

RAMP Atmospheric Codes Overview

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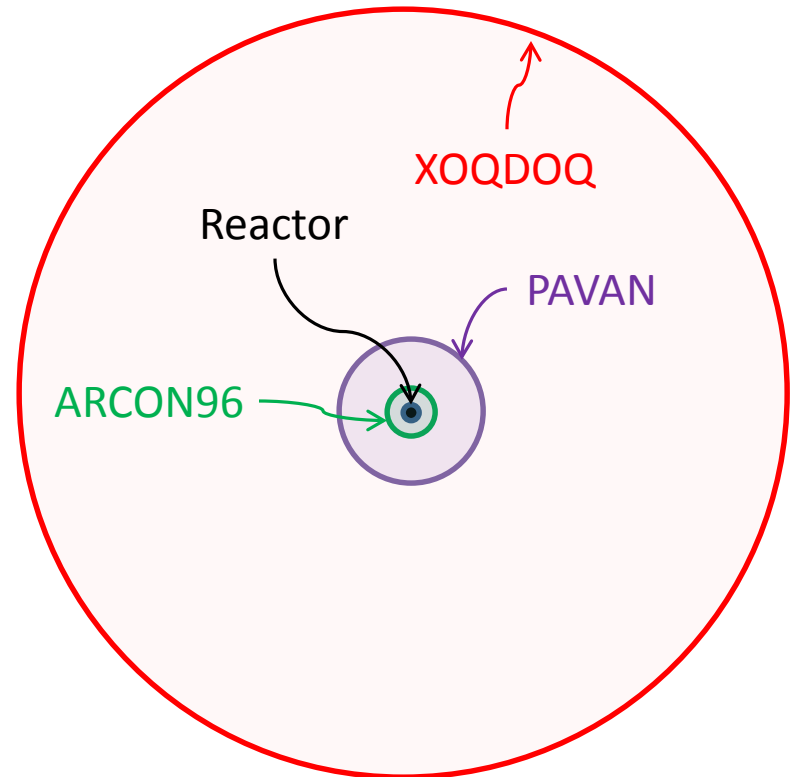


RAMP Atmospheric Codes Overview

- Three atmospheric codes for reactor licensing:
 - ARCON96
 - PAVAN
 - XOQDOQ
- Other atmospheric codes:
 - RASCAL (for emergency response)
 - HABIT (for assessing control room habitability from chemical releases)

Why Three Atmospheric Codes?

- Three dispersion distances to consider:
 - **ARCON96**: Near-field (~100's meters); design basis accidents (DBA's) at the control room (CR) and technical support center (TSC).
 - **PAVAN**: Mid-field (~10 km); DBA's at the exclusion area boundary (EAB) and low population zone (LPZ).
 - **XOQDOQ**: Far-field (out to ~80 km); normal effluent releases for sensitive receptors and population.



Regulatory Need for ARCON96

- 10 CFR Part 50, Appendix A, General Design Criterion 19 (GDC 19), Control Room (CR)
 - Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 5 rem (0.05 Sv) whole body, or its equivalent to any part of the body, for the duration of the accident
- 10 CFR Part 50, Paragraph IV.E.8 of Appendix E, to Emergency Facilities and Equipment
 - Onsite emergency facilities be provided, from which effective direction can be given and effective control can be exercised during an emergency
 - Per SRP 15.0.3, TSC should provide the same level of protection against radiation that the control room provides

ARCON96 Related Guidance

- RG 1.206, C.I.2.3.4: *Short-Term Atmospheric Dispersion Estimates for Accident Releases*
- SRP 2.3.4: *Short-Term Atmospheric Dispersion Estimates for Accident Releases*
- **RG 1.194: *Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants (2003)***
- **NUREG/CR-6331: *Atmospheric Relative Concentrations in Building Wakes (1997)***
 - ARCON96

NUREG/CR-6331
PNNL-10521
Rev. 1

Atmospheric Relative Concentrations in Building Wakes

Prepared by
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Prepared for
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ARCON96 Technical Basis

- Gaussian plume model
 - enhanced diffusion coefficients to account for dispersion under low wind speed conditions and building wakes
- Relative concentrations (χ/Q) values are estimated for various time-averaged periods:
 - 0-2 hrs, 2-8 hrs, 8-24 hrs, 1-4 days, 4-30 days
- Meteorological input consists of hourly values of wind speed, wind direction, and atmospheric stability class
- Calculates hourly χ/Q values
 - Hourly χ/Q values are combined to estimate χ/Q 's ranging in duration from 2 hours to 30 days
 - Cumulative frequency distributions are prepared from the average χ/Q values
 - χ/Q values that are exceeded no more than 5 percent of the time for each averaging period are selected

