A STANDARD FOR AUDITING

OF

METEOROLOGICAL MONITORING

SYSTEMS

by

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INTRODUCTION

The ability to have access to a representative meteorological data base is an integral part of the siting, construction, operation, and decommissioning of nuclear power plants. These data are essential for both long-term dose assessment and dose reconstruction, as well as real time emergency response planning and execution. Additionally, nuclear plants are using with increased frequency the onsite meteorology to document extreme weather phenomena, determine impacts on site activities and operations, and decide transmission line loading.

The U.S. Department of Energy (DOE) utilizes meteorological monitoring systems for a variety of long-term and real time applications. Representative onsite meteorological data are used for emergency response and compliance modeling at DOE weapons sites around the U.S. Additionally, the Department of Defense (DOD) maintains a major meteorological monitoring network around the Kennedy Space Center in Cape Canaveral, Florida in support of manned and unmanned space launches. Critical decisions such as which weapons facilities to move, close, or expand, or whether to launch or scrub often are based on impacts of local meteorology.

Unfortunately, many meteorological monitoring systems operating at both the industrial and governmental level today are in need of upgrade. Most of these systems were installed during the regulatory crunch of the 1970's. Personnel cuts, budget constraints, and apathy since the late 1980's have left most of these systems in disarray.

A comprehensive audit performed approximately every five years on your onsite meteorological monitoring system is one way to ensure the data collected are both representative and defendable. This paper presents a standard from which an audit of this scope could be performed.

AUDITING

The mere mention of the word "audit" around either a nuclear or government facility is often immediately followed by extreme panic. Visions of tyrant QA people from Headquarters dressed in battle fatigues rifling through your files haunt you for days preceding the scheduled audit. A comprehensive audit of a meteorological system is a refreshing change to the above scenario.

The audit consists of three main parts: the systems audit, the performance audit, and the field audit. The systems audit centers around the equipment, siting, and specifications. The performance audit looks at the meteorological data, validation, quality assurance, and record-keeping practices. The field audit is a verification of the maintenance and calibration procedures through a hands on observation of an actual calibration. The auditor can either be a single individual who is familiar with all facets of meteorological monitoring or several auditors, each with different expertise. However, it is recommended that a meteorologist do the performance audit. Conversely, an instruments and calibrations (I&C) technician would be an excellent choice for the field audit. Some facilities have opted to use an independent contractor to perform the audit as a means of eliminating conflicts of interest. This approach does have benefits since experience has shown corporate officials cooperate and act more quickly in resolving problems uncovered by independent auditors.

Prior to the audit, the auditor(s) should develop a series of checklists outlining in detail the specific areas to be covered. Unlike audit checklists that require specific reference to requirements, these checklists should be comprehensive in technical content but include common sense items as well. For example, include in your checklist a check to see if the meteorological shelter air-conditioning exhaust vent is facing away from the tower. This detail is not included in any siting guidance, but is important at sites collecting sensitive delta-t (ΔT) measurements.

METEOROLOGICAL MONITORING GUIDELINES

The Environmental Protection Agency (EPA), Nuclear Regulatory Commission (NRC), American Nuclear Standards Institute (ANSI), American Nuclear Society (ANS), and the Department of Energy all have guidance documents written for designing, siting, installing, and operating meteorological monitoring systems. The documents the auditor should be most familiar with are:

- NRC Regulatory Guide 1.23, "Meteorological Programs in Support of Nuclear Power Plants," Proposed Revision 1, September 1980.
- NRC Safety Guide 23, "Onsite Meteorological Programs," February 1972.
- EPA/450/4-87-013, "Onsite Meteorological Program Guidance for Regulatory Modeling Applications," June 1987.
- EPA/600/4-90-003, "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV: Meteorological Measurements," Revised August 1989.

* ANSI/ANS-2.5, "Standard for Determining Meteorological Information at Nuclear Power Sites," 1984.
* DOE/EH-0173T, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," January 1991.

Fortunately, these documents provide an excellent reference tool and are consistent in their recommended guidance. A detailed review of the facility internal requirements, such as the Final Safety Analysis Report (FSAR), and Technical Specifications (Tech Specs) is also essential before beginning the audit. Often, internal requirements are stricter than those listed in the referenced documents. Additionally, some facility documents reference only specific guidelines as compliance documents and facilities will balk at any attempt to audit them against non-referenced guidelines. Being familiar with these documents and adopting a common sense approach is all the auditor needs to make an honest assessment of a meteorological monitoring program.

