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October 8, 2012
U7-C-NINA-NRC-120064

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
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South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
Supplemental Response to Request for Additional Information

The Attachment provides a supplemental response to NRC staff question 02.03.01-24 related to the Combined License Application (COLA) Part 2, Tier 2, Section 3H.11. Following the audit performed during the week of July 23, 2012 and subsequent phone calls, the NRC Staff requested that Nuclear Innovation North America LLC provide additional information to support the review of the COLA. This response completes the actions requested by the NRC Staff.

Where there are COLA markups, they will be made at the first routine COLA update following NRC acceptance of the RAI response. There are no commitments in this letter.

If you have any questions regarding these responses, please contact me at (361) 972-7136 or Bill Mookhoek at (361) 972-7274.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 10/8/12

Scott Head
Manager, Regulatory Affairs
South Texas Project Units 3 & 4

jep

Attachment:

RAI 02.03.01-24, Supplement 4

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NRO

STI 33601999

cc: w/o attachment except*

(paper copy)

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RAI 02.03.01-24, Supplement 4

QUESTION:

10 CFR 52.79(a)(1)(iii) states, in part, that the COL FSAR should include the meteorological characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. 10 CFR 100.20(c)(2) states that the meteorological characteristics of the site that are necessary for safety analysis or that may have an impact upon plant design must be identified and characterized and 10 CFR 100.21(d) states, in part, that the meteorological characteristics of the site must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site.

10 CFR Part 50, Appendix A, GDC 2 requires that SSCs that are important to safety be designed to withstand the effects of natural phenomena, such as tornadoes and hurricanes, without loss of the ability to perform their safety functions. 10 CFR Part 50, Appendix A, GDC 4 requires that SSCs that are important to safety be appropriately protected against the effects of missiles that may result from events and conditions outside the nuclear power unit.

Nuclear power plants must be designed so that they remain in a safe condition under extreme meteorological events, including those that could result in the most extreme wind events (tornadoes and hurricanes) that could reasonably be predicted to occur at the site. Initially, the U.S. Atomic Energy Commission (predecessor to the NRC) considered tornadoes to be the bounding extreme wind events and issued RG 1.76, ''Design-Basis Tornado for Nuclear Power Plants,'' in April 1974. The design-basis tornado wind speeds were chosen so that the probability that a tornado exceeding the design basis would occur was on the order of 10^{-7} per year per nuclear power plant. In March 2007, the NRC issued Revision 1 of RG 1.76, ''Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants." Revision 1 of RG 1.76 relied on the Enhanced Fujita Scale, which was implemented by the National Weather Service in February 2007. The Enhanced Fujita Scale is a revised assessment relating tornado damage to wind speed, which resulted in a decrease in design-basis tornado wind speed criteria in Revision 1 of RG 1.76. Since design-basis tornado wind speeds were decreased as a result of the analysis performed to update RG 1.76, it was no longer clear that the revised tornado design basis wind speeds would bound design-basis hurricane wind speeds in all areas of the United States. This prompted an investigation into extreme wind gusts during hurricanes and their relation to design basis hurricane wind speeds, which resulted in issuing RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," in October 2011.

RG 1.221 also evaluated missile velocities associated with several types of missiles considered for different hurricane wind speeds. The hurricane missile analyses presented in RG 1.221 are based on missile aerodynamic and initial condition assumptions that are similar to those used for the analyses of tornado-borne missile velocities adopted for Revision 1 to RG 1.76. However, the assumed hurricane wind field differs from the assumed tornado wind field in that the hurricane wind field does not change spatially during the missile's flight time but does vary with height above the ground. Because the size of the hurricane zone with the highest winds is large relative to the size of the missile trajectory, the hurricane missile is subjected to the highest wind speeds throughout its trajectory. In contrast, the tornado wind field is smaller, so the tornado missile is subject to the strongest winds only at the beginning of its flight. This results in the same missile having a higher maximum velocity in a hurricane wind field than in a tornado wind field with the same maximum (3-second gust) wind speed.

The STP COLA incorporates by reference the ABWR Design Control Document (DCD). Section 3.5.1.4 of the DCD states, in part, that "tornado-generated missiles have been determined to be the limiting natural phenomena hazard in the design of all structures required for safe shutdown of the nuclear power plant. Since tornado missiles are used in the design basis, it is not necessary to consider missiles generated from other natural phenomena." However, Section 3.5.4.2 of the DCD states, in part, that the COL applicant "shall identify missiles generated by other site-specific natural phenomena that may be more limiting than those considered in the ABWR design and shall provide protection for the structures, systems, and components against such missiles."

Accordingly, the applicant is requested to address the following:

a. Consistent with the requirements of 10 CFR 52.79(a)(1)(iii), 10 CFR 100.20(c)(2), 10 CFR 100.21(d), and the Combined License Information requirement of ABWR DCD Section 3.5.4, please identify hurricane wind speed and missile spectra for the STP site. RG 1.221 describes a method that the staff considers acceptable in selecting site-specific hurricane wind speed and hurricane-generated missiles.

b. Pursuant to the requirements of GDC 2, GDC 4, and the Combined License Information requirement of ABWR DCD Section 3.5.4, please confirm that the ABWR standard plant and STP site-specific SSCs important to safety are designed to protect against the combined effects of hurricane winds and missiles defined in question a above.

c. Please revise the appropriate FSAR sections to appropriately reflect the results of questions a and b above.

SUPPLEMENTAL RESPONSE:

Supplement 3 to the response to RAI 02.03.01-24 was submitted with Nuclear Innovation North America (NINA) letter U7-C-NINA-NRC-120059, dated August 29, 2012. Supplement 4 to RAI 02.03.01-24 provides the response to Punch List Item 276 shown below:

> Provide additional details for hurricane evaluation in Section 3H.11, as requested by NRC ***(Punch List Item 276)***

Staff's request for enhancement of COLA Section 3H.11 is shown below:

The applicant is requested to review the following information and determine the enhancements that are needed in various sections and subsections of 3H.11.

1. Hurricane Evaluation Parameters

   a. Maximum wind and missile impact speed for the design basis hurricane

   b. Procedures used to determine the loadings (transform the wind velocity into an effective pressure) on structures induced by the design basis wind

   c. Hurricane missile spectrum considered (wt., foot print, velocity, etc)

   d. Describe automobile missile impact load –triangular pulse with peak magnitude (1024K for horizontal and (?) for vertical load. Discuss dynamic load factor considered due to automobile missile impact (always greater than or equal to 1.0).

   e. Design criteria including approaches and procedure to determine the effects of hurricane wind and hurricane missiles (with emphasis on auto missile impact evaluation).

   f. Total effect of the design hurricane on seismic Category I structures; identify appropriate combinations of individual effects of the hurricane wind pressure and hurricane-associated missiles. Specify loads and load combinations considered in the structural evaluation including the acceptance criteria. Identify specific industry codes and standards and regulations considered in the structural evaluation.

2. Evaluation of "DCD" Structures for design basis hurricane wind and hurricane missile

   a. Identify and provide brief description of "DCD" structures considered for the hurricane evaluation. Provide appropriate reference (DCD/FSAR sections) for detailed description of these structures

   b. Approaches and procedures considered for local and global effects and provide evaluation summary and results (demand and capacity). Also discuss whether shear or flexure controls the design and whether any design modifications are made and describe the design modification.

3. Evaluation of site-specific structures for design basis hurricane wind and hurricane missile

   a. Identify and provide brief description of site-specific structures considered for the hurricane evaluation. Provide appropriate reference (DCD/FSAR sections) for detailed description of these structures.

b. Design approaches and procedures considered for local and global effects and provide evaluation summary and results (demand and capacity). Also discuss whether shear or flexure controls the design and whether any design modifications are made and describe the design modification.

4. Summary and Conclusions

Add a new section under 3H.11.3, 'Summary and Conclusion' that provides an overall summary and conclusions of the hurricane evaluation.

(Note: In RAI response 02.03.01-24, supplement 1 on (page 88 of 97) a statement is made in the evaluation summary, "Therefore this change does not result in any significant adverse impact to the plant design". This statement should be augmented (in the summary/conclusion section) with what changes, structural (reinforcement/thickness) or otherwise have been made as a result of the hurricane evaluation and discuss what is meant by 'significant adverse impact'.

5. General Comments:

a. Include material from the two presentations to the staff on February 29, 2012 and July 23, 2012, as appropriate.

b. Identify specific industry codes and standards and regulations considered in the structural evaluation.

The response to the Staff's request is provided below:

Item 1.a:

See COLA Section 3H.11.1 for maximum hurricane wind speed and missile impact velocities.

Item 1.b:

The procedure and parameters for hurricane wind pressure calculation are described in COLA Section 3H.11.1.

Item 1.c:

Hurricane missile spectrum (i.e. missile types), missile mass, missile dimensions (i.e. foot print), and missile horizontal and vertical impact velocities are provided in COLA Section 3H.11.1.

Item 1.d:

For missile impact load definition and associated Dynamic Load Factor, see notes of COLA

Tables 3H.11-1 through 3H.11-5 in RAI 02.03.01-24 Supplement 3 response that was submitted with Nuclear Innovation North America (NINA) letter U7-C-NINA-NRC-120059, dated August 29, 2012.

Item 1.e:

For design criteria including approaches and procedures for evaluation of hurricane wind and hurricane generated missiles, see COLA Section 3H.11.2 markups of the Enclosure.

