NUREG-75/087

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 3.3.2 TORNADO LOADINGS

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - Site Analysis Branch (SAB)
Accident Analysis Branch (AAB)
Auxiliary and Power Conversion Systems Branch (APCSB)

I. AREAS OF REVIEW

The following areas relating to the design of structures that have to withstand the effects of the design basis tornado specified for the plant are reviewed.

1. The design parameters applicable to the tornado, including the tornado wind translational and tangential velocities, the tornado-generated pressure differential and its associated time interval, and the spectrum of tornado-generated missiles including their characteristics, are reviewed from the standpoint of use in defining the input parameters for the structural design criteria appropriate to account for tornado loadings. The bases for the selection and the values of these parameters are within the review responsibility of the Site Analysis Branch (SAB) and the Accident Analysis Branch (AAB), as stated in Standard Review Plans 2.3.1, 2.3.2,and 3.5.1.4.

2. The procedures that are utilized to transform the tornado parameters into effective loads on structures are reviewed, including the following.
   a. The transformation of the tornado wind into an effective pressure applied to exposed surfaces of structures, with particular emphasis on shape coefficients and the pressure distribution on flat surfaces and circular structures such as containments.
   b. If venting of a structure is utilized, the procedures for transforming the tornado-generated differential pressure into an effective reduced pressure are reviewed, upon request, by the Auxiliary and Power Conversion Systems Branch (APCSB).
   c. The transformation of tornado-generated missile loadings, which are considered impactive dynamic loads, into effective loads.
   d. The combination of the above individual loadings in a manner that will produce the most adverse total tornado effect on structures.

3. The information provided to demonstrate that failure of any structure or component not to be designed for tornado loads will not affect the capability of other structures or components to perform necessary safety functions.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review are as follows:

1. The acceptance criteria for the tornado wind velocity, the differential pressure and its associated time interval, the spectrum of tornado-generated missiles and their characteristics, and the bases for determining these parameters, are established by the Site Analysis Branch (SAB) and the Accident Analysis Branch (AAB) and are contained in Standard Review Plans 2.3.1, 2.3.2 and 3.5.1.4. The approved values of these parameters should serve as basic input to the review and evaluation of the structural design procedures.

2. The acceptance criteria for the procedures utilized to transform the tornado parameters into effective loadings on structures are as follows:
   a. For transforming the tornado wind velocity into an effective pressure applied to exposed surfaces of structures, the criteria delineated in either the American Society of Civil Engineers (ASCE) Paper No. 3269, "Wind Forces on Structures" (Ref. 1), or in ANSI A58.1-1972, "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures" (Ref. 2), are, in general, acceptable. In particular, the following shall apply:
      (i) The maximum velocity pressure, p, should be based on the maximum tornado velocity, V, using the following formula:

      $p = 0.00256\ V^2$ psf, in which V is in mph.

      (ii) The velocity pressure should be assumed constant with height.
      (iii) The maximum velocity pressure, p, applies at the radius of the tornado funnel at which the maximum velocity occurs. It can therefore be modified or reduced at points away from this radius. The manner of such a reduction will be reviewed on a case-by-case basis.
      (iv) For calculating velocity pressures on external surfaces of structures, on external portions thereof, and on internal surfaces, where there are openings in the structure, appropriate shape coefficients shall be used in accordance with ASCE Paper No. 3264 (Ref. 1). Gust factors may be taken as unity.
   b. If venting of a structure is adopted as a design measure to permit transforming the tornado-generated differential pressure into an effective reduced pressure, the acceptance criteria are established on a case-by-case basis, upon request, by the Auxiliary and Power Conversion Systems Branch (APCSB).
   c. The acceptance criteria for transforming the tornado-generated missile impact into an effective or equivalent static load on structures are delineated in Section II of Standard Review Plan 3.5.3.
   d. Having established the effective loads for each of the above three individual tornado-generated effects, the combination thereof should then be determined in a conservative manner for each particular structure, as applicable. An acceptable method of combining these effects is as follows:

(i) $W_t = W_w$
(ii) $W_t = W_p$
(iii) $W_t = W_m$
(iv) $W_t = W_w + .5\ W_p$
(v) $W_t = W_w + W_m$
(vi) $W_t = W_w + .5\ W_p + W_m$

where: W_t ..... total tornado load,
W_w ..... tornado wind load,
W_p ..... tornado differential pressure load, and
W_m ..... tornado missile load.

