorological Measurements Program," USNRC, April 1996

NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants," ESRP 9.3 (Subsection III(8)), NSNRC, October 1999

Nuclear Reactor Regulation, Review Standard, RS-002, "Processing Applications for Early Site Permits," USNRC, May 2004

Draft Regulatory Guide, DG-1145, "Combined License Applications for Nuclear Power Plants (LWR Edition)," USNRC, June 2006

An industry standard, ANS/ANSI 3.11-2000/2005, "Determining Meteorological Information at Nuclear Facilities", December 2005

Nuclear Energy Institute, NEI 01-02, Industry Guideline For Prepare An Early Site Permit Application – 10 CFR Part 52, Subpart A", September 2001

Nuclear Energy Institute, NEI 04-01, "Standard Format for COL Application Outlines, Section 2.3.3 – Onsite Meteorological Measurement Program", 2006

NUREG/CR-2919, "XOQDOQ: Computer Program for Meteorological Evaluation of Routine Releases at Nuclear Power Stations," PNL/USNRC, September 1977

NUREG/CR-2858, "PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials form Nuclear Power Stations," PNL/USNRC, November 1982

NUREG/CR-0523, "MESODIF-II: A Variable Trajectory Plume Segment Model to Assess Ground-Level Air Concentrations and Deposition of Effluent Releases from Nuclear Power Facilities," USNRC, March 1979

NUREG/CR-6331 Revision 1, "ARCON96: Computer Program for Estimating Atmospheric Relative Concentrations in Building Wakes," PNNL/USNRC, May 1997

NUREG/CR-6210, "HABIT: Computer Codes for Evaluation of Control Room Habitability," USNRC, June 1996

NUREG/CR-6613, "MACCS2: Computer Code System for accident consequence assessment," SNL/USNRC, May 1998

USEPA, "CALPUFF: Proposed Appendix A Model of the Guidelines on Air Quality Models,"

EPRI CS-3404-CCM, "SACTI: Seasonal/Annual Cooling Tower Plume Prediction Code," Argonne National Laboratory, April 1984

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