Item 1.f:

Hurricane wind parameters, hurricane generated missile parameters, hurricane wind pressure, hurricane load combinations, acceptance criterion for evaluation of steel and concrete barriers, regulations, and industry codes and standards used in the structural strength and stability evaluations are provided in COLA Sections 3H.11.1 and 3H.11.2.

Item 2.a:

The following are the DCD Seismic Category I structures:

- Reactor Building (RB)
- Control Building (CB)
- Diesel Generator Fuel Oil Tunnels (DGFOT)

As described in COLA Section 3H.11, each of these structures is considered for the hurricane evaluation. For description of RB, see DCD Tier 1 Section 2.15.10 and DCD Tier 2 Section 3H.1.3. For description of CB, see DCD Tier 1 Section 2.15.12 and DCD Tier 2 Section 3H.2.3. For description of DGFOT, see DCD Tier 1 Section 2.15.10 and COLA Section 3H.7.3.

Item 2.b:

For approaches and procedures used for evaluation of DCD structures for local and global effects of hurricane, see COLA Section 3H.11.2 markups of the Enclosure. For evaluation summary and results and whether shear or flexure controls, see COLA Tables 3H.11-3 through 3H.11-5 in RAI 02.03.01-24 Supplement 3 response that was submitted with Nuclear Innovation North America (NINA) letter U7-C-NINA-NRC-120059, dated August 29, 2012. As shown in these tables, and summarized in Section 3H.11.3, DCD designs were found to be adequate for the design hurricane wind and missiles without requiring any modification.

Item 3.a:

The following are the site-specific Seismic Category I structures:

- Ultimate Heat Sink (UHS)/Reactor Service Water (RSW) Pump House
- Reactor Service Water (RSW) Piping Tunnels

- Diesel Generator Fuel Oil Storage Vaults (DGFOSV)

As described in COLA Section 3H.11, each of these structures is considered for the hurricane evaluation. For description of UHS/RSW Pump House, see COLA Sections 3H.6.3.1 through 3H.6.3.3. For description of RSW Piping Tunnels, see COLA Section 3H.6.3.4. For description of DGFOSV, see COLA Section 3H.6.7.

Item 3.b:

For approaches and procedures used for evaluation of site-specific Seismic Category I structures for local and global effects of hurricane, see COLA Section 3H.11.2 markups of the Enclosure. For evaluation summary and results and whether shear or flexure controls, see COLA Tables 3H.11-1 through 3H.11-2 in RAI 02.03.01-24 Supplement 3 response that was submitted with Nuclear Innovation North America (NINA) letter U7-C-NINA-NRC-120059, dated August 29, 2012. As noted in Table 3H.11-2, shear ties were required for walls 9, 10, and 16 of DGFOSV due to missile impact. See COLA Figure 3H.6-141 for location of DGFOSV walls 9, 10, and 16.

Item 4:

See new COLA Section 3H.11.5 provided in the Enclosure.

Item 5.a:

For material from the two presentations to the NRC staff on February and July of 2012 in regards to hurricane evaluations, see COLA Sections 3H.11.2, 3H.11.3, and 3H.11.3.1 through 3H.11.3.6 markups of the Enclosure.

Item 5.b:

The regulations, and industry codes and standards used in the structural strength and stability evaluations are provided in COLA Sections 3H.11.1 and 3H.11.2.

See Enclosure for COLA markups.

Enclosure

COLA MARKUPS

(Note: The following COLA markups are based on Revision 8 of the COLA and markups submitted with Supplement 3 of this RAI. In addition, for clarity sake, the entire text of Section 3H.11 is provided)

3H.11 Design for Site-Specific Hurricane Winds and Missiles

Regulatory Guide 1.221, “Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants,” October 2011, provides guidance for designing structures for hurricane wind and hurricane generated missiles.

The STP site-specific design-basis hurricane wind speed and resulting hurricane generated missile spectrum were determined in accordance with Regulatory Guide 1.221, as shown in Table 2.0-2 and described in Subsection 3H.11.1.

Design requirements and exceptions related to design basis tornado wind speed and corresponding missiles where noted throughout the FSAR are also applicable to the hurricane wind and hurricane generated missiles.

3H.11.1 Hurricane Parameters, Loads and Load Combinations

Parameters

- Maximum hurricane wind speed (from Table 2.0-2):................ 210 mph (338 km/h)

- Hurricane missile spectrum:

Per Tables 1 and 2 of Regulatory Guide 1.221, the hurricane missile spectrum and velocities corresponding to maximum hurricane wind speed of 210 mph (338 km/h) are as follows:

Missile Types	Dimensions	Mass	Missile Velocity Horizontal	Missile Velocity Vertical
Automobile	16.4 ft x 6.6 ft x 4.3 ft (5 m x 2m x 1.3m)	4,000 lb (1,810 kg)	134 mph (59.7 m/s)	58 mph (26 m/s)
Schedule 40 Pipe	6.625 in. dia. x 15 ft long (0.168 m dia. x 4.58 m long)	287 lb (130 kg)	104 mph (46.5 m/s)	58 mph (26 m/s)
Solid Steel Sphere	1 in. diameter (25.4 mm diameter)	0.147 lb (0.0669 kg)	92 mph (41.1 m/s)	58 mph (26 m/s)

Loads

The following hurricane load effects are considered in the design:

- Wind pressure .... (W_h)
- Missile impact.. (W_{mh})
- Total hurricane load, including missile effects.. (W_{th})
  Where, $W_{th} = W_h + W_{mh}$

(1) Hurricane Wind Pressure (W_h)

Unlike tornado wind pressures, there is no reduction in hurricane wind pressures due to size of the structure. In addition, hurricane wind pressures vary along the height of the structure, whereas, tornado wind pressures are considered uniform along the height of the structure. Hurricane wind pressures are computed using the procedure described in Chapter 6 of ASCE 7-05, in conjunction with the maximum wind speed defined above and the following parameters:

- Exposure Category C
- Importance factor 1.15
- Velocity pressure exposure coefficient as per ASCE 7-05 Table 6-3, but ≥ 0.85
- Topographic factor 1.0
- Wind directionality factor 1.0

(2) Hurricane Missile Impact (W_{mh})

Structures are evaluated for the effects of hurricane missile impact. Hurricane missile impact effects are evaluated for the following two conditions:

(a) For concrete barriers, local damage in terms of penetration, perforation, and spalling, is evaluated using the TM 5-855-1 formula (Reference 3H.6-1). For steel barriers, local damage prediction is performed using the Ballistic Research Laboratory (BRL) formula (Reference 3H.6-2).

(b) Global overall damage evaluations are performed in a manner similar to that for tornado loads in accordance with Revision 3 of SRP 3.5.3. In these evaluations, the hurricane load (Wth) is included in combination with other applicable loads.

For any critical missile hit location considered, the structure is analyzed for the resulting equivalent static load due to hurricane missile impact in conjunction with hurricane wind pressure. The resulting induced forces and moments from this analysis are combined with the induced forces and moments due to other applicable loads within the load combination to determine the total demand for design of the structural elements.

Load Combinations

Notations

S = Normal allowable stress for allowable stress design method
U = Required strength for strength design method
D = Dead load
F = Load due to weight and pressure of fluid with well-defined density and controllable maximum height
H = Lateral soil pressure and groundwater effects under normal operating

conditions

L = Live load

Ro = Piping and equipment reaction under normal operating condition (excluding dead load, thermal expansion and seismic)

To = Normal operating thermal expansion loads from piping and equipment

W_{th} = Total hurricane load, including missile effects

Load Combinations

Structural Steel:

$1.6S^{(\text{Note 1})} = D + L + F + H + Ro + To + W_{th}$

Note 1: The stress limit coefficient in shear shall not exceed 1.4 in members and bolts.

Reinforced Concrete:

$U = D + L + F + H + Ro + To + W_{th}$

3H.11.2 Evaluations for Hurricane Design

Local Evaluations

Local evaluations consist of the following:

- Local damage evaluation in terms of penetration, perforation, and spalling as described in Subsection 3H.11.1.

For concrete barriers, the minimum required thickness is based on the largest of the following:

- Penetration Depth
- Thickness required to prevent back-face scabbing
- Minimum thickness per SRP 3.5.3 for Tornado Region II

Formulation for penetration determination in concrete barriers is as follows:

$$X = \frac{222 \cdot P_p \cdot d^{0.215} V_{impact}^{\;1.5}}{\sqrt{f'_c}} + 0.5 \cdot d$$

where:

X = penetration depth (in), [Formulation Per TM 5-855-1]

d = outer missile diameter (in)

Pp = weight of missile (lbf) divided by missile cross-sectional area (in2)

V_{impact} = missile impact velocity in units of 1000 ft/sec

f'c = concrete compressive strength (psi), no dynamic increase factor is considered because the empirical equation is based on dynamic tests.

- When impact velocity (V_{impact}) is less than 1000 ft/sec, the calculated penetration depth (X) is increased by a factor of 1.3.
- The minimum thickness required to prevent back-face scabbing is calculated by doubling the penetration depth (X), including the 30% increase factor when V_{impact} is less than 1000 ft/sec.

- Flexural and shear capacity evaluation of the panel impacted by the hurricane missile considering the total hurricane load (W_{th}) in conjunction with all other applicable loads per load combinations in Subsection 3H.11.1.