For each particular structure or portion thereof, the most adverse of the above combinations should be used, as appropriate.

These combined effects constitute the total tornado load which should then be combined with other loads as specified in Standard Review Plans 3.8.1, 3.8.4, and 3.8.5.

3. The information provided to demonstrate that failure of any structure or component not to be designed for tornado loads will not affect the capability of other structures or components to perform necessary safety functions, is acceptable if found in accordance with either of the following:
   a. The postulated collapse or structural failure of structures and components not to be designed for tornado loads, including missiles, can be shown not to result in any structural or other damage to safety-related structures or components.
   b. Safety-related structures are designed to resist the postulated structural failure, collapse, or generation of missiles from structures and components not designed for tornado loads.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes material from the review procedures described below, as may be appropriate for a particular case.

1. The site-related parameters described in Section I.1 of this plan are reviewed by the Site Analysis Branch (SAB) and the Accident Analysis Branch (AAB) in accordance with Standard Review Plans 2.3.1, 2.3.2, and 3.5.1.4. The structural reviewer examines the approved values of these parameters to assure himself that the design basis and procedures utilized in designing structures to withstand tornado loads are appropriate and applicable.

2. After the applicability of the site-related parameters is established, the reviewer proceeds with his review of the structural aspects of tornado design in the following manner:
   a. The procedures utilized by the applicant to transform tornado wind velocities into effective pressures are reviewed and compared with those procedures delineated in

either ASCE paper No. 3269 or in ANSI A58.1-1972, whichever is selected, and, in particular, with the acceptance criteria delineated in Section II.2.a of this review plan.

b. Where venting is utilized, procedures for transforming the tornado-generated differential pressure into an effective reduced pressure are reviewed, upon request, by the Auxiliary and Power Conversion Systems Branch (APCSB).

c. The treatment of tornado-generated missiles is covered in Standard Review Plan 3.5.1.4 and the review procedures for design of missile barriers are described in Standard Review Plan 3.5.3.

d. After procedures for determining the individual tornado effects are reviewed, the manner in which these effects are then combined to arrive at the most adverse total tornado effect is reviewed and compared with the acceptance criteria delineated in Section II.2. d of this plan. Other proposed methods which may depend on the geometry and configuration of a particular structure are reviewed on a case-by-case basis.

3. The information provided to demonstrate that failure of any structure or component not to be designed for tornado loads will not affect the capability of other structures or components to perform necessary safety functions is reviewed to assure that one of the acceptance criteria of Section II.3 of this plan is satisfied.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided to satisfy the requirements of this review plan, and concludes that his evaluation is sufficiently complete and adequate to support the following type of statement to be included in the staff's safety evaluation report:

"The procedures utilized to determine the loadings on structures induced by the design basis tornado specified for the plant are acceptable since these procedures provide a conservative basis for engineering design to assure that the structures withstand such environmental forces.

"The use of these procedures provides reasonable assurance that in the event of a design basis tornado, the structural integrity of the plant structures that have to be designed for tornadoes will not be impaired and, in consequence, safety-related systems and components located within these structures will be adequately protected and may be expected to perform necessary safety functions as required. Conformance with these procedures is an acceptable basis for satisfying, in part, the requirements of General Design Criterion 2."

V. REFERENCES

1. ASCE Paper No. 3269, "Wind Forces on Structures," Transactions of the American Society of Civil Engineers, Vol. 126, Part II (1961).

2. ANSI A58.1-1972, "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures," Committee A58.1, American National Standards Institute (1972).

3. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

11/24/75

SRP 3.4.1