A STATE-OF-THE-ART METEOROLOGICAL MONITORING UPGRADE AT THE PERRY NUCLEAR POWER PLANT

By

James Holian
Universe Technologies, Inc.
Frederick, Maryland

Jamie Balstad
Cleveland Electric Illuminating, Co.
N. Perry, Ohio

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INTRODUCTION

The Perry Nuclear Power Plant is located on the southern shore of Lake Erie approximately 50 miles east of Cleveland, Ohio. Meteorological data have been collected from the 10- and 60-meter levels on a guyed tower onsite since the preconstruction era of the early 1970s. In the early 1980s, the meteorological monitoring system was upgraded to an elaborate system which included a Primary and Validity set of wind sensors as well as a Backup and corresponding Validity set of wind sensors at the 10-meter level. The 60-meter level contained only the Primary wind sensors and a corresponding Validity set of sensors. Sophisticated software would determine if the parameter measured was valid for each system by comparing it with its validity sensor. If the difference in the values exceeded predetermined criteria established as a statistical function for collocated sensors, the data were considered invalid.

The system with all of the software checks and balances was effective at catching sensors that were on the brink of failure and notifying the daily data reviewer through a system of flags that a potential problem exists. What the system could not do is tell the reviewer which sensor was failing, only that they do not match. When data did not match, the parameter for that given averaging period was coded as invalid. In addition, it had a high false alarm rate, particularly when minor tower interferences affected one sensor and not the other, or when the onset of precipitation caused a rapid change in wind or temperature. This resulted in countless hours each month of additional labor to manually edit the raw meteorological file and replace computer-generated invalid data with actual valid data from the digital printout or strip charts. Additionally, the system itself was very expensive to maintain, since there were six sets of sensors which must be calibrated and recertified every 6 months. Finally, as the age of the system increased, the frequency of downtime began to increase as well.

In 1997, the Perry Nuclear Power Plant decided to upgrade the meteorological monitoring system. This upgrade included removing some of the elaborate redundancy of the current system and replacing it with a more cost-effective system of the 90s. The sophisticated software is being replaced with a simplified site-specific software which uses common meteorological principles and onsite climatology to determine the validity of a given parameter.

MONITORING EQUIPMENT CHANGES

The first change to the system was done on paper and may be the most important. The Primary and Backup Systems were renamed Systems A and B. This change eliminates the panic that ensues in the Control Room whenever they are notified that a Primary system is not working and the Backup System is now online. There is always that feeling that the Backup System is just not as good as the Primary System, when indeed the systems are identical!

Physically, the monitoring system is being upgraded to include two basically independent meteorological monitoring systems (A and B). Each system has a wind speed and direction sensor at 10 and 60 meters. System A sensors are positioned approximately nine feet from the tower on swing-out booms while System B sensors are positioned approximately 11.5 feet from the tower on slide-out booms. In addition, aspirated temperature sensors are mounted six feet from the tower at each level for both the A and B Systems. System A also includes a dew-point temperature sensor mounted approximately six feet from the tower at the 10-meter level, and Precipitation and Station Pressure sensors located at the surface near the base of the tower. Measurement of these variables meets the intent of the regulatory position in Section C.1 of the NRC Regulatory Guide 1.23.

Systems A and B each include two dataloggers and two communications modems located in a new environmentally controlled shelter near the tower. This shelter replaces two well-seasoned shelters which housed the old Primary and Backup Systems, respectively. One datalogger in each system is dedicated to storing data for retrieval via remote dial up from either offsite or the control room in the event the main plant computer fails. The second datalogger is hard wired directly to a dedicated personal computer (PC) in the shelter. This PC receives averaged digital meteorological data from the dedicated dataloggers for storage and transmittal to the plant computer or can be accessed via remote interrogation. Modem links automatically transfer the digital data record to the plant computer for preparation of dose assessment and reporting of results to the emergency response facilities, and for easy access by the Control Room should the direct line fail.

The communication lines between the meteorological tower and each datalogger are surge protected. The tower, as well as individual systems for each parameter on the tower, are lightning protected, except for the dew-point system.

Systems A and B provide multiple routes for communicating data to the plant computer for dispersion modeling and dose assessment as part of the CADAP software program. From the shelter PC, meteorological data are sent to the plant computer for emergency support and are available on monitors in the Control Room. The information sent includes: 1) routine meteorology for emergency dose assessment calculations, and 2) the most recent, routine 15-minute meteorological data and hourly data. In addition, routine 15-minute and hourly meteorological data are available via remote dial up of either the shelter PC or the System A or B datalogger.