The local panel flexure and shear evaluation requires the following steps:

- Impact force definition
- Impacted element load-deflection diagram
- Application of acceptance criteria

Impact Force Definition for Automobile Missile:

The Impact Forcing Function for automobile missile is per Figure C.2.2-8 of "Report of the ASCE Committee on Impactive and Impulsive Loads Proceeding." Second Conference on Civil Engineering and Nuclear Power, 1981 (see Figure 3H.11-1).

$$F_{impact} = \frac{V_{impact}(mph)}{60(mph)} 460(kip)$$

The impact force equation above is based on a linear relationship between the peak impact force (shown in Impact Forcing Function Figure 3H.11-1) and the peak impact velocity. This impact forcing function is idealized by a triangular impulse as shown in Figure 3H.11-2.

Impacted Element Load-Deflection Diagrams:

a) Panel response is in elastic range:

When panel response is in elastic range, the idealized load-deflection is as shown in Figure 3H.11-3(a), where:

R_m = Concentrated force capacity of panel
R_{m1} = Available concentrated force capacity of panel
δ_1 = deflection under present loads (all applicable loads present except

missile load)
δ_e = deflection at elastic range limit

b) Panel response extends into plastic range:

When panel response extends into plastic range, the idealized load-deflection is as shown in Figure 3H.11-3(b), where:

R_m = Concentrated force capacity of panel
R_{m1} = Available concentrated force capacity of panel
δ_1 = deflection under present loads (all applicable loads present except missile load)
δ_y = deflection at yield point

Acceptance Criteria:

The acceptance criterion depends on whether the response is in the elastic range or the response extends into the plastic range.

a) Response is in elastic range:

When the response is in the elastic range, the dynamic response is acceptable, provided the following is met:

$$DLF \cdot F_{impact} \leq R_{m1}$$

- The Dynamic Load Factor (DLF) is based on impact force time history and the parameter (t_d/T), where t_d is the impact duration and T is period of vibration. The minimum DLF value used in hurricane evaluations is 1.0.

- When the DLF is less than 1.2, the dynamic increase factor in Section C.2.1 of ACI 349-97 is not permissible per Regulatory Guide 1.142.

b) Response extends into plastic range

- When the response extends into the plastic range, the dynamic response is acceptable, provided the following is met:

$$\mu_{demand} \leq \mu_{limit}$$

- The ductility demand (μ_{demand}) is based on impact force time history and the parameters (t_d/T) and (R_{m1}/F_{impact}). In order to determine the acceptable ductility limit for the panel, it should be determined whether shear or flexure controls the design. Paragraph C.3.6 of ACI 349-97 states that flexure controls the design if the shear capacity exceeds the flexural capacity by

20%.

- For designs controlled by flexure, the ductility limit (μ_{limit}) is $0.05/(\rho - \rho')$, not to exceed 10.

- For designs controlled by shear, the ductility limit is 1.3.

Global Evaluations

Global evaluations consist of the following:

- The structure, in its entirety, is evaluated for the total hurricane load (W_{th}) in conjunction with all other applicable loads per load combinations in Subsection 3H.11.1.

  For structures designed using Finite Element analysis, the missile loads are applied at critical missile locations (i.e. top and/or mid-height) of walls running parallel to missile impact loads. For large structures, such as UHS/RSW Pump House, conservatively several missile hits at various locations are considered to minimize the number of load combinations. For smaller structures such as DGFOSV single missile hits are considered in various load combinations.

- The sliding and overturning stability of the structure is evaluated considering the total hurricane load (W_{th}) in conjunction with all other applicable loads. The load combination and the required safety factor for this stability evaluation are as follows:

  Stability load combination: $D + H + W_{th}$

  Minimum Required Safety Factor for sliding and overturning = 1.1

3H.11.3 Structures Designed for Site-Specific Hurricane

Seismic Category I Structures

The following Seismic Category I structures are designed for site-specific hurricane loads:

- Reactor Building (RB)
- Control Building (CB)
- ~~Reactor Service Water (RSW) Piping Tunnels~~
- Ultimate Heat Sink (UHS)/Reactor Service Water (RSW) Pump House
- Diesel Generator Fuel Oil Storage Vaults (DGFOSV)
- Diesel Generator Fuel Oil Tunnels (DGFOT)

Tables 3H.11-6 and 3H.11-7 provide a comparison of hurricane wind and missiles with tornado wind and missiles for the above structures.

Non-Seismic Category I Structures

Site-specific hurricane loads are used for stability evaluations and design of lateral load resisting systems of the following Non-Seismic Category I structures with potential interaction with Seismic Category I structures:

- Turbine Building (TB)
- Service Building (SB)
- Radwaste Building (RWB)
- Control Building Annex (CBA)
- Stack on the Reactor Building roof

3H.11.3.1 Hurricane Evaluations for the Reactor Building

The Reactor Building was evaluated under hurricane loading for local damage, panel capacity, global effects, and stability.

The minimum required wall thickness to prevent penetration, perforation, and scabbing is 15.4 inches (391 mm). The minimum wall thickness of the Reactor Building is 16.7 inches (425 mm). The minimum required roof thickness to prevent penetration, perforation, and scabbing is 11.4 inches (290 mm). The minimum roof thickness of the Reactor Building is 13.2 inches (335 mm).

The results of panel evaluations for hurricane generated missile impacts on the Reactor Building are presented in Table 3H.11-4.

The global hurricane wind pressure on the Reactor Building is enveloped by the global tornado wind pressure from grade up to approximately 60 ft above grade (see Figure 3H.11-4). From approximately 60 ft above grade to the top of the Reactor Building, the global hurricane wind pressure exceeds the global tornado wind pressure. A comparison of the seismic shear versus the total hurricane shear on the Reactor Building shows that the hurricane load is significantly less than the seismic loading (see Figure 3H.11-5). Therefore, the hurricane loading has no impact on the global design or stability. See Table 3H.1-23 for Reactor Building stability.

3H.11.3.2 Hurricane Evaluations for the Control Building

The Control Building was evaluated under hurricane loading for local damage, panel capacity, global effects, and stability.

The minimum required wall thickness to prevent penetration, perforation, and scabbing is 15.4 inches (391 mm). The minimum wall thickness of the Control Building is 23.6 inches (600 mm). The minimum required roof thickness to prevent penetration, perforation, and scabbing is 11.4 inches (290 mm). The minimum roof thickness of the Control Building is 15.75 inches (400 mm).

The results of panel evaluations for hurricane generated missile impacts on the Control Building are presented in Table 3H.11-5.

The global hurricane wind pressure on the Control Building is enveloped by the global tornado wind pressure (see Figure 3H.11-6). A comparison of the seismic shear versus the total hurricane shear on the Control Building shows that the hurricane load is significantly less than the seismic loading (see Figure 3H.11-7). Therefore, the hurricane loading has no impact on the global design.

The factors of safety against sliding and overturning for the hurricane load combination are reported in Table 3H.2-5.

3H.11.3.3 Hurricane Evaluations for the RSW Piping Tunnels

The RSW Piping Tunnels including their access regions were evaluated under hurricane loading for local damage, panel capacity, global effects, and stability.

The minimum required wall thickness to prevent penetration, perforation, and scabbing is 15.4 inches (391 mm). The minimum wall thickness of the RSW Piping Tunnel is 36 inches (914 mm). The minimum required roof thickness to prevent penetration, perforation, and scabbing is 11.4 inches (290 mm). The minimum roof thickness of the RSW Piping Tunnel is 24 inches (610 mm).

Based on the UHS/RSW Pump House, DGFOSV and DGFOT panel designs for site-specific hurricane wind and missiles, the RSW Piping Tunnel exterior wall and slab panels are adequate for site-specific hurricane wind and missiles.

The global hurricane wind pressure on the RSW Piping Tunnel is enveloped by the global tornado wind pressure used for design of the structure (see Figure 3H.11-8).

The factors of safety against sliding and overturning for the hurricane load combination are reported in Table 3H.6-16.

3H.11.3.4 Hurricane Evaluations for the UHS/RSW Pump House

The UHS/RSW Pump House was evaluated under hurricane loading for local damage, panel capacity, global effects, and stability.

The minimum required wall thickness to prevent penetration, perforation, and scabbing is 15.4 inches (391 mm). The minimum wall thickness of the UHS/RSW Pump House is 24 inches (610 mm). The minimum required roof thickness to prevent penetration, perforation, and scabbing is 11.4 inches (290 mm). The minimum roof thickness of the UHS/RSW Pump House is 18 inches (457 mm).

The results of a panel evaluation for hurricane generated missile impacts on the UHS/RSW Pump House are presented in Table 3H.11-1.

The global hurricane wind pressure on the UHS/RSW Pump House is enveloped by the global hurricane wind pressure used for design of the structure (see Figures 3H.11-9 and 3H.11-10).

The factors of safety against sliding and overturning for the hurricane load combination are reported in Table 3H.6-5.

3H.11.3.5 Hurricane Evaluations for the DGFOSV

The DGFOSV was evaluated under hurricane loading for local damage, panel capacity, global effects, and stability.

The minimum required wall thickness to prevent penetration, perforation, and scabbing is 15.4 inches (391 mm). The minimum wall thickness of the DGFOSV is 24 inches (610 mm). The minimum required roof thickness to prevent penetration, perforation, and scabbing is 11.4 inches (290 mm). The minimum roof thickness of the DGFOSV is 18 inches (457 mm).

The results of a panel evaluation for hurricane generated missile impacts on the DGFOSV are presented in Table 3H.11-2.

The global hurricane wind pressure on the DGFOSV is enveloped by the global tornado wind pressure used for design of the structure (see Figure 3H.11-11).

