The Role of Meteorology in the Nuclear Power Industry

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1.0 Abstract

The science of meteorology plays several roles in the nuclear power industry. Meteorological measurements are used as input for decisions on site acceptability (design basis accident analyses), plant construction, plant procedures, emergency response, and continued operation (Off-site Dose Calculation Manual dose projections) of the plant.

The Nuclear Regulatory Commission (NRC) has provided guidance on the collection, reduction, and application of meteorological data. A summary of this guidance, as well as other appropriate information, is presented.

The NRC focus on risk-informed and performance-based regulation, coupled with the deregulation of the electric generating industry, has lead to reductions in staff and discretionary spending in our industry. Resources are expended in the areas that directly affect electricity generation, and other areas may not receive as much attention as they have in the past.

Framatome ANP, responding to current issues in our industry, has developed a software application to aid meteorologists and non-meteorologists in maintaining high quality meteorological data. This application allows for data storage, data checking, data editing, and the determination of annual data summaries and atmospheric dispersion factors. Further discussion is provided on this software application and how it can help the non-meteorologist in charge of the plant's meteorological monitoring system.

2.0 Meteorology and Its Uses

Meteorology is the study of atmospheric phenomena. As such, it encompasses a broad spectrum, the most recognizable sub-field to the layman being weather forecasting. This paper concentrates on the roles meteorology plays in the nuclear power industry.

Commercial nuclear power stations are required to take meteorological measurements before construction (see Reference 1) and during operation (see Reference 2). The meteorological data collected onsite have many applications at nuclear power plants:

- Site acceptability studies for construction of nuclear power plants,
- Estimating the maximum potential annual radiation doses to the public resulting from routine effluent releases,
- Determining when protective measures should be considered to protect the health and safety of the public in the event of an accidental release of radioactive materials,
- Assessing potentially adverse environmental effects of a radiological or nonradiological nature resulting from the construction or operation of a nuclear power plant, and
- Design engineering.

Meteorological information can be found in the Final Safety Analysis Report/Updated Final Safety Analysis Report (FSAR/UFSAR), the Offsite Dose Calculation Manual (ODCM), emergency response procedures, and plant operating procedures.

3.0 Guidance

The United States Nuclear Regulatory Commission has provided guidance for meteorological applications at nuclear power plants. This guidance ranges from the onsite meteorological monitoring systems to atmospheric dispersion calculations. In addition, there are other sources of guidance on meteorology, such as the American National Standard on determining meteorological information at nuclear facilities, and the Quality Assurance Handbook for Air Pollution Measurement Systems published by the United States Environmental Protection Agency.

NRC Safety Guide 23, Onsite Meteorological Programs, was published in 1972 (Reference 3). This guidance document provides information on which meteorological parameters to measure, siting of instrumentation, data recording, instrument accuracy, maintenance and servicing, data reduction and compilation, and documentation. It is from this document that the 90% annual data recovery requirement originates.

NRC Regulatory Guide 1.21, Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants, Revision 1, was published in 1974 (Reference 3). This guidance document stipulates that a summary report of the meteorological measurements taken onsite should be submitted with the plant semiannual (now annual) effluent report as joint frequency distributions of wind direction and wind speed by atmospheric stability class.

NRC Regulatory Guide 1.78, Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release, Revision 1, was published in 2001 (Reference 5). This guidance document mentions the NRC computer code HABIT and stipulates that the value of the atmospheric dispersion factor between the release point and the control room air intake should be that value which is exceeded only 5% of the time.

NRC Regulatory Guide 1.111, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, Revision 1, was published in 1977 (Reference 6). This guidance document provides information on atmospheric dispersion of plant effluents and presents the so-called constant mean wind direction model (Gaussian plume theory). It defines an elevated release point as being at a level that is more than twice the height of adjacent solid structures.

NRC Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, Revision 1, was published in 1982 (Reference 7). This guidance document provides information on the methodology to use when determining atmospheric dispersion factors for accident analyses. It stipulates the use of the minimum distance from the stack, or in the case of releases through vents or building penetrations, the nearest point on the building to the receptor location within a 45-degree sector centered on the compass direction of interest. It defines an elevated release point as being at a level that is at least two and one-half times the height of adjacent solid structures.

NRC Regulatory Guide 1.183, Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors, was published in 2000 (Reference 8). This guidance document stipulates which atmospheric dispersion factors for the Exclusion Area Boundary (EAB), Low Population Zone (LPZ), and the control room, may be used in performing radiological analyses identified in the guide. The NRC computer codes for determining atmospheric dispersion factors, PAVAN and ARCON96, are specifically mentioned.

NRC Regulatory Guide 1.194, Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants, was published in 2003 (Reference 9). This guidance document describes methods acceptable to the NRC for determining atmospheric dispersion factors for control room habitability due to radiological releases. It addresses the use of the NRC computer code ARCON96 and stipulates that the meteorological data used should be obtained from an onsite meteorological measurement program based on the guidance of Safety Guide 23 that includes quality assurance provisions consistent with Appendix B to 10 CFR Part 50.