For each parameter, the system develops hourly values that are derived from 15-minute values. The 15-minute values are developed from sub-second sampling. The system automatically performs electronic and status checks and continually monitors for reduced voltage (i.e. air flow) in the temperature aspirators. The system also recognizes manually initiated bypass codes which may be used during maintenance or calibrations.

Before the 15-minute value for a given parameter is accepted by the system computer to store or transmit, a real-time reasonability check is performed. For wind speed and direction, the System A parameter is compared to the corresponding System B parameter.

If the difference exceeds reasonable predetermined criteria established for the Perry Plant Site, the parameter is compared with the A and B System values at the other level (10 or 60 meters). The value chosen for the initial parameter will be the one closest to the other two values. A number flag is then initiated for each parameter notifying the reviewer that the two systems did not initially agree and that a judgement was made depending upon other similar values. For temperature and delta-T, if the difference between Systems A and B exceed predetermined criteria, the value closest to the previous 15-minute value is accepted and flagged accordingly. For the single sensor parameters such as dew point and precipitation, reasonability checks include comparisons between previously accepted values and climatological extremes.

The redundant set of meteorological parameters is also programmed into the site dose assessment programs. In the event that the System A or B 10- or 60-meter wind speed, wind direction, sigma theta, 10-meter ambient temperature, or delta-t data are unavailable or invalid, the equivalent data from the redundant system will be provided for input to the emergency dose assessment computer program. Regional weather data are also available for manual input to the emergency dose program from the Cleveland Hopkins National Weather Service (NWS) Office. These data are available 24 hours per day and are representative of the meteorological conditions at the Perry Plant.

SITE-SPECIFIC SOFTWARE

There are many varieties of commercially-available software which will compare meteorological data and send electronic messages or flags which key the end user into the quality of the data. However, most of these software packages do not have the capability to include regional or seasonal variations in weather or include onsite climatology in the decision-making process. Conversely, the current realtime meteorological validation software installed at the Perry Site is complicated and uses only statistic comparisons, not meteorological principles to determine data validation. As a result, new software was developed which uses algorithms based on the logical methods followed by experienced meteorologists to determine the validity of meteorological data.

The new validity software is designed to assist the data reviewer in determining whether the data are good, questionable, or likely to be bad. This software is not designed to eliminate the need for data review by someone familiar with some concepts of meteorology and the particulars of the Perry site. Unlike the previous system software, which eliminated any data which failed the comparability statistics resulting in hours of manual labor to re-enter perfectly good data, this software allows data to pass through at all times, but notifies the reviewer through a system of flags that it requires closer scrutiny. More times than not, data which are flagged as questionable are good data, but vary somewhat due to variations in meteorological conditions over a short period of time, even in collocated systems. Only when the software indicates questionable data for the same parameter for multiple hours should the reviewer become concerned that a system problem may be occurring or about to occur.

The software uses a tiered approach in determining if a measured parameter for a given time period is reasonable. Parameters which have a sensor for both the A and B system, i.e. wind speed and wind direction at both levels, perform normal validation by comparing data between identical sensors at the same level. When this comparison exceeds predetermined criteria, a secondary validation is performed by comparing with data at the other level, choosing the value which closely follows the data at that level. Delta-T and ambient temperature, which have duplicate systems, compare values between each other as normal validation, and then use previous reported data to determine if trend criteria is exceeded for secondary validation. Single sensor parameters, such as dew point and barometric pressure, use previous reported data to determine if data trends are exceeded as normal validation, and use Perry Plant site climatological extremes as secondary validation. In cases where the software validation determines predetermined criteria have been exceeded, but these differences are the result of either tower interferences or other normal meteorological phenomenon, the system A parameter is chosen and the value flagged accordingly. Examples of these include tower interference for wind direction through the tower before impacting the sensors, natural wind shear between levels, or rapid temperature changes around sunrise and sunset. No validation is performed on temperature or delta-t if the software determines one or more aspirators has failed. Finally, no validation is performed if either the system A or B parameter has been manually turned off for maintenance or calibration.

The software validity flags are numbered from 0 to 9, depending upon the type and results of the validation performed. Specific flags are outlined in Table 1. In general, flags 0,1,2, and 3 indicate good data; 4 indicates only system A data were passed because outside factors influenced the validation and the data should be reviewed, but is likely good; 5 and 6 indicate no validation was done and the parameter passed through should be checked for consistency; 7 and 8 indicate the software detected a potential problem and the data passed through needs to be checked closely to determine manually if it is consistent; and 9 indicates no data were received from the datalogger or the sensor was turned off.