The DGFOSV was assessed for hurricane loads using finite element analysis, and the design results are included in Table 3H.6-11.

The factors of safety against sliding and overturning for the hurricane load combination are reported in Table 3H.6-12.

3H.11.3.6 Hurricane Evaluations for the DGFOT

The DGFOT and their access regions were evaluated under hurricane loading for local damage, panel capacity, global effects, and stability.

The minimum required wall thickness to prevent penetration, perforation, and scabbing is 15.4 inches (391 mm). The minimum wall thickness of the DGFOT is 24 inches (610 mm). The minimum required roof thickness to prevent penetration, perforation, and scabbing is 11.4 inches (290 mm). The minimum roof thickness of the DGFOT is 24 inches (610 mm).

The results of a panel evaluation for hurricane generated missile impacts on the DGFOT are presented in Table 3H.11-3.

The global hurricane wind pressure on the DGFOT is enveloped by the global tornado wind pressure used for design of the structure (see Figure 3H.11-12).

The factors of safety against sliding and overturning for the hurricane load combination are reported in Table 3H.7-2.

3H.11.3.7 Hurricane Evaluations for Non-Seismic Category I Structures

The Non-Seismic Category I structures with potential interaction with Seismic Category I structures were evaluated for stability under hurricane loading. For the Turbine

Building, Service Building, Radwaste Building, and Control Building Annex, the total hurricane driving forces were compared with the total seismic driving forces. In all cases, the seismic driving forces govern for stability. For the Reactor Building stack, hurricane wind pressures were compared to tornado wind pressures. The tornado wind pressures envelop the hurricane wind pressures. Therefore, the stability of all Non-Seismic Category I structures with potential interaction with Seismic Category I structures is adequate for hurricane loading.

3H.11.4 Protection of Openings of Seismic Category I Structures

The passage of hurricane generated missiles through openings in the roof slabs and exterior walls is prevented by the use of missile-proof covers and doors, or the trajectory of missiles through the opening is limited by labyrinth walls configured to prevent safety-related substructures and components from being impacted.

In addition, the following features are provided for the UHS/RSW Pump House fan enclosure compartments:

- The air intakes for each fan enclosure compartment are located at the bottom of the enclosure and are configured to eliminate the trajectory of hurricane missiles into the enclosures, thereby preventing damage to safety-related components.

- Heavy steel grating, which is supported by structural steel beams, is installed at the top of each fan enclosure compartment. This grating allows for the passage of air out of the compartment and prevents the intrusion of hurricane missiles. The clear spacing of the grating bars is 15/16 inch to prevent entrance of a 1 inch diameter solid steel sphere missile.

3H.11.5 Summary and Conclusions for Hurricane Design

DCD Seismic Category I structures (i.e. RB, CB, and DGFOT), site-specific Seismic Category I Structures (i.e. UHS/RSW Pump House, RSW piping Tunnels, and DGFOSV), and Non-Seismic Category I structures with potential interaction with Seismic Category I structures are evaluated for hurricane wind and missiles. The results of these evaluations are summarized in Tables 3H.11-1 through 3H.11-5.

As described in these tables, the maximum hurricane wind and missile loads were found to be generally less than the minimum capacity of the structures. The only exceptions were certain panels of site-specific structures that required additional reinforcement. These limited design changes did not change the dimensions of any structure, and did not have an adverse effect on the capability of any structure to fulfill its design function.

Table 3H.11-6: Comparison of RG 1.221 and Tornado Requirements for DCD Structures

Wind type	RG Guide	Wind speed (mph)	Horizontal Missile Velocity (m/s)			Vertical Missile Velocity (m/s)		
			Auto	Pipe	Sphere	Auto	Pipe	Sphere
Hurricane	1.221	210	59.7	46.5	41.1	26	26	26
Tornado	DCD	300	47	47	47	32.9	32.9	32.9

Table 3H.11-7: Comparison of RG 1.221 and RG 1.76 Tornado Requirements for Site-Specific Structures

Wind type	RG Guide	Wind speed (mph)	Horizontal Missile Velocity (m/s)			Vertical Missile Velocity (m/s)		
			Auto	Pipe	Sphere	Auto	Pipe	Sphere
Hurricane	1.221	210	59.7	46.5	41.1	26	26	26
Tornado	1.76 Rev. 1	200	34	34	7	22.8	22.8	4.7

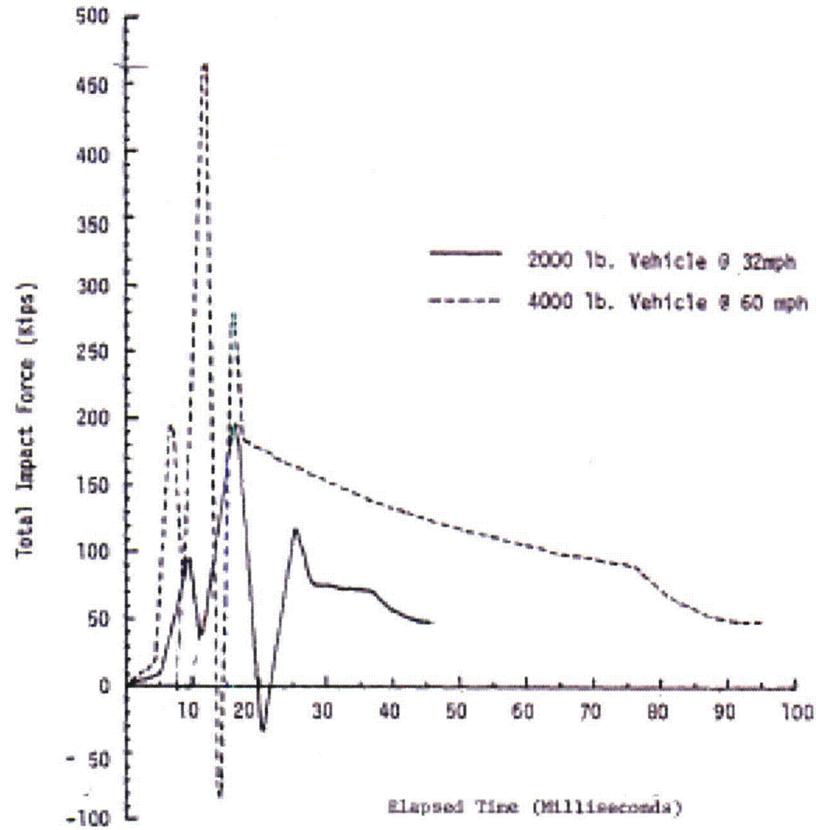


Figure 3H.11-1 Automobile Missile Impact Forcing Function

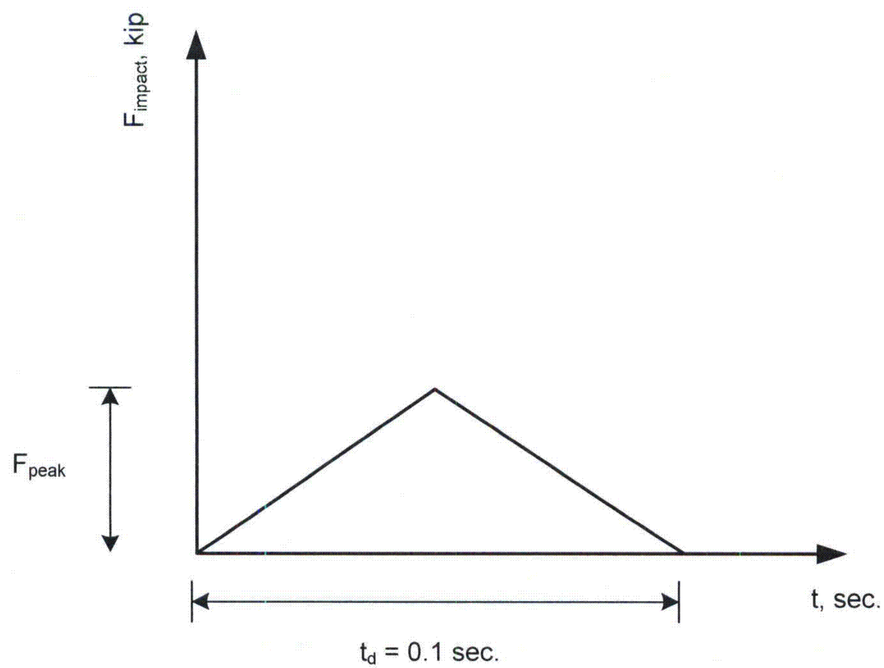
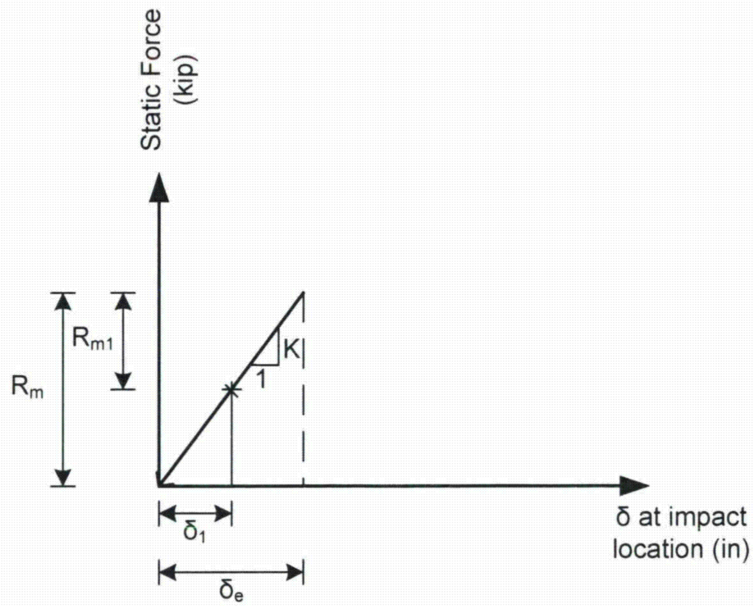
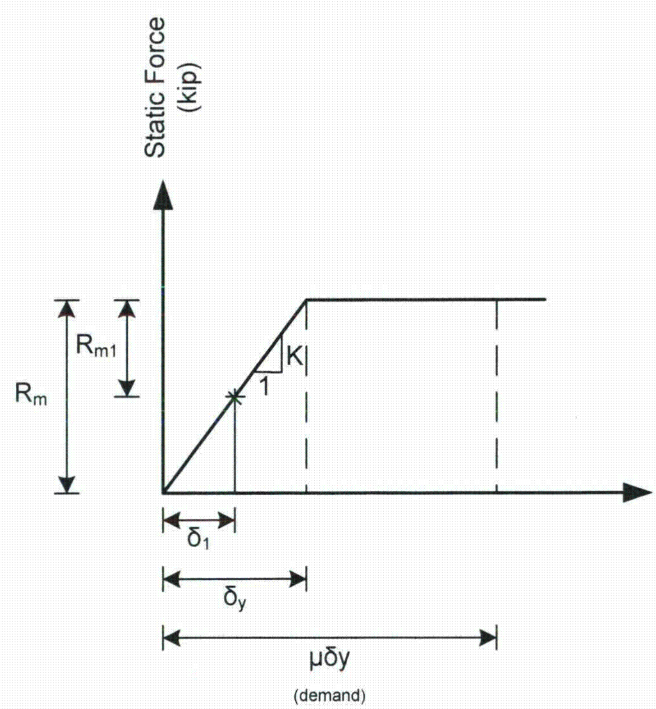


