RAMP Atmospheric Codes

Atmospheric Codes Discussion

Radiological Releases

1. Design Basis Accidents - DBAs (ARCON96, PAVAN)
   - Control Room (CR)/Technical Support Center (TSC) habitability from intake/inleakage
   - Offsite (exclusion area boundary [EAB], low population zone[LPZ])
2. Routine Releases (XOQDOQ)
   - Site Boundary
   - Special Receptors (nearest resident, garden, milk/meat animal)
   - Population Dose (80 km radius)
3. Emergency Response (RASCAL)
4. Severe Accident Releases (MACCS - not in RAMP)

Toxic Gas Releases (onsite and offsite)

5. Control Room (HABIT)

ARCON96: DBAs to the CR and TSC

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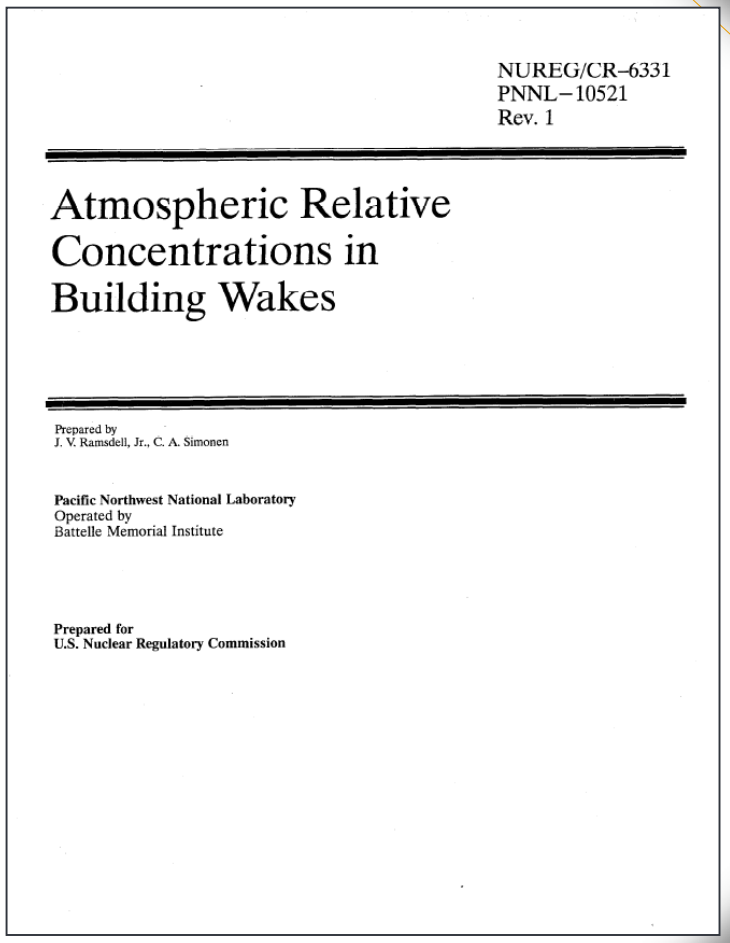
DBA Releases to the CR and TSC: Regulations

- 10 CFR Part 50, Appendix A, General Design Criterion 19 (GDC 19), Control Room
  - 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

DBA Releases to the CR and TSC: 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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RAMP

ARCON96: Overview

- Gaussian plume model
  - enhanced diffusion coefficients to account for dispersion under low wind speed conditions and building wakes
- 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 then combined to estimate concentrations 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

