3.3 WIND AND TORNADO LOADINGS

Structures, systems or components whose failure due to design wind loading could prevent safe shutdown of the reactor, or result in significant uncontrolled release of radioactivity from the unit, are protected from such failure by one of the following methods:

a) the structure or component is designed to withstand design wind, or

b) the system or components are housed within a structure which is designed to withstand the design wind.

Structures, systems or components whose failure could prevent safe shutdown of the reactor, or result in significant uncontrolled release of radioactivity from the unit, are protected from such failure due to design tornado wind loading or missiles by one of the following methods:

a) the structure or component is designed to withstand tornado wind and/or tornado missile loads (refer to Subsection 3.5.1.4 for tornado missile criteria), or

→ (DRN 00-1172)

b) the system or components are housed within a structure and/or protected by a barrier which is designed to withstand the tornado wind and/or missile loads, or

c) system or component failure is not credible because tornado induced failure modes are considered improbable as mentioned in section 3.5.1.4.1

← (DRN 00-1172)

Table 3.2-1 lists all safety related structures, systems and components and the method of wind/tornado protection where applicable. The a or b designation in the table refers to item a or b above.

3.3.1 WIND LOADINGS

3.3.1.1 Design Wind Velocity

The plant structures defined as seismic Category I structures are designed for a maximum wind of 200 mph at 30 feet above plant grade.

3.3.1.2 Basis for Wind Velocity Selection

The basis for the selection of the above wind velocity for design is presented in Section 2.3. The 100 year recurrence interval indicates a maximum wind velocity of approximately 100 mph. However, to assure the integrity of these structures under extreme wind conditions, a 200 mph wind is selected to provide sufficient conservatism in design.

3.3.1.3 Determination of Applied Forces

The wind loads which are applied to structures as static forces are derived from, the recommendations of ASCE paper No. 3269, "Wind Forces on Structures

The dynamic wind pressure (q) in pounds per square foot is calculated from the wind speed using the formula: (1)

$$q = 0.002558 V^2$$

where V is the wind speed in miles per hour.

The local pressure at any point on the surface of a building is equal to:

$P_L = C_{pe}q$ (2)

where C_{pe} represents the local pressure coefficient which depends upon the geometric form of the building and the relative location of the point in question with respect to the direction of the wind. Values of C_{pe} for several different shapes, of buildings are presented in ASCE Paper No. 3269 and ASCE Paper No. 4933[(2)]. Values of C_{pe} for the containment dome as shown in Figures 3.3-1 and 3.3-2 are slightly simplified from those of Reference 2. The values of C_{pe} are assumed constant across the width of the dome instead of using more than one value of C_{pe} for each strip as suggested in the ASCE-paper.

In general, C_{pe} is positive for windward parts of buildings and negative for leeward parts of buildings.

The values given in equation (2) represent the dynamic wind pressure on the surface of the building only in the case in which the building is airtight. If there are openings on the surface of a building, then an internal pressure (P_i) will be increased or decreased depending on whether the openings are mainly on the windward or leeward surfaces as given in the following:

$P_i = C_{pi}q$ (3)

where C_{pi} is the internal pressure coefficient. Detailed test values of C_{pi} for certain buildings are listed in Reference 1.

In the design of walls and roofs, the pressure coefficient includes the summation of the external and the internal pressures. Considering equation (2) and equation (3), the total dynamic pressure (P_t):

$P_t = P_L + P_i$

or $P_t = q(C_{pe} + C_{pi})$ (4)

The total directional wind pressure for the building, in the direction of the wind is given by:

$P_t = C_Dq$ (5)

where C_D.is the average drag or shape coefficient for the building and q is the dynamic wind pressure at the given height. C_D includes the effects of positive pressure on the windward wall and negative pressure on the leeward wall.

C_D and the pressure distribution around the cylindrical Reactor Building are determined by using References 1 and 2.

Table 3.3-1 and Figures 3.3-1 and 3.3-3 list the applied force magnitude gust factor used, and pressure distribution calculated for each plant safety related structure.

