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National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES

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Dear Leta:

As we discussed on the telephone, I have several comments on the draft "Proposed Revision to Regulatory Guide 1.23, Meteorological Programs in Support of Nuclear Power Plants."

(1) Section 2 (siting of instruments), p.6, lines 7-10. I believe the guidance on location of instruments relative to the large structures typically found at a nuclear power plant needs to be more explicit. Consider lines 7-10, which say that flow obstacles should be lower than the height of measurement out to a distance of ten measuring heights. This is not always adequate to insure that the instruments are in a flow uninfluenced by strong wake effects. For example, according to the guide, there should be no obstructions higher than 10 m within 100 m of the met. tower if the instruments at the 10 m level are properly exposed. Suppose however, there is a block-like structure 50 m high and 150 m wide located 150 m upwind of the tower. The recirculating wake cavity of this structure will extend about 150 m from its lee face (eg, Hosker, 1980), so that the wind instruments at 10 m height, although they are situated according to the guide, are actually within a region of strong building wake influence. In particular, the instruments would probably indicate a much greater degree of wind fluctuation than actually exists in the atmosphere. Estimates of plume dilution made using the indicated value of σ_θ would probably not be at all conservative in this situation.

(2) Section 2 (siting of instruments), p. 7, para.3, lines 1-4, and para. 4, lines 3-5. At any coastal site, it would be extremely useful to have a local climatology of the marine inversion layer depth, since it forms a "lid" for vertical dispersion. The guide is somewhat vague on how many measurements should be utilized in selecting the tower site within this layer. I feel that a year's worth of data from, say, an acoustic sounder would fill the dual role of providing adequate data to locate the tower, and sufficient information to make reasonable estimates of available mixing depth under a variety of weather conditions. Furthermore, we should probably have the

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capability of performing direct inversion layer height measurements during emergency situations. Again, an acoustic sounder located at the site would fulfill this need. A similar situation exists in valleys, where an inversion developing at roughly the height of the surrounding hills or ridges will put a "lid" on the "box", producing high concentrations. A direct measurement capability again appears to be needed.

(3) Section 3 (data recorders), p.8, para. 2, lines 5-7. It was not clear to me whether the displays at the nearsite emergency facility would include important data such as σ_θ and ΔT. These would be essential for quick estimates of plume dispersion parameters for concentration modeling during emergencies. If the backup system is in use, estimates of σ_θ could be made from the width of the wind direction chart trace. In any event, some indication of these important variables should be provided at the remote sites as well as in the reactor control room.

(4) Section 4 (system accuracy), p.9, para.2, wind direction. The American Society for Testing and Materials (ASTM) has recently developed a standard method for testing wind vanes (copy attached); balloting on member acceptance of the method is now underway. This standard method, like most ASTM standards, will most likely eventually be adopted by the American National Standards Institute (ANSI), and will probably become the generally accepted test procedure for evaluating wind vane performance. My point in mentioning this is that the ASTM and proposed NRC techniques vary in one important particular -- namely, the value of the initial deflection angle θ_o used for determining damping ratio and delay distance. The ASTM method prescribes $\theta_o = 10°$, in agreement with Mazzarella's (1972) recommendation and National Weather Service specifications. Wieringa (1967) says that vane tests should always be conducted with $\theta_o < 15°$, because the apparent damping ratio is incorrect for larger initial values. In view of these comments, and recognizing that many manufacturers already test their vanes with $\theta_o = 10°$, I see no reason not to bring the NRC proposed guide into agreement with the ASTM method. The damping ratio and delay distance are pretty much independent of θ_o for values less than 15°, so the specified values for these parameters should remain unchanged. One obvious advantage of adopting the ASTM recommendation is that a complete and detailed method is then available for uniform testing of direction vanes, and could be specified by the NRC.