Figure 3H.11-2 Idealized Impact Force Time History for Automobile Missile



(a) – Response is in Elastic Range



(b) – Response Extends into Plastic Range

Figure 3H.11-3 Idealized Load-Deflection Diagrams

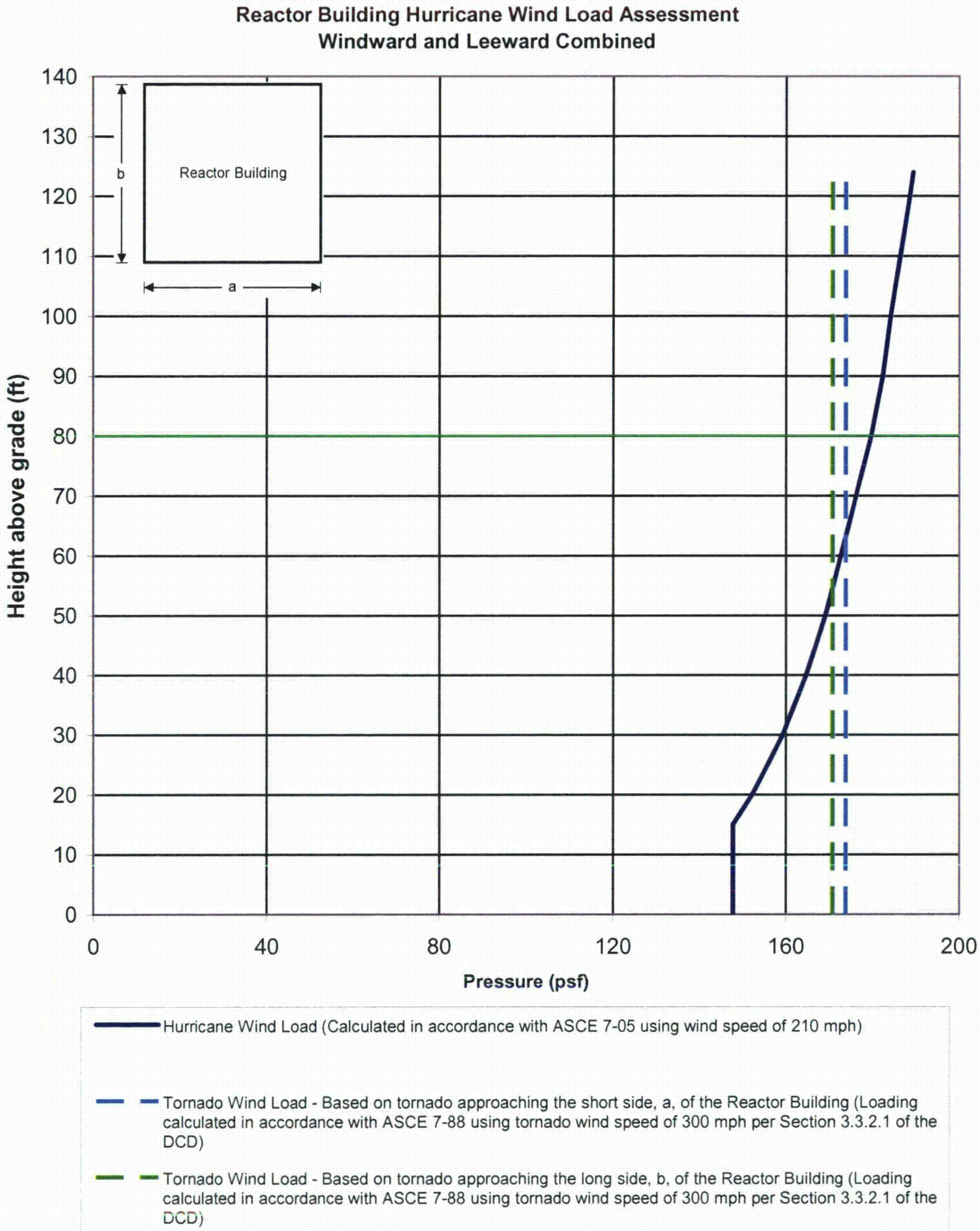


Figure 3H.11-4 Comparison of Hurricane and Tornado Wind Pressures for Reactor Building

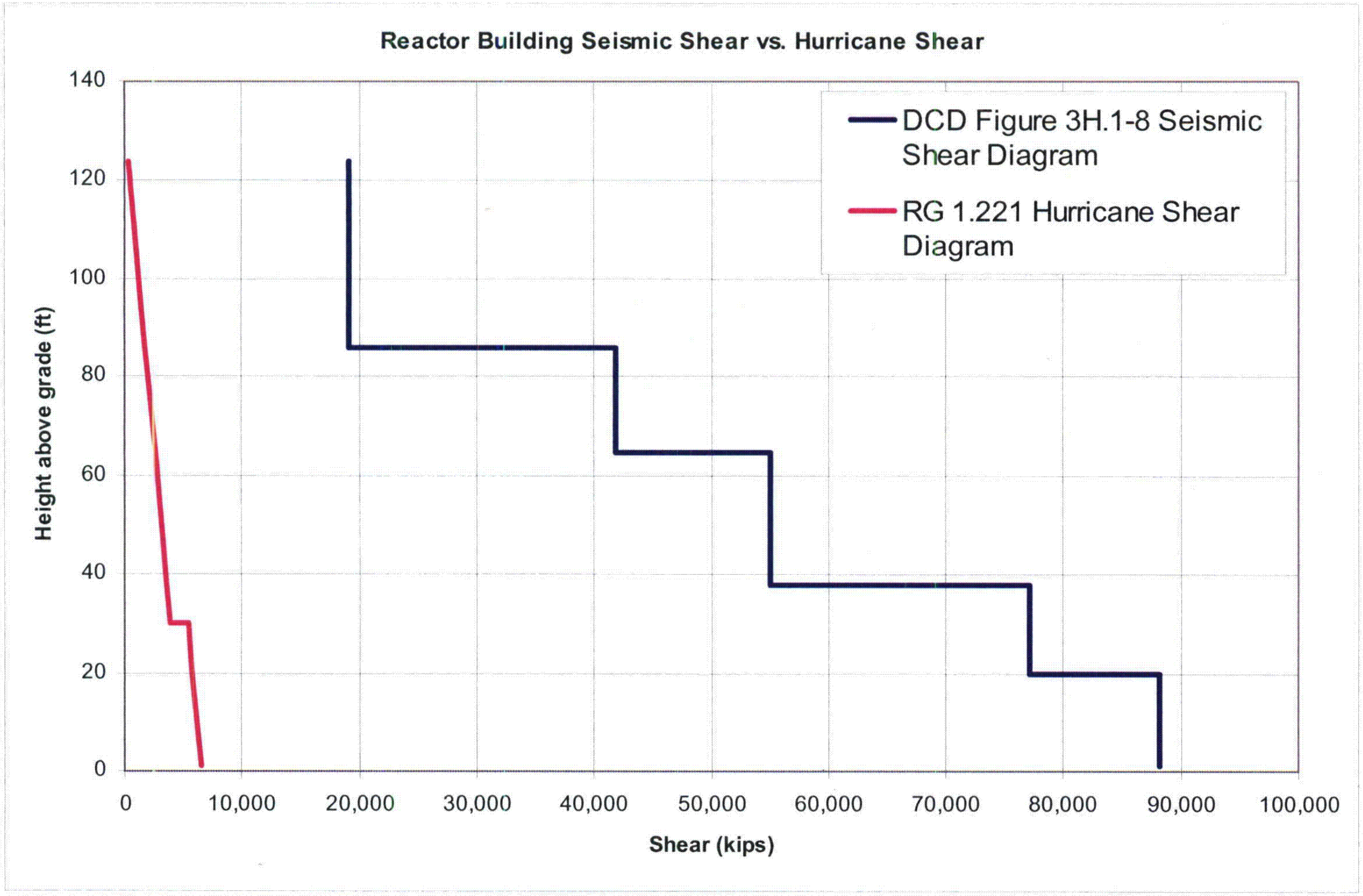


Figure 3H.11-5 Comparison of Hurricane and Seismic Shear Forces for Reactor Building