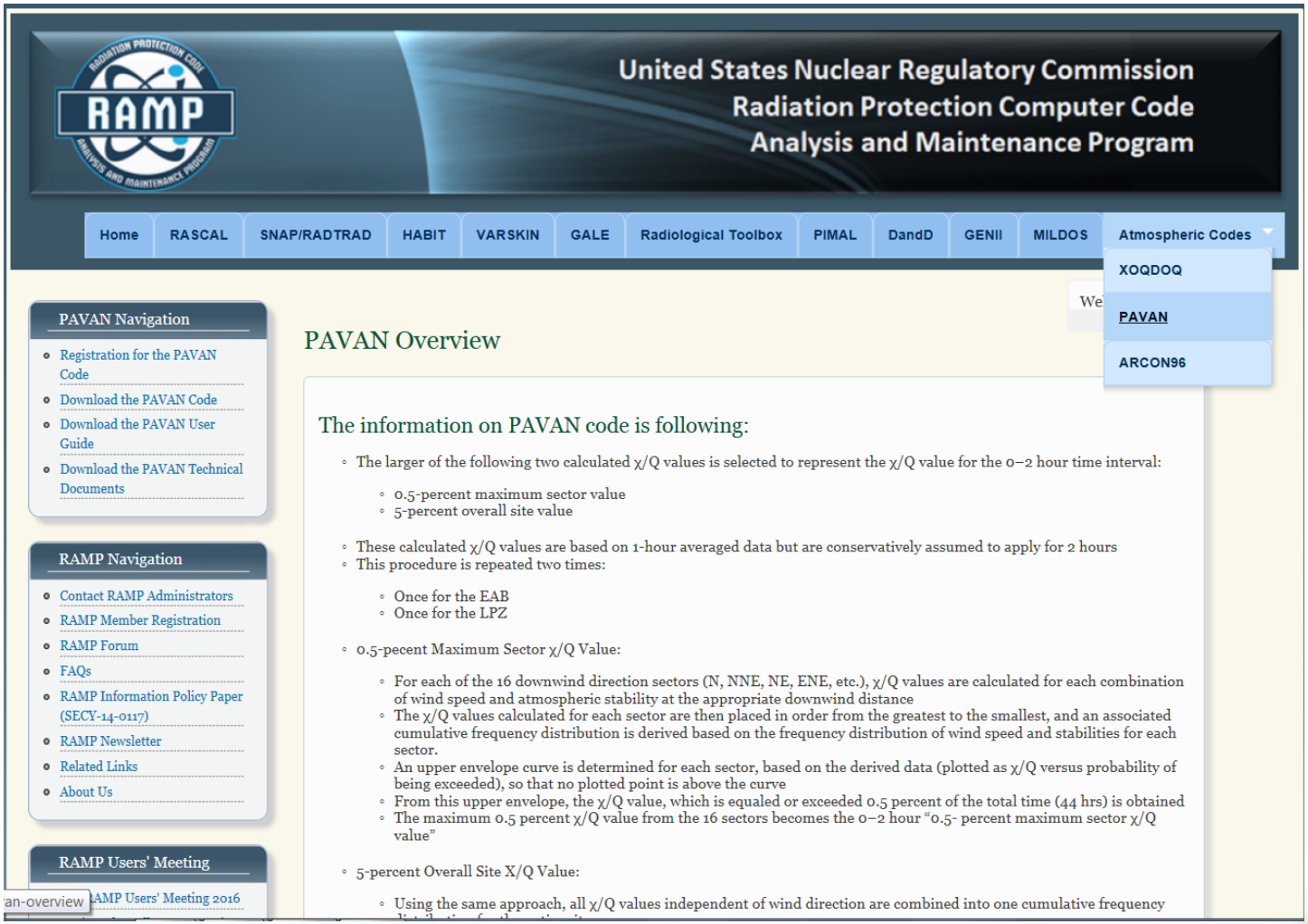
ARCON96: Input Considerations

- 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

ARCON96: RUNNING THE CODE

- The original ARCON96 DOS Windows executable will *NOT* run on 64-bit operating systems; only the ARCON96 Fortran executable (ARCON96F.EXE) can be used on these systems.
- To run ARCON96 (Window 7 and higher), systems:
  - create a properly formatted ARCON96 run specification file (.rsf) and associated hourly meteorology file
  - open a Windows Command window and navigate to the ARCON96 folder
  - type the executable name followed by the .rsf file on the command line:
    - *ARCON96F.EXE INPUT.RSF*
  - press the enter key and ARCON96 will run; the model output will be written to the user-defined output files specified in the input file.

PAVAN: DBA Releases to the EAB and LPZ



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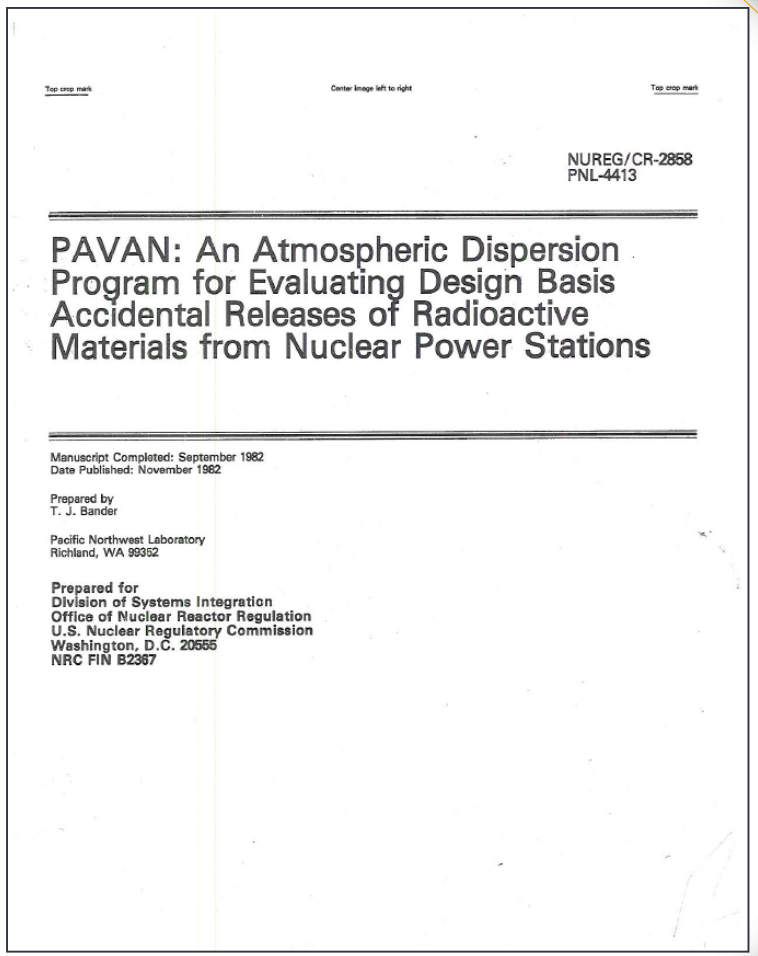
DBA Releases to the EAB and LPZ: Regulations