(5) Section 4 (system accuracy), p.9, para.2, wind speed. No distance constant is specified for the anemometer. Is this an oversight? For good matching of wind speed and direction sensors, MacCready and Jex (1964) recommend that the anemometer's distance constant be equal to the vane's delay distance.

If you have any questions about these comments and remarks, please call (FTS 626-1248). Please keep me posted on the progress of the proposed revision.

Best regards.

Sincerely yours,

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Enclosure: ASTM vane standard

RPH:ohp

REFERENCES

Hosker, R. P., Jr., 1980: Dispersion in the vicinity of buildings. In Proc. of 2nd Joint Conf. on Applications of Air Poll. Meteorol. and 2nd Conf. on Indust. Meteorol., New Orleans, LA, March 24-28 (Amer. Meteorol. Soc., Boston, MA), pp 92-107.

MacCready, P. B., Jr., and H. R. Jex, 1964: Response characteristics and meteorological utilization of propeller and vane wind sensors. J. Appl. Meteorol. [illegible], no [illegible], pp 182-193.

Mazzarella, D. A., 1972: An inventory of specifications for wind measuring instruments. Bull of Amer. Meteorol. Soc. 53, no. 9, pp 860-871.

Wieringa, J., 1967: Evaluation and design of wind vanes. J. Appl Meteorol. 6, no. 6, pp 1114-1122.

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ITEM # 1

Draft No. 5
4/9/80

STANDARD METHOD FOR DETERMINING THE DYNAMIC PERFORMANCE OF A WIND VANE

1. Scope

1.1 This method covers the determination of the

Starting Threshold

Delay Distance

Overshoot

Dynamic Vane Bias

of a wind vane from direct measurement in a wind tunnel for wind vanes having measurable overshoot.

1.2 This method provides for determination of the performance of the wind vane and its transducer in wind tunnel flow. Transference of values determined by these methods to atmospheric flow must be done with an understanding that there is a difference between the two flow systems.

2. Applicable Documents

D 1356 Definitions of Terms Relating to Atmospheric Sampling Analysis

E 380 Metric Practice Guide

3. Summary of Method

3.1 This method requires a wind tunnel described in Section 6, Apparatus.

3.2 Wind Direction (θ, degrees) is measured as the angular position of the vane with respect to some index (real or imaginary) position on the sensor assembly. Initial displacement of 10 degrees must be within ± 1 degree.

3.3 Starting Threshold (S_0, m/s) is determined by measuring the lowest speed at which a vane released from a position 10 degrees off the wind tunnel centerline moves to within five degrees of the centerline. Tests must include initial displacements to each side of the centerline.

3.4 Delay Distance (D, m) may be measured at a number of wind speeds but must include 5 m/s, and 10 m/s. A measurement is made of the time required for the vane to reach 50 percent of the initial displacement from 10 degrees off wind tunnel centerline release. This time in seconds (s) is converted to the Delay Distance by multiplying by the tunnel wind speed in metres per second. Tests must include displacements to each side of the centerline.

3.5 Overshoot (Ω) may be measured at the same time as the Delay Distance. The maximum angular excursion on the opposite side of the at-rest position from the initial 10 degrees off wind tunnel centerline displacement is measured. This value is divided by the initial displacement to obtain the ratio Ω.

3.6 Dynamic Vane Bias (θ_B) is the maximum displacement of the vane from the undisturbed flow direction at the center of the wind tunnel (typically the wind tunnel centerline) caused by the free response of the vane to the tunnel flow at all speeds above three times the vane Starting Threshold. This measurement will identify wind vanes with unbalanced aerodynamic response because of damage (bent tail) or design. θ_s must be $\leq |1°|$.

4. Significance and Use

This method will provide a standard for comparison of wind vanes of different types. Specifications by regulatory agencies (1-4) and industrial societies have specified performance values. This standard provides an unambiguous method for measuring Starting Threshold, Delay Distance, Overshoot and Dynamic Vane Bias.