ARCON96 Inputs

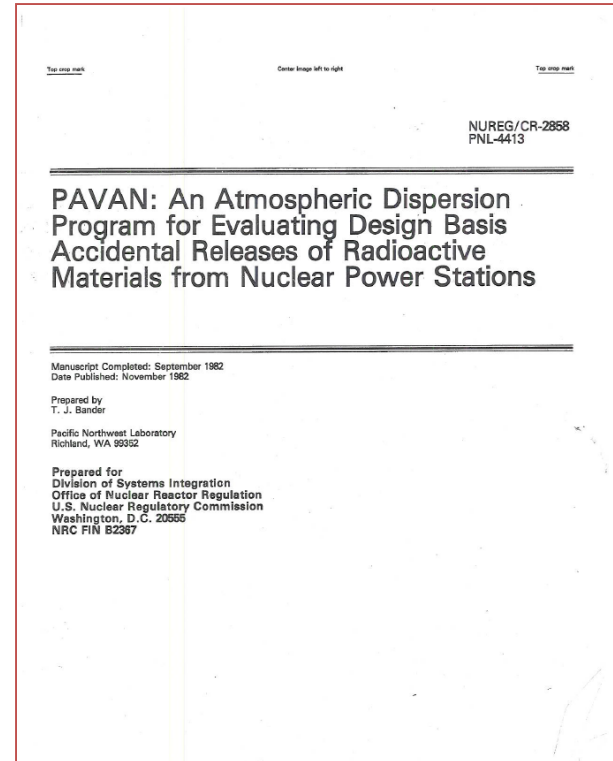
- Meteorology
 - Hourly file of wind speed, direction, stability
 - Wind measurement heights
- Source
 - Type: ground, vent, or stack
 - Height (vent or stack release)
 - Building area (ground or vent release)
 - Vertical velocity, stack flow, and radius
- Receptor
 - Distance to receptor
 - Intake height
 - Elevation difference
 - Direction to source

Regulatory Need for PAVAN

- 10 CFR 52.79(a)(1)(vi), Contents of applications; technical information in final safety analysis report
 - Perform an assessment assuming a fission product release from the core into the containment
 - An individual located at any point on the boundary of the EAB for any 2-hour period would not receive a dose in excess of 25 rem (0.25 Sv) TEDE
 - An individual located at any point on the outer boundary of the LPZ would not receive a dose in excess of 25 rem (0.25 Sv) TEDE during the entire period of the passage of the radioactive cloud

PAVAN Related Guidance

- RG 1.206, C.I.2.3.4: Short-Term Atmospheric Dispersion Estimates for Accident Releases
- SRP 2.3.4: Short-Term Atmospheric Dispersion Estimates for Accident Releases
- **RG 1.145: Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants (1983)**
- **NUREG/CR-2858: PAVAN: An Atmospheric Dispersion Program for Evaluating Design-Basis Accident Releases of Radioactive Materials from Nuclear Power Stations (1982)**
- NUREG/CR-2260: Technical Basis for Regulatory Guide 1.145, “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants” (1981)



PAVAN Technical Basis

- Gaussian plume model
 - simple modifications to diffusion coefficients to account for plume meander under low wind speed conditions and building wakes for ground-level releases
- Estimates χ/Q values for various time-averaged periods
 - 0-2 hrs and annual average
 - 0-8 hrs, 8-24 hrs, 1-4 days, 4-30 days are determined through logarithmic interpolation of the 0-2 hrs and annual average values
- Meteorological input consists of a joint frequency distribution (JFD)
 - wind speed (calms defined as below sensor threshold, historically ~ 1 mph)
 - wind direction (16 directions, 22.5 deg sectors, centered on true north)
 - atmospheric stability class A-G (preferably based on delta-T)
- Building wake impacts on release height
 - release point < 2.5 x the height of adjacent solid structures \rightarrow ground-level release
 - release point > 2.5 x the height of adjacent solid structures \rightarrow elevated release
- Part-time fumigation conditions assumed for stack releases

PAVAN Inputs

- The release mode can be ground-level or elevated
- Ground-level releases can have additional dispersion due to:
 - plume meander, and/or
 - entrainment into the wake of building structures
- For elevated releases, terrain height can be incorporated into a calculation of “effective plume height”
- Plume diffusion can be described by:
 - Pasquill-Gifford
 - Desert curves (Markee)
- Site-specific or default correction factors to account for non-straight trajectories may be used in the calculation of the annual average χ/Q values

Regulatory Need for XOQDOQ

- 10 CFR Part 20, Subpart D, Radiation Dose Limits for Individual Members of the Public
 - The *annual* average concentrations of radioactive material released in gaseous effluents at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B to Part 20
 - Intended to result in doses below 0.05 rem (0.5 mSv)
- 10 CFR Part 50, Appendix I, Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet ALARA Criterion for Radioactive Material in Reactor Effluents
 - Section II.B: Unrestricted *annual* air dose < 10 mrad (0.1 mGy) gamma or 20 mrad (0.2 mGy) beta
 - Section II.C: Unrestricted *annual* individual organ dose from all pathways of exposure < 15 mrem (0.15 mSv)
 - Section II.D: radwaste system cost-benefit analysis based on population dose out to 50 miles