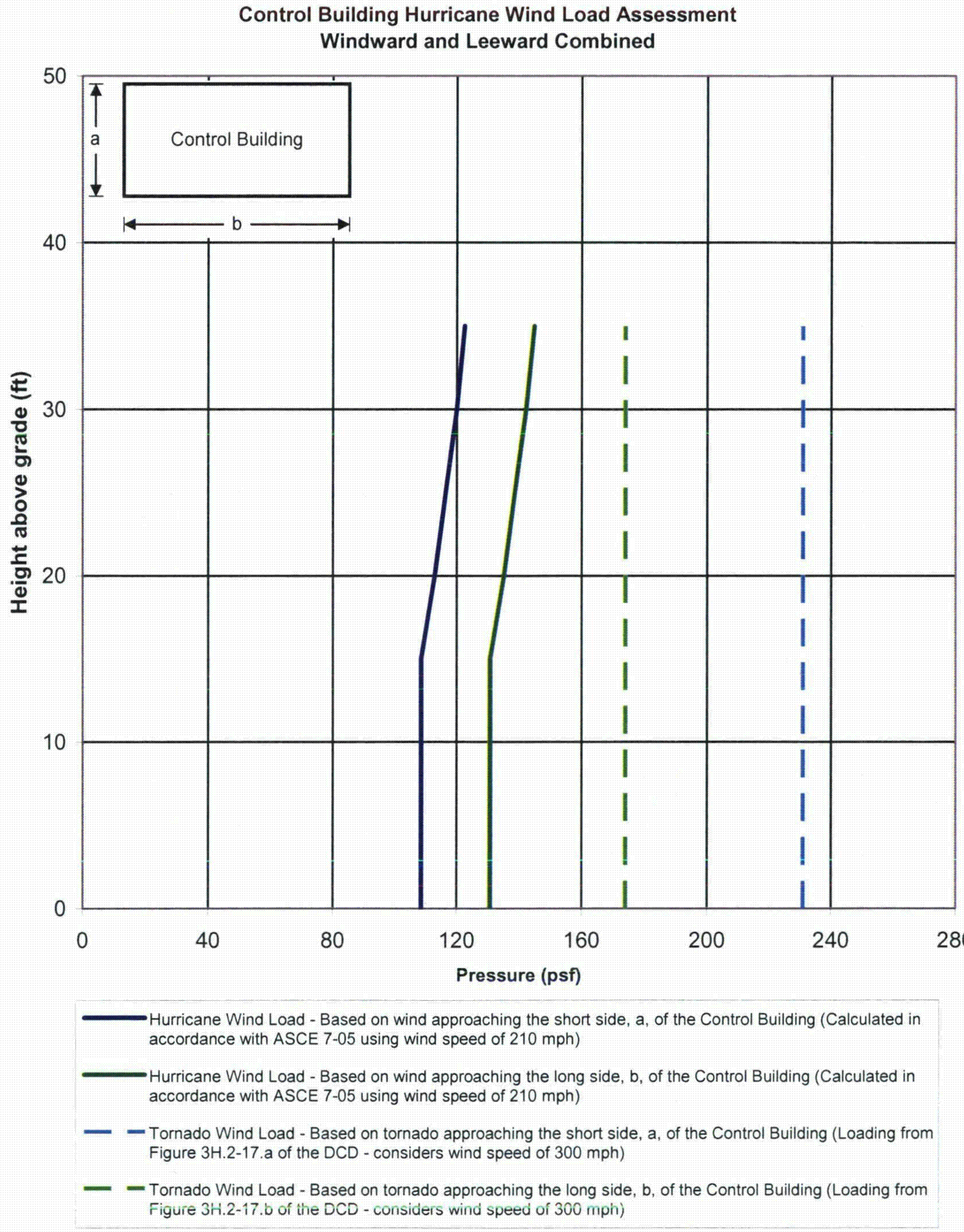


Figure 3H.11-6 Comparison of Hurricane and Tornado Wind Pressures for Control Building

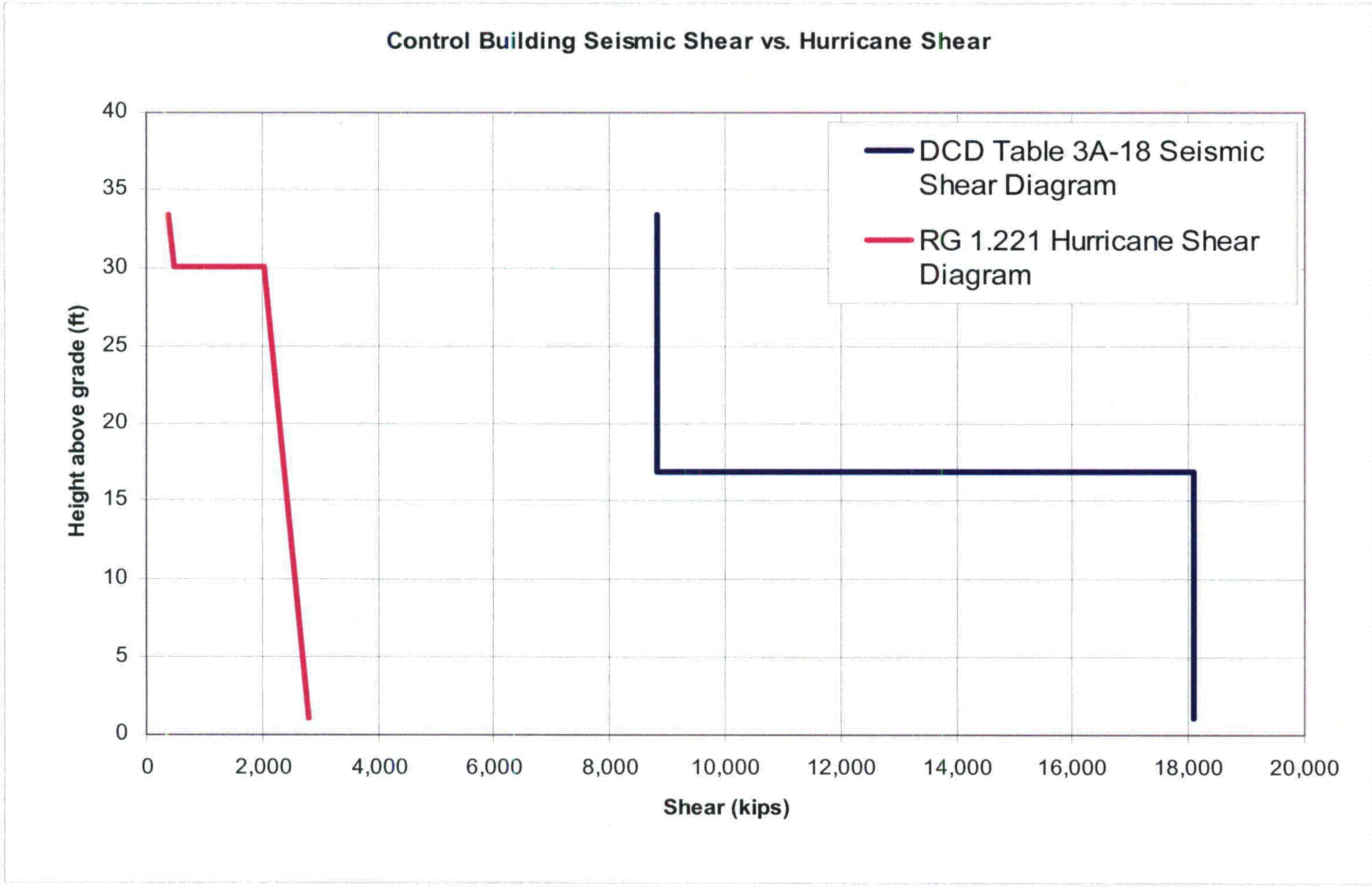


Figure 3H.11-7 Comparison of Hurricane and Seismic Shear Forces for Control Building