5. Terminology

5.1 Definitions*

delay distance (D)-- the distance the air flows past a wind vane during the time it takes the vane to return to 50 percent of the initial displacement

overshoot (Ω)--the ratio of the amplitudes of two successive deflections of a wind vane as it oscillates about the equilibrium position after release from an offset position, as expressed by the equation

$$\Omega = \frac{\theta_{(n+1)}}{\theta_n}$$

where θ_n and $\theta_{(n+1)}$ are the amplitudes of the n and n + 1 deflections, respectively. Because all deflections after the first to the side opposite the release point are small, the initial release point (i.e., the n = zero deflection) and the first deflection after release (n = 1) are used in practice in determining overshoot.

starting threshold--the lowest wind speed at which a vane will turn to within five degrees of θ_s from an initial displacement of 10 degrees.

5.2 Calculated or Estimated Values

damping ratio (η)--the damping ratio is calculated from the overshoot ratio (Ω) (5).

$$\eta \doteq \frac{\ln \frac{1}{\Omega}}{\sqrt{\pi^2 + \left(\ln \frac{1}{\Omega}\right)^2}}$$

damped natural wavelength (λ_d)--at sea level in the U.S. Standard Atmosphere, damped natural wavelength is related to delay distance (D) and damping ratio (η) by the empirical expression (5)

$$\lambda_d \doteq \frac{D\ (6.0 - 2.4\,\eta)}{\sqrt{1 - \eta^2}}$$

6. Apparatus

6.1 Wind Tunnel (6)

6.1.1 Size. The wind tunnel must be large enough so that the projected area of the sensor and vane in its displaced position is less than 5 percent of the tunnel cross sectional area.

6.1.2 Calibration. The mean flow rate must be verified at the mandatory speeds by use of transfer standards which have been calibrated at the National Bureau of Standards or by a fundamental physical method. Speeds below 2 m/s for threshold determination must be verified by some other technique, such as smoke puffs or heat puffs.

6.2 Measuring System

6.2.1 Direction. The resolution of the wind vane transducer limits the measurement. The resolution of the measuring or recording system must represent the 10 degree displacement on each side of the wind tunnel centerline with a resolution of 0.2 degrees. The accuracy of the position (resistance for example) to output conversion must be within ± 0.1 degree.

6.2.2 Time. The resolution of time must be consistent with the distance accuracy required. For this reason, the time resolution may be changed as the wind tunnel speed is changed. If one wants a distance constant measurement to 0.1 metre resolution one must have a time resolution of 0.05 seconds at 2 m/s and 0.01 seconds at 10 m/s. If time accuracy is based on 60 Hz power frequency it will be at least an order of magnitude better than the resolution suggested above.

6.3 Techniques. One simple technique is to use a fast-response recorder (flat to 40-60 Hz or better) with enough gain so that a vane can be oriented in the wind tunnel with the tunnel centerline direction represented at mid scale on the recorder and ± 10 degrees of vane displacement providing zero and full scale on the recorder. If the recorder has a fast chart speed of 10 to 50 mm/sec or more, one can record the vane performance and extract the data properly. Care must be taken to avoid electronic circuits with time constants which limit the apparent vane performance.

Digital recording systems and appropriate reduction programs will also be satisfactory if the sampling rate is at least 100 per second.

An FM tape recorder may be used for the signal. When played back at lower speed a slow analog strip chart recorder is acceptable. Oscilloscopes with memory and hard copy capability may also be used.

7. Sampling

7.1 Starting Threshold. Ten consecutive tests at the same speed meeting the method requirement, five in each direction off the wind tunnel centerline, are required for a valid starting threshold measurement.

7.2 Delay Distance and Overshoot. The arithmetic mean of ten tests, five in each direction off the wind tunnel centerline, is required for a valid measurement at each speed. The results of the measurements at two or more speeds should be averaged to a single value for delay distance and a single ratio for overshoot.

