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Statement of

The American Society of Civil Engineers

The Need to Maintain and Modernize the Nation's Electric Grid

United States Senate

Surface Transportation Subcommittee of the Commerce, Science, and Transportation Committee
Field Hearing

October 28, 2013

The American Society of Civil Engineers (ASCE)[1] would like to commend the Senate Committee on Commerce, Science, and Transportation for holding a hearing on the power outages that recently affected Metro North's New Haven line, and the larger issues related to the need for redundancy and improved reliability for the nation's electric grid. Virtually all infrastructure systems from trains and traffic lights, to clean drinking water delivery and wastewater disposal, rely on electricity.

This hearing today, on the eve of the anniversary of Hurricane Sandy, serves as an important reminder of how vulnerable we are, and how quickly one event can have a crippling effect on our communities when we are not adequately prepared.

An Aging Infrastructure System

Our infrastructure is the foundation on which the national economy depends, yet it is taken for granted by most Americans. Most of us do not notice until the road is closed, the water stops working, or the lights go out.

Deteriorating and aging infrastructure is not only an inconvenience, it financially impacts our families, local communities, and our entire country. Our inability to keep our infrastructure in good working condition undermines our nation's competitiveness and economic strength.

As stewards of the nation's infrastructure, civil engineers are responsible for the design, construction, operation and maintenance of our vital public works. With that responsibility comes the obligation to periodically assess the state of the infrastructure, report on its condition and performance, and advise on the steps necessary to improve it.

ASCE's *2013 Report Card for America's Infrastructure*[2] graded the nation's infrastructure a "D+" based on 16 categories and found that the nation needs to invest approximately $3.6 trillion by 2020 across those sectors to maintain the national infrastructure in good condition.

The energy category also received a grade of "D+" in the 2013 Report Card. To update just our energy systems would cost $736 billion between now and 2020. Unfortunately, we are only on track to spend $629 billion during that time period, leaving an investment gap of $107 billion.

The Report Card highlights the fact that, like everything, infrastructure has a lifespan. Good maintenance can extend that lifespan, but not forever, and a lack of maintenance can shorten it. This is not something that happens dramatically overnight, but a gradual worsening over time.

Far too many of our infrastructure systems lack the funding needed for proper maintenance and we continue to see categories that simply are not seeing the investment to improve day to day performance and save money in the long-term. The backlog of projects to maintain and modernize our infrastructure keeps growing.

[1] ASCE was founded in 1852 and is the country's oldest national civil engineering organization. It represents more than 146,000 civil engineers individually in private practice, government, industry, and academia who are dedicated to the advancement of the science and profession of civil engineering. ASCE is a non-profit educational and professional society organized under Part 1.501(c) (3) of the Internal Revenue Code. www.asce.org

[2] www.infrastructurereportcard.org

Conditions of the Nation's Electric Grid

America relies on an aging electrical grid and pipeline distribution systems, some of which originated in the 1880s. This interconnected system includes power plants, a transmission grid, and distribution networks. The transmission grid forms the critical link between generation infrastructure and distribution of electricity to households and businesses. Like our interstate highway system, failing to maintain adequate investment in this national asset has created congestion and the inability for power to flow efficiently from point A to point B.

Aging equipment has resulted in an increasing number of intermittent power disruptions, as well as vulnerability to cyber attacks. Reliability issues are also emerging due to the complex process of rotating in new energy sources and "retiring" older infrastructure. According to a recent report by the Executive Office of the President of the United States, *Economic Benefits of Increasing Electric Grid Resilience to Weather Outages*, severe weather is the leading cause of power outages in the United States[3]. The Edison Electric Institute reports that while transmission system outages do occur, roughly 90 percent of all outages occur along distribution systems[4].

The National Electrical Safety Code[5], which is adopted by all states except California, currently exempts all utility structures less than 60 feet tall, i.e. "distribution poles", from meeting the loads normally required in extreme weather for other structures derived by ASCE standards. [6]Structures greater than 60 feet tall, i.e. transmission structures, must meet these minimum ASCE standards. The only 'storm loading' that structures less than 60 feet tall must meet was last revised in 1941, and the minimum load was actually decreased at that time.