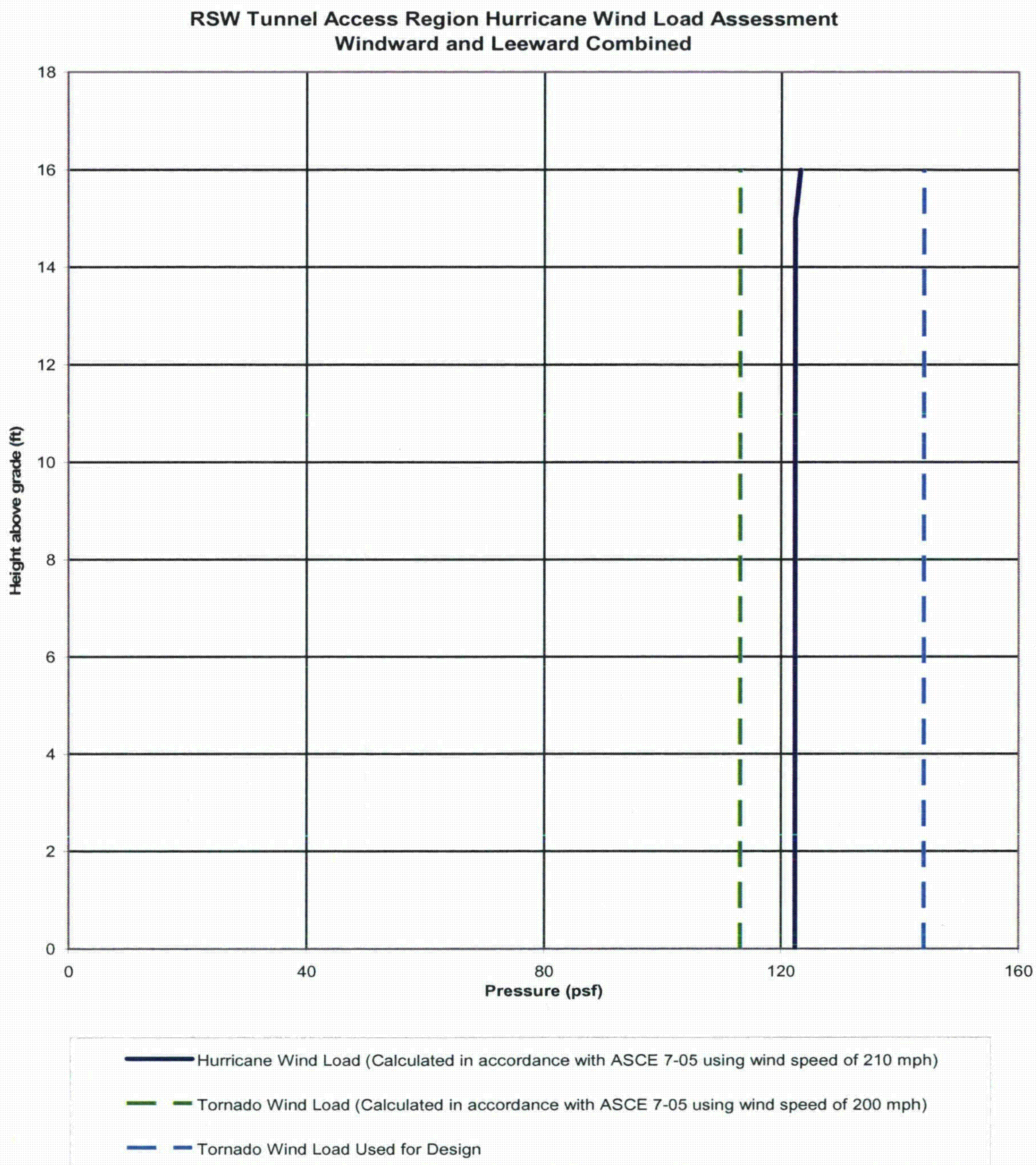


Figure 3H.11-8 Comparison of Hurricane and Tornado Wind Pressures for RSW Piping Tunnels

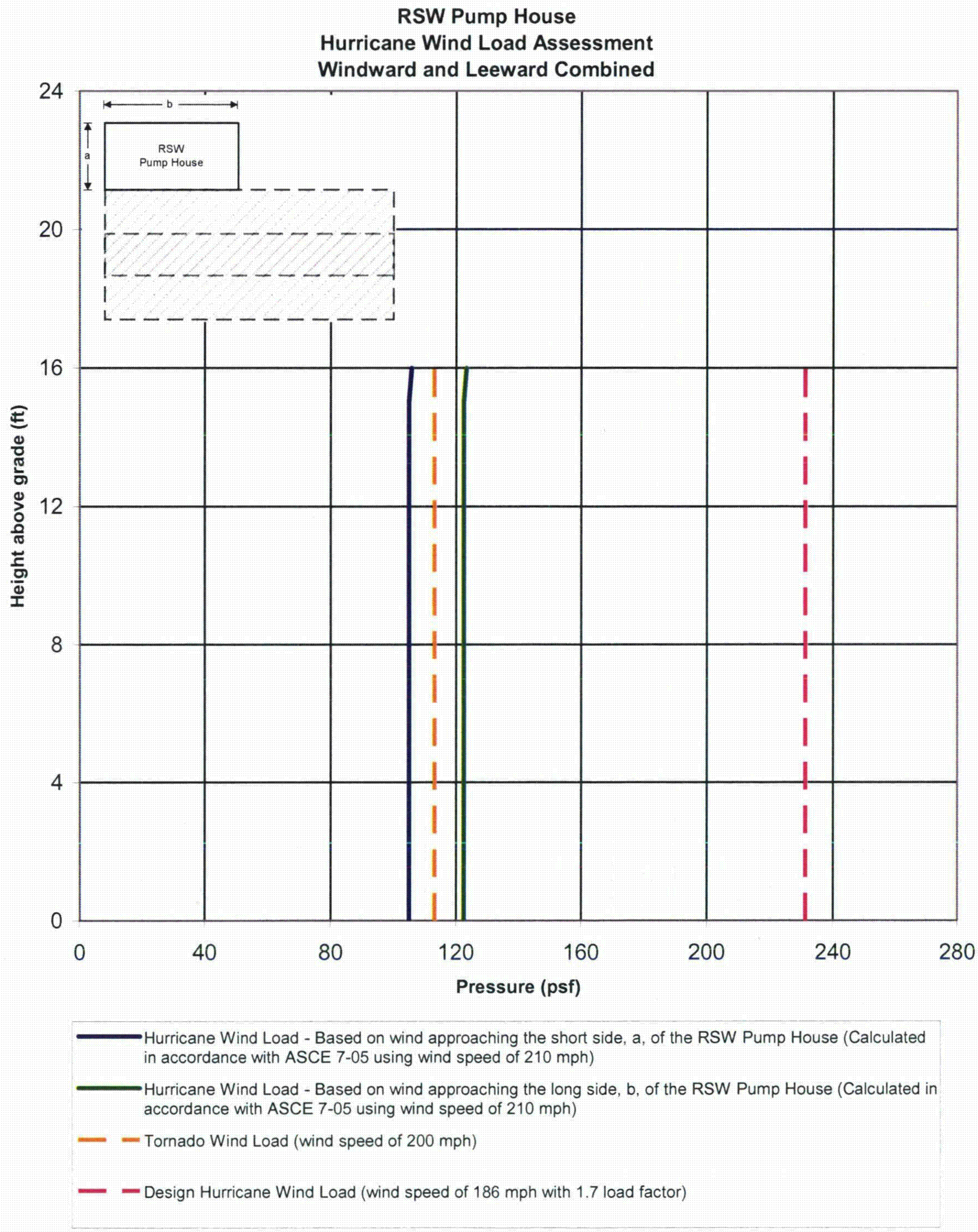


Figure 3H.11-9 Comparison of Hurricane and Tornado Wind Pressures for RSW Pump House