8. Procedure

8.1 Starting Threshold

8.1.1 Provide a mechanical method for holding and releasing the vane at 10 degrees from θ_s. Test the release mechanism with the wind tunnel off to verify that the release method moves the vane by less than 0.5 degrees when activated. The release device must not move in the direction the vane will move when released.

8.1.2 Set the wind tunnel to a speed which you expect will be lower than the starting threshold. Displace the vane 10 degrees and release by the procedure described in 8.1.1. Observe where the vane stops. Adjust the speed until the vane consistently stops within five degrees of θ_s.

8.1.3 Using this speed record five consecutive samples to one side of the centerline followed by five samples to the other side.

8.1.4 If all ten samples resulted in the vane coming to rest within five degrees of θ_s, the wind speed may be used as the starting threshold in accordance with this method. The average of the absolute angular displacement, θ_s, on each side should be calculated. The higher of the two is the accuracy at the threshold speed. For example, if the average displacement is two degrees from θ_s the accuracy of the wind vane at threshold is specified as two degrees. To match the accuracy at starting threshold to the accuracy of the vane measurement at higher speeds, find the starting speed where the accuracy at starting threshold equals the wind vane measurement accuracy.

8.2 Delay Distance

8.2.1 Set the wind tunnel speed to 2 m/s. Displace the vane 10 degrees and release by method in 8.1.1. Take four more samples in the same direction and five samples in the opposite direction.

8.2.2 Repeat procedure of 8.2.1 using 5 and 10 m/s.

8.2.3 Measure the time from release to crossing five degrees (or 50 percent of the actual release displacement at a nominal 10 degrees) for each of the samples (10 at each speed). Convert each of these times to a distance by multiplying by the tunnel speed. Average the distances to arrive at the delay distance.

8.3 Overshoot

8.3.1 Read the maximum overshoot from the data recorded for 8.2 above. Convert each of the samples to a ratio by dividing the overshoot by the difference between initial displacement and the equilibrium direction. Average the ratios to arrive at the overshoot.

9. Precision and Accuracy

9.1 Precision. Using this equipment and procedure, an estimate of the precision of the method follows.

9.1.1 Starting Threshold. The precision of the speed reported as the threshold relates to the wind tunnel used for this method. A precision of the average of the angular displacement from θ_s is the same as the precision for measuring the position of the direction vane. The apparatus prescribed will provide a precision of 0.2 degrees. A precision of one degree is required.

9.1.2 Delay Distance

The precision by this method is 0.1 metre.

9.1.3 Overshoot

The precision by this method is 0.02.

9.2 Accuracy

9.2.1 Starting Threshold. The accuracy of the wind tunnel is the accuracy of this method. An accuracy of 0.1, m/s is required. This must be documented at the wind tunnel facility and be related to measurements at National Bureau of Standards by National Bureau of Standards report on the transfer standard which will carry the same accuracy limit. Documentation of other methods is required. The accuracy of the angle measurement will be 0.5 degrees for this method.

9.2.2 Delay Distance

The accuracy of this method is 0.1 metre.

9.2.3 Overshoot

The accuracy of this method is 0.05.

References

1. American Nuclear Society-Guideline for Obtaining Meteorological Information at Nuclear Power Sites (ANS-2.5, draft).

2. International Atomic Energy Agency-Safety Guide on Meteorology-Climatology, Diffusion and Transport in Nuclear Power Plant Siting.

3. U.S. Environmental Protection Agency-Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) (OAQPS No. 1.2-096).

4. U.S. Nuclear Regulatory Commission-Safety Guide 1.23

5. MacCready, Jr., P. B. and H. R. Jex, 1964: Response characteristics and meteorological utilization of propeller and vane wind sensors. J. Appl. Meteor., Vol. 3, No. 2, pp 185.

6. Pope, A. and J. J. Harper, 1966: Low-Speed Wind Tunnel Testing. John Wiley and Sons, New York, xii and 457 pp.