ANSI/ANS-3.11-2000, Determining Meteorological Information at Nuclear Facilities, was published in 2000 (Reference 10). This guidance document was written after a comprehensive review of ANSI/ANS-2.5 by the Nuclear Utility Meteorological Data Users Group (NUMUG) and the Department of Energy Meteorological Coordinating Council (DMCC). It addresses life cycle issues associated with nuclear facilities and technological advances for in situ and remote sensing of the atmosphere. Copies of this document may be purchased from the American Nuclear Society.

The Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV – Meteorological Measurements was revised by the United States Environmental Protection Agency in 1989 (Reference 11). The stated purpose of this document is to provide information and guidance for both the meteorologist and non-meteorologist tasked with making judgments on the validity and accuracy of measurement systems.

4.0 Recent Issues

Licensees have had problems recently ranging from programmatic issues within the meteorological monitoring program to data processing errors. It should be noted that the NRC requests and peruses the meteorological data used to determine atmospheric dispersion factors employed in radiological analyses. Any questions the NRC meteorologists have may result in Requests for Additional Information (RAI's) and impede the progress of the licensee's submittal.

Some issues seen recently include:

- No ownership of the meteorological monitoring program,
- Conflicting or unattainable procedural requirements,
- Loss of experienced personnel with little or no transition,
- Data manipulation errors, and
- Outdated and/or unsupported software applications.

Who owns the meteorological monitoring program at your plant? Why is it important? One licensee found that out via an audit. The multi-unit site had different groups using the meteorological data in different ways, and operating under different procedures with little or no communication between the groups. Some of the steps in their I&C

procedures for the meteorological instruments led to conflicts between the groups; some resulted in unattainable requirements.

Who has experience working with the meteorological monitoring program at your plant? Why is it important? One licensee found that out when a submittal generated Requests for Additional Information from the NRC meteorologists. It became evident during the licensee's analysis that the loss of experienced personnel with little or no transition had led to loss of control of their program.

Who has the appropriate background and/or experience to manipulate the meteorological data at your plant? Why is it important? More than one licensee has found that out when their submittal generated Requests for Additional Information from the NRC meteorologists. Simple errors can cause sometimes drastic changes in the meteorological data, for example:

- The delta-temperature measurement is always the upper sensor temperature value minus the lower sensor temperature value; if it is done the other way, the diurnal atmospheric stability pattern will be reversed.
- Wind direction values range from 0 to 360, with both 0 and 360 denoting North. Some instrumentation systems set the range from 0 to 360, some set it from 0 to 540 in an attempt to get around this circular nature. A commonly seen mistake is to throw out all values greater than 360 even though the acceptable range on the system is 0 to 540 degrees; this may exclude many hours of valid data from the analysis in question.
- Incorrectly calculated unit conversions and format changes may cause erroneous results.

What software is being used at your plant to edit and manipulate the meteorological data? Why is it important? Licensees may have software that was written in house or purchased from a vendor. In some cases, it has been found that the in house software currently in use at their plants have less than the desired pedigree, e.g., lack of documentation or poor control of the code. Other licensees have found that the software they purchased from a vendor is no longer supported.

5.0 The Solutions

The solutions to the issues discussed earlier in this paper can be summarized as such:

- Ensure that someone owns the meteorological monitoring program;
- If in doubt about your program, have an outside expert perform an audit;
- Capture the experience of personnel leaving the organization;

- Vigorously check meteorological data manipulations, unit conversions, and format changes; and
- Ensure that you have the proper software tools to do the job.

Framatome ANP has developed a software application to aid meteorologists and non-meteorologists in maintaining high quality meteorological data. This application allows for data storage, data checking, data editing, and the determination of annual data summaries and atmospheric dispersion factors. It is Microsoft Windows © based, tested, and documented.

The data checking module produces a report with an explanation of why the data were considered suspect, and, in some cases, suggestions of how to check data validity. The user may flag data as "bad" with a click of the mouse. Annual data summaries in the form of joint frequency distribution (JFD) tables of wind speed and direction as a function of atmospheric stability can be produced. A second JFD output file is in a form suitable for use as input to the NRC computer code PAVAN. Atmospheric dispersion factors can be produced for use in determining doses due to routine gaseous effluent releases. These factors can also be used to rank locations in the annual Land Use Census.

6.0 References

1. Title 10, Code of Federal Regulations Part 100, Subparagraph 100.10(c)(2).
2. Title 10, Code of Federal Regulations Part 50, Subparagraph 50.36a(a)(2).
3. NRC Safety Guide 23, Onsite Meteorological Programs, 1972.
4. NRC Regulatory Guide 1.21, Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants, Revision 1, 1974.
5. NRC Regulatory Guide 1.78, Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release, Revision 1, 2001.
6. NRC Regulatory Guide 1.111, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, Revision 1, 1977.
7. NRC Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, Revision 1, 1982.
8. NRC Regulatory Guide 1.183, Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors, 2000.
9. NRC Regulatory Guide 1.194, Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants, 2003.

10. ANSI/ANS-3.11-2000, Determining Meteorological Information at Nuclear Facilities, 2000.

11. The Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV –- Meteorological Measurements, revised by the United States Environmental Protection Agency in 1989.