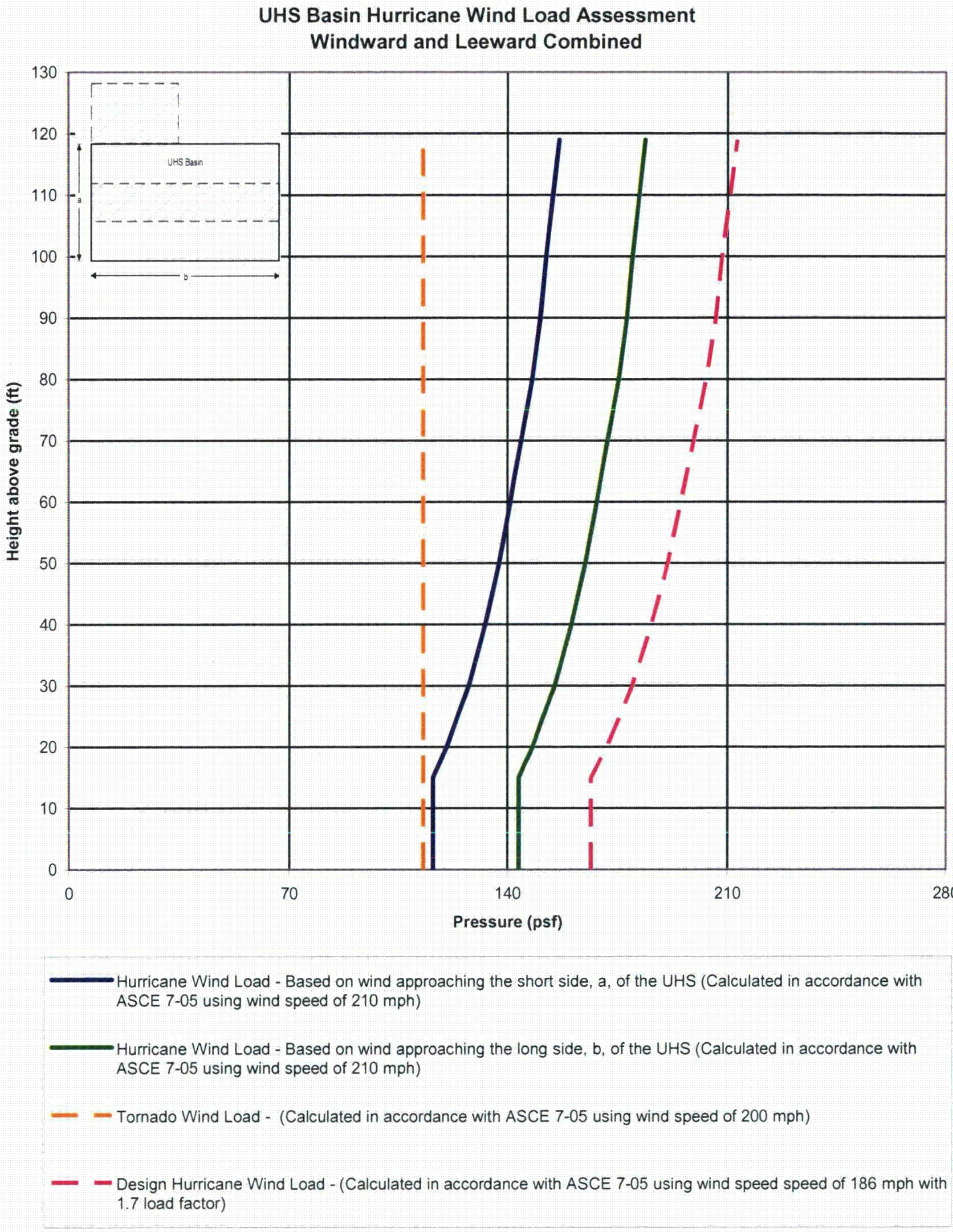


Figure 3H.11-10 Comparison of Hurricane and Tornado Wind Pressures for UHS Basin and Cooling Towers

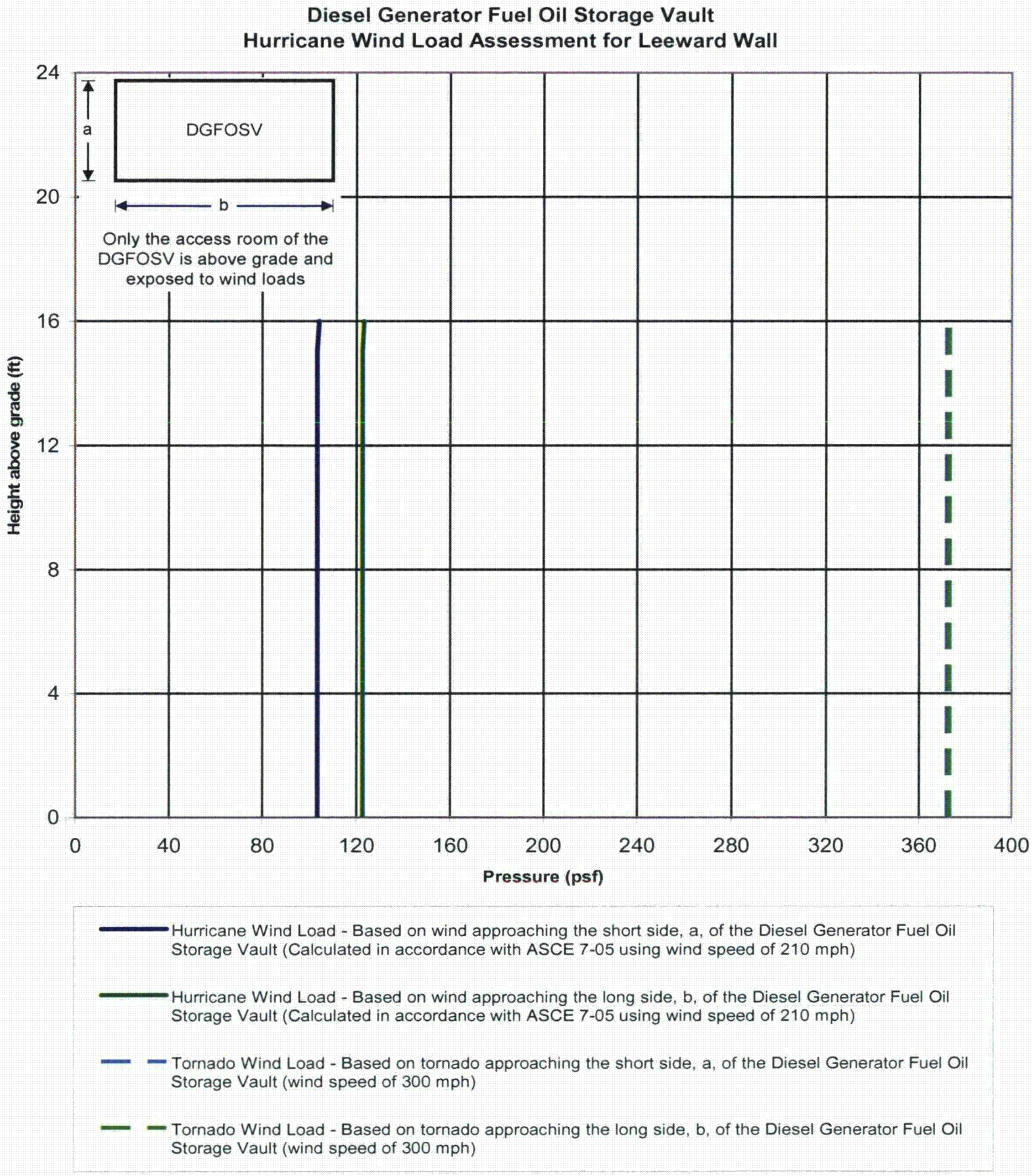


Figure 3H.11-11 Comparison of Hurricane and Tornado Wind Pressures for Diesel Generator Fuel Oil Storage Vaults

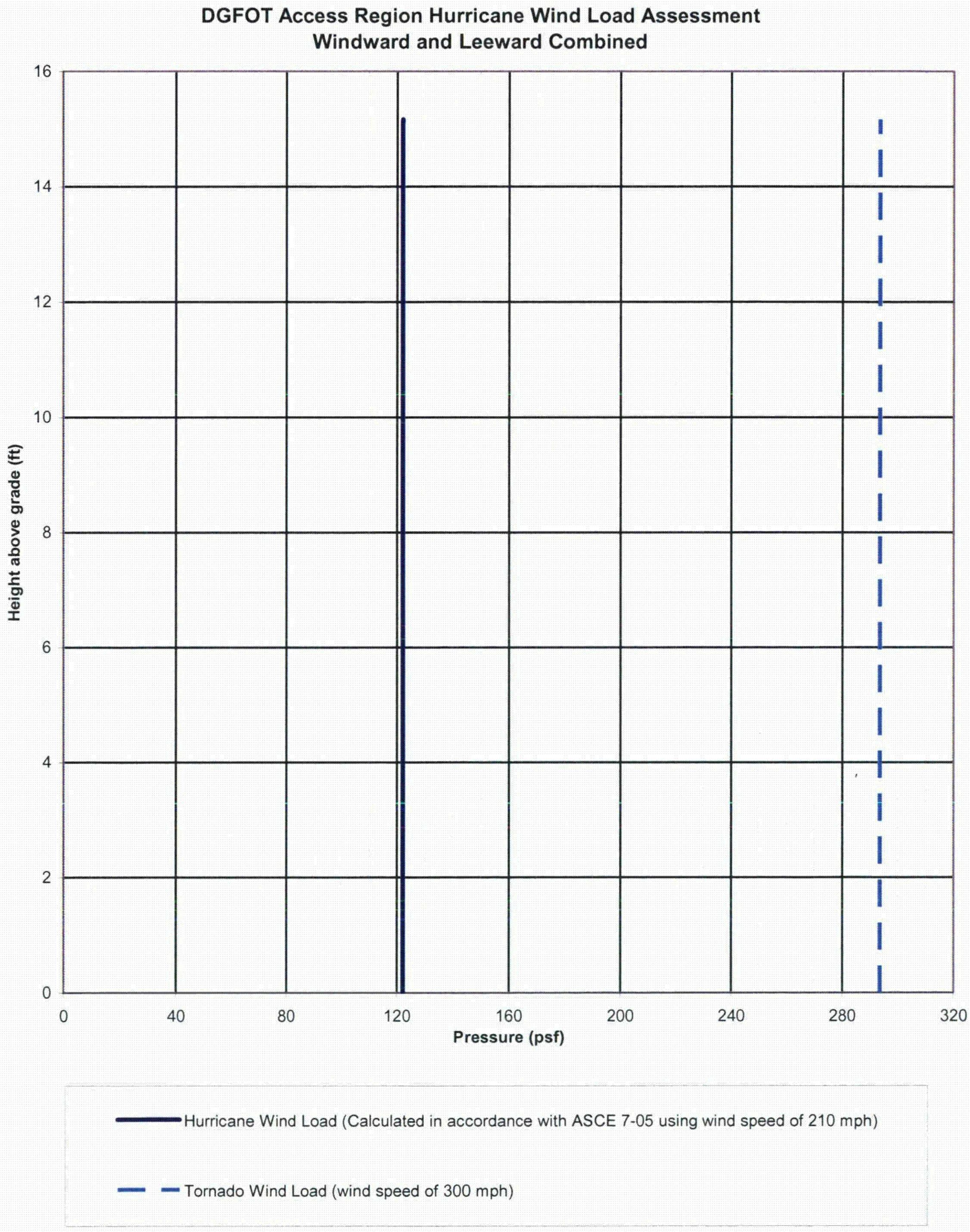


Figure 3H.11-12 Comparison of Hurricane and Tornado Wind Pressures for Diesel Generator Fuel Oil Tunnels