SYSTEMS AUDIT

The systems audit is designed to verify that the proper equipment has been procured, installed and is operating according to the applicable guidelines. It includes both a visual inspection as well as a review of the equipment and design specifications.

A sample checklist for a standard systems audit is included in Table 1. Most facilities today do not fair well when being audited against this checklist, particularly when it comes to meeting siting criteria. This is because most of the multi-level meteorological towers were erected in areas cleared from forest in the early 1970's. Sites that were once void of trees for 1000 feet around are now splattered with 30-40 foot tall trees within 200 feet of the tower! This slow encroachment over the years goes largely unnoticed by I&C personnel whose expertise is calibration, not forestry. This problem is even more severe with single-level supplemental towers since they are usually in an offsite remote area and visited less frequently. It is worth noting that facilities with meteorologists on staff do tend to have fewer problems in this arena.

How to correct an identified siting problem due to tree encroachment is difficult. Facilities today are under increased pressure to protect the environment and are absolutely averse to cutting down trees. Some have even balked at the suggestion of just trimming. Moving the tower to a better area is expensive and may upset the representativeness of the historical record. These concerns must be balanced against the longstanding guideline that suggests obstacles such as trees must be a minimum of 10 times their height away from the meteorological tower. The only solution for the auditor is a compromise between the strict 10:1 rule and common sense. The facility should be advised to keep the trees trimmed to 20-25 feet tall and at a 7:1 or 8:1 distance-to-height ratio.

Another common problem with obstructions is with items on the tower itself. Junction boxes, microwave dishes, cellular dishes, and even hawk nests can appear on the tower and be formidable obstructions. The auditor usually finds the solution to the junction boxes and dishes to be easy, but pleads no contest when negotiating with birds!

The most common problem associated with the instrument shelter is with the roof. Twenty years ago, shelters were shiny new light-colored buildings with white metal roofs or lightly shingled roofs. However, many of these roofs have developed leaks and have been repaired with a thick coat of black tar. This wonderful heat absorbent material can upset the sensitive ΔT measurements and should be avoided.

The condition of the equipment, including the tower, should be checked. A rusty tower, chipping paint, or loose guyed wire could all be signs of problems to come. The auditor should also visually check all of the sensors at all levels (binoculars recommended) to insure consistency between levels. Threshold problems can sometimes be spotted on this inspection before they show up on the analog or digital data. Compare the visual checks with the analog and digital data in the shelter.

The siting of the rain gauge is also usually questionable. Although precipitation is not a critical parameter at most sites, improper siting can render the data nearly useless. Many facilities' gauges have no shield and are mounted on fences, shelter roofs, or poles 5 feet off the ground. Studies have shown that the gauge catch efficiency drops by 30% as wind speed increases from 5 to 10 mph for an unshielded gauge, 10% for shielded. The rain gauge should be well shielded and mounted as close to the ground as possible, but not lower than the maximum annual snow depth.

Few problems have been encountered concerning equipment specifications. Accuracy, threshold, sampling frequency, and total system error specifications are usually fixed during initial installation and rarely change over the years.

PERFORMANCE AUDIT

The performance audit is designed to verify the performance of the entire meteorological monitoring program, including data collection, validating, reporting, quality assurance, and archiving. Table 2 includes the suggested performance audit checklist.

The first part of this audit is to observe the facility personnel in their routine of accessing, reviewing, and validating the meteorological data. How weekly, monthly, semiannual, and annual reports and data files are generated should also be observed. Deviations from written procedures should be noted.

The auditor should verify that the most current data being collected is within expected values for all parameters. This can be done by comparing the accessed data with nearby National Weather Service data, if available, or by simply applying your knowledge of the current meteorological conditions. Note that, although this was done at the shelter as part of the systems audit, it must be repeated here because the data accessed may have been generated through different electronic means. Additionally, a representative sample of the most recent monthly and annual averages such as joint frequency distributions and wind roses should be compared to the historical record.

Quality assurance is another important aspect of the performance audit and cannot be overstated. Many facilities classify their meteorological data and associated equipment as safety-related. The auditor should verify that procedures exist that allow traceability of the steps from the raw meteorological data through the final validated data set.

Data supplemented from other sources such as onsite printouts or analog charts are often keyed into the digital data set. Procedures should exist for checking a minimum of 10 percent of the keyed data for accuracy by someone other than the keypuncher.