XOQDOQ Technical Basis

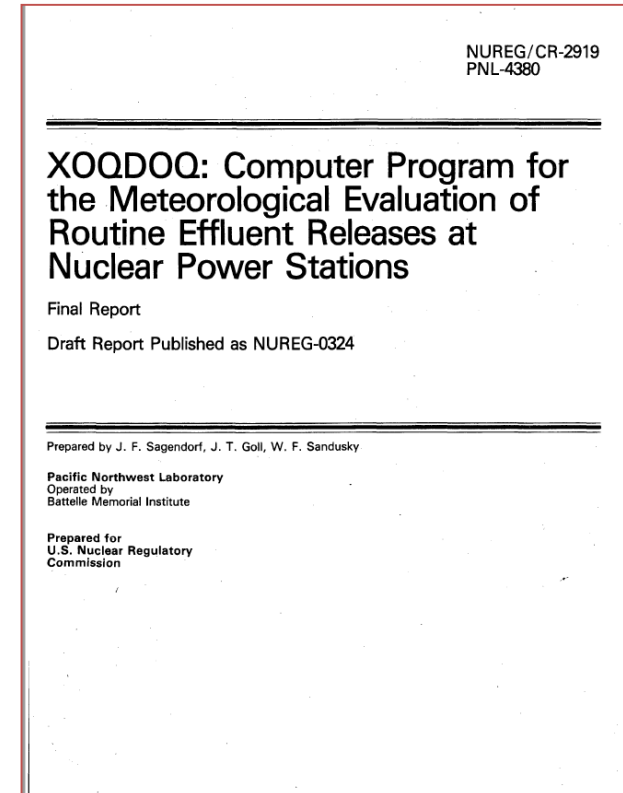
- Gaussian plume model
 - plume horizontal distribution is assumed to be evenly distributed within the 22.5 degree downwind sector (sector-averaging)
 - for ground-level releases, plume vertical diffusion coefficient modified to account for building wake
- Meteorological input consists of a JFD of hourly values of:
 - wind speed (calms defined as $\frac{1}{2}$ sensor threshold)
 - wind direction (16 directions, 22.5 degree sectors, centered on true north)
 - atmospheric stability class (preferably based on delta-T)
- Building wake impacts on release height
 - release points below adjacent solid structures → ground-level releases
 - release points at, but less than 2 x higher than adjacent solid structures → mixed-mode (part-time ground, part-time elevated) releases
 - function of the ratio of plume vertical exit velocity to horizontal wind speed
 - release points higher than 2 x adjacent solid structures → elevated releases
 - calculates effective plume height
- Allows adjustment of χ/Q and D/Q values to account for the effects of local air recirculation or stagnation using default or user-supplied site-specific correction factors

XOQDOQ Technical Basis (Cont'd)

- Dry depletion/deposition
- Annual estimates of χ/Q and D/Q values
 - No Decay/Undepleted χ/Q values: used to evaluate ground level concentrations of long lived noble gases (e.g., tritium and C-14)
 - 2.26-Day Decay/Undepleted χ/Q values: used to evaluate ground-level concentrations of short-lived noble gases (based on half-life of Xe-133m)
 - 8.00-Day Decay/Depleted χ/Q values: used to evaluate ground level concentrations of radioiodine and particulates assuming dry deposition (based on the half-life of I-131)
 - No Decay D/Q values
- Receptor locations
 - plant boundary
 - nearest resident, milk and meat animal, and vegetable garden
 - 22 standard radial distances out to 50 miles
 - 10 standard distance-segments out to 50 miles

XOQDOQ Related Guidance

- RG 1.206, C.I.2.3.5: Long-Term Atmospheric Dispersion Estimates for Routine Releases
- SRP 2.3.5: Long-Term Atmospheric Dispersion Estimates for Routine Releases
- **RG 1.111: Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors (Revision 1, 1977)**
- **NUREG/CR-2919: XOQDOQ Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations (1982)**



XOQDOQ Inputs

- Sources
 - Elevated
 - can include plume rise from momentum/buoyancy
 - can include topography for use in “effective height” calculation
 - Ground-level
 - can include additional dispersion from building wakes
 - Mixed-mode
 - vents at or above height of adjacent structures
- Meteorology
 - joint frequency distribution of wind direction (16 sectors), wind speed (up to 14 bins), stability class (7 classes, A through G)
 - diffusion: Pasquill-Gifford (P-G) or desert curves (Markee)
 - wind speed extrapolation to release height
- Plume decay for varied half-lives
- Plume depletion from dry deposition
- χ/Q modified for recirculation or air stagnation

Running the Codes

- Currently, Fortran executables
 - Require formatted input files
 - User guides provide input & format
 - Use Windows “Command Prompt”
 - See “Readme.txt” file in download
 - Executable name > Input File Name > Output File Name
- Developing User-Friendly Interfaces
 - ARCON96

Questions?

- *Jeremy Rishel*
 - *Mr. Rishel supports the RAMP Atmospheric Codes, including ARCON96, PAVAN, and XOQDOQ. In addition, Mr. Rishel supports the development of the NRC's RASCAL emergency response code.*
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