3.3.2 TORNADO

3.3.2.1 Applicable Design Parameters

Parameters applicable to the design basis tornado for seismic Category I structure design are in accordance with the following criteria:

a) external wind forces resulting from a tornado funnel with a horizontal rotation velocity of 300 mph and a horizontal translational velocity of 60 mph. The tornado rotational (tangential) velocity and translational velocity are summed algebraically, and applied on the entire building structure,

b) a decrease in atmospheric pressure of three psi at a rate of one psi/sec,

→ (DRN 00-1172)

c) the effect on (a) and (b) are considered to act simultaneously, and/or in accordance with Standard Review Plan Section 3.3.2

← (DRN 00-1172)

d) the external tornado generated missiles considered, as described in Subsection 3.5.1.4.

e) Category I structures are designed without venting (eg. blow-out panels) provisions.

In the design of steel structures, an increase in code allowable stresses was permitted for tornadic loading in combination with other loadings. Stresses less than or equal to 90 percent of yield for flexure and less than or equal to 58 percent of yield for shear were allowed.

The design basis tornado for Waterford 3 is based upon the tornado wind and pressure characteristics considered appropriate by the nuclear industry and the AEC at the time the plant was designed prior to the issuance of Regulatory Guide 1.76 in April 1974. Both the total wind speed and the maximum negative pressure are the same for the Waterford design basis tornado as those specified in Regulatory Guide 1.76. In addition, the effect of 2 psi/sec pressure drop as specified in Regulatory Guide 1.76 has been evaluated. The natural period of the structure systems is 0.02 to 0.30 sec. Utilizing the method to determine the maximum dynamic load factor, (DLF) maximum of one-degree elastic systems, undamped and subjected to constant force with finite rise time as given in "Introduction to Structural Dynamics" by John M. Briggs, (DLF) maximum is determined to be approximately equal to 1.00 and 1.02 for the pressure drop rate of 1 and 2 psi/sec respectively. The increase of two percent in (DLF) maximum is acceptable within the conservatism used in calculating the equivalent static pressure loads. Therefore, the design of the seismic Category I structure meets the intent of Regulatory Guide 1.76.

3.3.2.2 Determination of Forces on Structures

Tornado wind speed is converted into equivalent dynamic pressure loadings and the computations for wind pressure, their distribution on surface area of buildings, shape factors and drag coefficients are based on the procedures outlined in ASCE Paper No. 3269. Because of the unique characteristics of tornados, gust factor and velocity variation with height are not considered. With respect to the pressure distribution around the Reactor Building, wind force data reported in ASCE Papers 3269 and 4933 are used in the design.

The effect of (a), (b), and (c) given in Subsection 3.3.2.1 are considered.

The dynamic pressure corresponding to the 360 (i.e., 300 mph + 60 mph) mph wind velocity calculated in the standard form is:

$$q = 0.002558\ V^2$$

$$q = 0.002558\ (360)^2 = 332\ \text{psf}$$

For large structures or parts of structures whose horizontal dimensions perpendicular to the wind force are comparable to the radius of the tornado vortex at which the maximum tangential wind speed occurs, a more realistic, average tornado wind speed of 300 mph can be used in equation(1) to calculate the dynamic wind pressure for the structure as a whole[(1)] . Local dynamic wind pressure is still based on 360 mph for equations (2), (3), and (4).

→(DRN 00-1172, R11)

The pressure differential (p) noted in Subsection 3.3.2.1 (b) is considered in calculating tornado pressure loading for closed buildings. The maximum pressure drop of three psi occurs at the center of the vortex and diminishes with distance from the vortex center. Theoretically, this pressure drop ranged from 1.5 psi at the point of maximum tornado tangential wind speed to three psi at the center of the tornado where the tangential speed is zero. However, the plant design conservatively used the maximum pressure drop of three psi throughout for structural analysis. For these buildings, the local pressure loading, equation (2), is combined with the pressure differential (p) to give:

$$P = qC + p \qquad (6)$$

$P = qC_{pe} + 0.5\ p$ (for Special Doors and Maintenance Hatch Shield Door Only and RAB Roof Hatch HC-31 Covers)

The total directional wind pressure on the entire building in the direction of the maximum wind speed will remain the same as given by equation (5). The equivalent static pressure loading for the various structures are given on Table 3.3-2 and Figures 3.3-2 and 3.3-4.