Software verification is another quality assurance area often overlooked. The auditor should verify that all software programs used in the monitoring program are verified annually. The verification should include test cases which check every subroutine in the software. This verification requirement applies to the often forgot data access and formatting software.

The performance audit described here is generally confined to the meteorological data and how it is validated. However, depending on the scope, the audit could be expanded to include the radiological reporting and dose assessment areas.

FIELD AUDIT

The field audit is designed to verify that the maintenance and calibration of the meteorological monitoring system is being performed accurately and in accordance with established procedures. This aspect of the comprehensive audit is important because the maintenance and calibration of a meteorological system is very different from maintenance and calibration of other systems around the facility. For example, most calibrations include a known standard input to produce a known standard output. For a meteorological system, the input is unknown so the output is based only on an understanding of the meteorological conditions at the time. Additionally, I&C personnel responsible for maintaining and calibrating the system are usually part of a large pool of technicians. With at most, quarterly calibrations, the I&C technicians have little hands on time to become familiar with the system. Therefore, it is essential that procedures be detailed and continuously updated. A periodic field audit such as this is a way to insure that maintenance and calibrations are performed to specifications. Some facilities have recognized the I&C pool of personnel as a problem and have wisely chosen 3 or 4 I&C technicians whose primary focus is the meteorological tower.

An example field audit checklist is included in Table 3. Prior to the field audit, the auditor should obtain a copy of the maintenance and calibration procedures for review. Obtain copies of the data sheets from the previous calibration as well. The auditor should then observe the next scheduled calibration and verify compliance step by step with the established procedures. Deviations from acceptable calibration practices should also be noted.

Verifying compliance with non-routine or emergency maintenance procedures (i.e. sensor failures, aspirator trips) will be limited to reviewing files of recent occurrences since it is unlikely to occur during the limited time of the field audit. Also, for sites with multi-level guyed towers, verify that the tower has been inspected by a certified inspector in the last 5 years.

Procedures outlining the controlled storage, calibration, and certification of test equipment should be reviewed. Verify that the wind sensor and test equipment calibrations are traceable to the National Institute of Standards and Technology (NIST). The auditor should also review the performance based training records for the I&C personnel performing the maintenance and calibrations.

Most of the problems encountered during the field audit usually involve record keeping. Calibration record sheets are frequently unreadable due to blotches from raindrops, coffee spillage, etc. Others are crumpled beyond recognition from being sat on in the truck! In these instances it is recommended that the calibration sheets be recopied and signed after completing the field work. The original sheets should be attached to the back of these sheets. The other problem frequently encountered with record keeping is with shelter logbooks. Often entries are incomplete, unreadable, or missing entirely. Many times, entries which contain the pertinent information about what was done are not dated or initialled. The auditor should inspect the logbook and note discrepancies.

SUMMARY

Meteorological monitoring systems are relied upon to provide accurate and dependable data for both real time and long-term studies for industry and government. With the advanced age of many of the systems in use today, it is important to have a program established which includes adequate procedures and proper training of personnel to insure the data collected are valid. Performing a comprehensive audit every five years as outlined here can help identify problems that largely go unnoticed on a day-to-day basis. This audit consists of a systems audit, a performance audit and a field audit. It includes a review of equipment specifications and siting compliance, the data access, validation, reporting and archiving procedures, the software verification and quality assurance practices, and the maintenance and calibration of the entire system. This audit verifies compliance with all applicable guidance, when possible, while adopting a common sense approach.

TABLE 1. EXAMPLE SYSTEMS AUDIT CHECKLIST

A. Equipment Siting:

1) Instrumentation of sufficient distance from trees or buildings to measure unobstructed flow?	☐ Yes ☐ No
2) Base of the tower is of natural vegetation?	☐ Yes ☐ No
3) Tower instrumentation oriented in direction of mean wind? (or perpendicular to mean wind with bimodal flow)	☐ Yes ☐ No
4) Wind-direction siting markers in place and clearly visible?	☐ Yes ☐ No
5) Wind instruments on boom are at least twice the tower width from tower?	☐ Yes ☐ No
6) Instrument shelter distance from tower OK?	☐ Yes ☐ No
7) Instrument shelter AC or heater vent on wall facing away from tower?	☐ Yes ☐ No
8) No tower obstructions (junction boxes, bird nests, microwave dishes) to impede flow?	☐ Yes ☐ No
9) Other (list)	☐ Yes ☐ No

Explain all "No's"________________________________

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B. Equipment Condition:

1) Wind-speed sensors spinning consistently between levels?	☐ Yes ☐ No
2) Wind-direction sensors appear consistent between levels?	☐ Yes ☐ No
3) Temperature aspirators running?	☐ Yes ☐ No
4) Tower guyed wires appear OK?	☐ Yes ☐ No
5) Rain gauge shielded, is as close to the ground as possible, and debris free?	☐ Yes ☐ No

TABLE 1. EXAMPLE SYSTEMS AUDIT CHECKLIST (cont.)