TRANSMISSION OF VALIDATED METEOROLOGICAL DATA

Telecommunication software is used to transmit the following files every 15-minute period: the system A raw data as received from the data loggers, system B raw data as received from the data loggers and the validated 15-minute data. At the end of every hour, in addition to the last 15-minute data, hourly averaged and validated data are transmitted. At the end of each day (2400), the top five highest instantaneous wind gusts recorded during the previous 24 hours will be transmitted.

The system A and B raw data were provided so that Perry Plant personnel could construct or reconstruct the 15-minute validated data at the discretion of the user. It is also provided so that archiving of the historical data could be performed using the main Plant computer.

The hourly data combines the four 15-minute data periods into a single "hourly average". This hourly average can then be used to represent the meteorological data for the past

hour. It is the basis for further analysis by the Perry Plant personnel in the calculation of dispersion estimates.

It should be noted that two times were given for each record in each data file stored on the shelter computer, and transmitted to the Perry Plant. The time is express in both Eastern Standard Time and Daylight Savings Time. The adjustment from EST to DST is automatically handled by the shelter computer software. If the shelter computer time needs to be adjusted for any reason, prompts are provided reminding the users to input time as local time, either EST or DST as appropriate.

In addition to daylight savings time, the software contains provisions for handling the year 2000 rollover and future leap years. This feature will allow for a continuous record of meteorological data through the turn of the century.

SUMMARY

The meteorological monitoring system at the Perry Nuclear Power Plant was installed in the early 1970's, upgraded in the early 1980's, and has been becoming increasingly more expensive to maintain in recent years. In addition, the original data validation software has become outdated. As a result, the Cleveland Electric Illuminating Company elected to upgrade their current monitoring system to a more cost-effective and user-friendly system. This new system replaces the complex series of primary and validity sensors and backup and validity sensors with a two independent and identical systems. A new equipment shelter complete with four dataloggers and modems, as well as a dedicated personal computer are being installed near the tower. State-of-the-art software has been developed which compares data between the two redundant systems with predetermined values based on regional meteorology and onsite climatology, and makes decisions on the quality of the data. The software generates one meteorological data set which is the 'best of' the two independent systems after eliminating spurious data from either system which could influence one system or the other, such as tower interference, aspirator motor failures, etc. The new software always allows data to pass through, leaving the ultimate decision to eliminate data up to the reviewer and saving hundreds of labor hours annually in manually re-entering data. The Perry Plant will realize additional cost savings with the reduction of the number of sensor recertification and the reduced costs associated with maintenance and calibrations.

Table 1. Values and Description of Validity Flags

Value of Validity Flag	Description
0	Normal data validation. Using System A
1	Secondary validation required, using System A. For dew point the freeze-point was converted to dew point or dew point slightly above the ambient temperature and has been set to the ambient temperature.
2	Secondary validation required, using System B
3	Used only for delta temp and temperature: one aspirator failed. Using the other system sensor.
4	Using System A Data. Validation exceed predetermined criteria because: Both System A and B wind directions were blowing through the tower. Secondary wind direction validation detected wind direction change with height greater than 30 degrees. Wind speed below light wind limit or wind speed less than predetermined criteria. Delta-T differences occurred during sunrise/sunset transition periods.
5	No Validation. Problem detected with System B sensor (turned "off" or problem with time/date stamp or reading data logger file) using System A
6	No Validation. Problem detected with System A sensor (turned "off" or problem with time/date stamp or reading data logger file) using System B
7	Ambient Temperature--Both aspirators off, results could be affected Delta Temperature--Both aspirators off. results could be affected . Dew-point temperature, possible "stuck" sensor (same reading for 5 readings) Precipitation--Difference between ambient temperature and dew point greater than 10 deg F. Wind Speed--One sensors at same level are "stuck" (same reading for 13 readings) Pressure, possible "stuck" sensor (same reading for 5 readings).
8	Failed all validation checks. System A values passed if possible. Dew point exceeded ambient temperature by greater than allowable criteria. Dew point reset to ambient temperature. Wind Speed--Both sensors at same level are "stuck" (same reading for 13 readings)
9	No data obtained from either data logger or all similar sensors on same level turned "off"