←(DRN 00-1172, R11)

→(DRN 00-1032, R11-A)

The total structural response due to the design basis tornado is determined by combining the static analysis results that account for the tornado pressure loading as given by equation (6) and the equivalent static loads as obtained from the missile impactive analysis discussed in Subsection 3.5-3.

←(DRN 00-1032, R11-A)

3.3.2.3 Effect of Failure of Structures or Components not Designed for Tornado Loads

→(DRN 00-1032, R11-A; 02-86, R11-A; 03-1823, R13)

Non-seismic structures such as the Intake superstructure framing, Intake structure crane, and Turbine Building (but not the Turbine Gantry crane) have been designed for tornadic wind on the exposed steel surfaces, but have not been designed to resist tornado generated missiles. The failure of any structural member or component in either of these non-seismic structures, that would be caused by being hit by a tornado generated missile, would be local in nature causing no damage to seismic Category I structures or components and would not prevent the safe shutdown of the reactor or result in uncontrolled release of radioactivity to the environment.

←(DRN 00-1032, R11-A; 02-86, R11-A; 03-1823, R13)

→(DRN 00-1032; 02-86)
←(DRN 00-1032; 02-86)

The Turbine Building has been evaluated for tornado loadings to the following extent:

→ (DRN 00-1172)

a) Siding in Place - The building is designed to resist a wind load of 200 mph (assume pressure drop to be zero).

← (DRN 00-1172)

b) Siding Failure - Siding fails for winds above 200 mph. The siding is designed to fail but remain balanced and restrained by the central portion of the panel against the girts. The exposed steel framing is designed to withstand a tornado load of 360 mph.

c) Tornado-born missiles are not considered in the design.

SECTION 3.3: REFERENCES

(1) ASCE 3269, "Wind Forces on Structures," American Society of Civil Engineers, Transactions, Vol 126, Part II, 1961

(2) "Wind Loads on Dome-Cylinder and Dome-Cone Shapes, "F J Maher, Journal of the Structural Division, ASCE Vol 92, No. S T 5 Proc Paper 4933, October 1966

TABLE 3.3-1

WIND SPEEDS AND RESULTING STATIC PRESSURE LOADINGS

Structure	Wind Speed (mph)	Pressure Coefficient	External Pressure (psf)
Reactor Building	Refer to Figures 3.3-1 and 3.3-3		
Reactor Auxiliary Building	200	0.9 (1) -0.5 (2) -0.7 (3) -0.8 (4)	92 -51 -72 -82
Fuel Handling Building	200	0.9 (1) -0.5 (2) -0.7 (3) -0.8 (4)	92 -51 -72 -82

(1) Windward

(2) Leeward

’-’ indicates suction

(3) Roof

(4) Sidewalls

TABLE 3.3-2

TORNADO WIND SPEEDS AND
RESULTING STATIC PRESSURE LOADINGS

Structure	Tornado Wind Speed (mph)	External Pressure Coefficient	External Loading (psf)	External Loading With Pressure Diff (psf)
Reactor Building	Refer to Figures 3.3-2 and 3.3-4			
Reactor Auxiliary Building	360	0.9	299 (1)	-133
		-0.5	-166 (2)	-598
		-0.5	-166 (3)	-598
		-0.8	-266 (4)	-698
Fuel Handling Building	360	0.9	299 (1)	-133
		-0.5	-166 (2)	-598
		-0.5	-166 (3)	-598
		-0.8	-266 (4)	-698

(1) Windward
(2) Leeward
(3) Roof
(4) Sidewalls

'- 'indicates suction