6) Shelter data recording systems functional and recording data accurately? ☐ Yes ☐ No

7) If battery backup, are batteries installed and charged? ☐ Yes ☐ No

8) Other (list) ☐ Yes ☐ No

Explain all "No's"______________________________

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C. Equipment Specifications:

1) Accuracy minimum requirements met? ☐ Yes ☐ No

2) Threshold minimum requirements met? ☐ Yes ☐ No

3) Sample frequency minimum requirements met? ☐ Yes ☐ No

4) Total system error minimum requirements met? ☐ Yes ☐ No

5) Other (list) ☐ Yes ☐ No

Explain all "No's"______________________________

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TABLE 2. EXAMPLE PERFORMANCE AUDIT CHECKLIST

A. Meteorological Data:

1) Meteorological data are representative when compared with previous years or local NWS data? ☐ Yes ☐ No

2) Data access procedures are sufficient and executed properly? ☐ Yes ☐ No

3) Data review and validation procedures are sufficient and are executed properly? ☐ Yes ☐ No

4) Data filing, storage, and retrieval practices sufficient? ☐ Yes ☐ No

5) Monthly and annual data recoveries meet minimum requirements? ☐ Yes ☐ No

6) System data backed up regularly? ☐ Yes ☐ No

7) Procedures exist for correcting missing or invalid data (i.e. recovery from strip charts or onsite printouts)? ☐ Yes ☐ No

8) Other (list) ☐ Yes ☐ No

Explain all "No's"____

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B. Quality Assurance:

1) Keyed-in supplemental data from other sources are spot checked (at least 10 percent)? ☐ Yes ☐ No

2) Yearly software verification tests performed on data access software? ☐ Yes ☐ No

3) Yearly software verification tests performed on data validation and reporting software? ☐ Yes ☐ No

4) Procedures exist which allow traceability from the raw unedited meteorological data through the finalized data set? ☐ Yes ☐ No

5) Performance based training records exist for all personnel responsible for data review? ☐ Yes ☐ No

TABLE 2. EXAMPLE PERFORMANCE AUDIT CHECKLIST (cont.)

6) Other (list) ☐ Yes ☐ No

Explain all "No's"____

TABLE 3. EXAMPLE FIELD AUDIT CHECKLIST

A. Maintenance and Calibration:

1) Routine calibrations performed on a minimum six-month interval? ☐ Yes ☐ No

2) Calibration procedures adequate? ☐ Yes ☐ No

3) Calibrations performed in accordance with procedures and acceptable calibration practices? ☐ Yes ☐ No

4) Non-routine and emergency maintenance procedures adequate? ☐ Yes ☐ No

5) Non-routine and emergency maintenance performed in accordance with procedures? ☐ Yes ☐ No

6) Tower been inspected by a certified inspector in the last 5 years? ☐ Yes ☐ No

7) Other (list) ☐ Yes ☐ No

Explain all "No's"____

B. Quality Assurance:

1) Traceability of sensors and test equipment calibrations to the NIST? ☐ Yes ☐ No

2) Procedures exist and are followed concerning the control of test equipment (e.g. storage, calibration, and certification)? ☐ Yes ☐ No

3) Performance based training records exist for all I&C personnel performing maintenance and calibrations on the system? ☐ Yes ☐ No

4) Other (list) ☐ Yes ☐ No

Explain all "No's"____

TABLE 3. EXAMPLE FIELD AUDIT CHECKLIST (cont.)

C. Record Keeping:

1) Calibration record sheets readable? ☐ Yes ☐ No

2) Logbooks in shelter up-to-date? ☐ Yes ☐ No

3) Filing of sensor and test equipment certifications adequate? ☐ Yes ☐ No

4) Inspection certificate for tower in file? ☐ Yes ☐ No

5) Other (list) ☐ Yes ☐ No

Explain all "No's"____