- 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

DBA Releases to the EAB and LPZ: 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)



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NUREG/CR-2858
PNL-4413

PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations

Manuscript Completed: September 1982
Date Published: November 1982

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PAVAN: Overview

- Gaussian plume model
  - for ground-level releases, diffusion coefficients modified to account for plume meander under low wind speed conditions and building wakes
- 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 points < 2.5 times the height of adjacent solid structures → ground-level releases
  - release points > 2.5 times the height of adjacent solid structures → elevated (stack) releases
- Part-time fumigation conditions assumed for stack releases

PAVAN: INPUT CONSIDERATIONS

- The release mode can be ground-level or elevated
- Ground-level releases can have additional dispersion due to:
  - plume meaner, 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

PAVAN: RUNNING THE CODE

- PAVAN is run using a Fortran executable called "PAVAN.exe"
- To run PAVAN:
  - create a properly formatted PAVAN input file per NUREG/CR-2858, which includes the JFD
  - open a Windows Command window and navigate to the PAVAN folder
  - type the executable name followed by the input and output file on the command line:
    - *PAVAN.EXE INPUT.TXT > OUTPUT.TXT*
  - press the enter key and PAVAN will run; the model output will be written to the user-defined output file

XOQDOQ: Routine Releases

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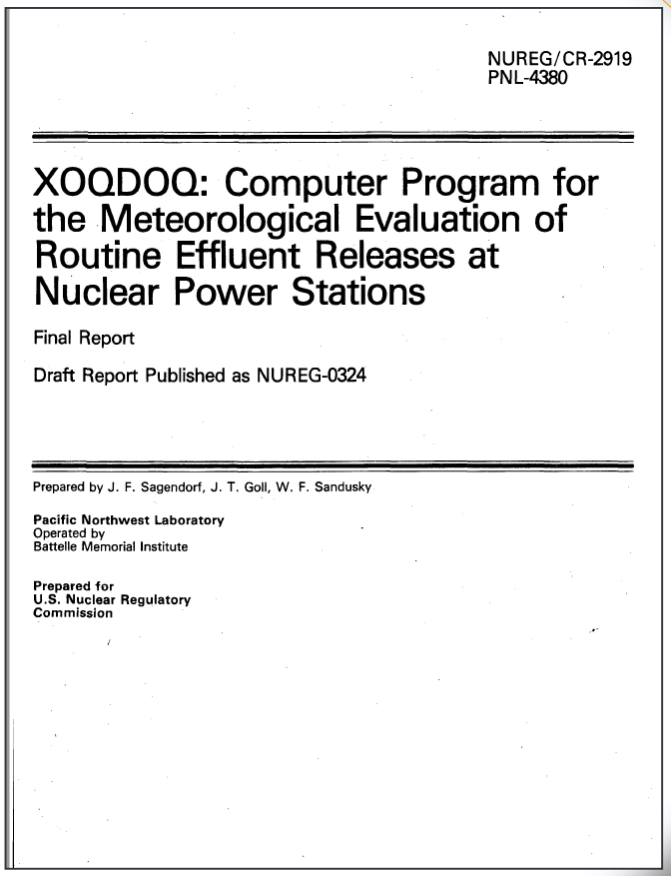
Routine Releases: Regulations

- 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

Routine Releases: 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)



NUREG/CR-2919
PNL-4380

XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations

Final Report

Draft Report Published as NUREG-0324

Prepared by J. F. Sagendorf, J. T. Goll, W. F. Sandusky

Pacific Northwest Laboratory
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Prepared for
U.S. Nuclear Regulatory Commission

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RAMP

XOQDOQ: Overview

- 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 ½ 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 times 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 times 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: Overview (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: Input Considerations

- 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

XOQDOQ: RUNNING THE CODE

- XOQDOQ is run using a Fortran executable called "XOQDOQ.exe"
- To run XOQDOQ:
  - create a properly formatted XOQDOQ input file per NUREG/CR-2919, which includes the JFD
  - open a Windows Command window and navigate to the XOQDOQ folder
  - type the executable name followed by the input and output file on the command line:
    - *XOQDOQ.EXE INPUT.TXT > OUTPUT.TXT*
  - press the enter key and XOQDOQ will run; the model output will be written to the user-defined output file
- XOQDOQ output can be used in GASPAR or GENII to estimate individual and population doses.

QUESTIONS?

- *Jeremy Rishel*
  - *Mr. Rishel support 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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RAMP
RADIATION PROTECTION CODE
ANALYSIS AND MAINTENANCE PROGRAM