Florida Power and Light (FPL) began a Storm Hardening program in 2007 that included a significant decision to design all structures, regardless of height, according to the ASCE standard. As a result, in May of 2013 it was announced that "*FPL's experience with the recent tropical storms shows main power lines that have been hardened are roughly half as likely to experience an outage during severe weather.*"[7]

Congestion at key points in the electric transmission grid has been rising over the last five years, which raises concerns with distribution, reliability and cost of service. This congestion can also lead to system-wide failures and unplanned outages. These outages are not only an inconvenience, but they put public safety at risk and increase costs to consumers and businesses. The average cost of a one-hour power outage is just over $1,000 for a commercial business.

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[3] Economic Benefits of Increasing Electric Grid Resilience to Weather Outages, Executive Office of the President (of the Unities States), August 2013. p. 3 http://energy.gov/sites/prod/files/2013/08/f2/Grid Resiliency Report_FINAL.pdf

[4] Edison Electric Institute. "Underground vs. Overhead Distribution Wires: Issues to Consider." Washington, D.C. Accessed July 22, 2013.

[5] 2012 National Electrical Safety Code , p. 191 – 203, http://standards.ieee.org/about/nesc/

[6] ASCE 7-10, Minimum Design Loads for Buildings and Other Structures, http://www.asce.org/Product.aspx?id=2147487569&productid=194395836

[7] FPL announces plan to accelerate strengthening of Florida's electric grid during annual storm drill, May 2, 2013, http://www.fpl.com/news/2013/050213.shtml

In the near term, it is expected that energy systems have adequate capacity to meet national demands. From 2011 through 2020, demand for electricity in all regions is expected to increase 8% or 9% in total, based on population growth and projections from the U.S. Energy Information Administration. After 2020, capacity expansion is forecast to be a greater problem, particularly with regard to generation, regardless of the energy resource mix. Excess capacity is expected to decline in a majority of regions, and generation supply could dip below demand by 2040 in every area except the Southwest without prudent investments.[8]

The permitting and siting of needed transmission lines often meets with public resistance, which can result in significant project delays or eventual cancellations while driving up costs. Over three times as many low-voltage line projects, which are typically built in more urban areas, were delayed in 2011, compared to high-voltage lines.[9] The result is that while new transmission lines are anticipated and planned, they are not being built due to permitting issues.

Investment for transmission has been increasing annually since 2001 at a nearly 7% annual growth rate. For local distribution systems, however, national-level investment peaked in 2006 and has since declined to less than the level observed in 1991.[10] Construction spending has decreased in recent years, although the aging of local distribution networks, lack of funding for maintenance, and resulting equipment failures have received public attention and put pressure on some utilities to make improvements.

Economic Implications of Continued Underinvestment

In an effort to examine the broader economy's link to the health of the nation's infrastructure, ASCE released a series of economic studies in 2012 that answers a critical question – what does a "D+" mean for America's economic future? The study on energy, *Failure to Act: The Economic Impact of Current Investment Trends in Electricity Infrastructure* shows that an investment in our nation's generation, transmission, and distribution systems can improve reliability, reduce congestion, and build the foundation for economic growth.

While investments in the transmission sector have been promising since 2005, unless the investment gap is filled, electricity interruptions will rise, increasing costs for households and businesses.

Interruptions may occur in the form of equipment failures, intermittent voltage surges and power quality irregularities due to equipment insufficiency, or blackouts or brownouts as demand exceeds capacity for periods of time. The periods of time can be unpredictable in terms of frequency and length.

By 2020, there is estimated to be an investment shortfall of $107 billion across generation, transmission and distribution systems needed to keep up with the projected demand for energy.

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[8] ASCE*, Failure to Act: Economic Impact of Current Investment Trends in Electricity Infrastructure*, 2012, p. 30.

[9] NERC 2011 Long-Term Reliability Assessment, p. 35

[10] Transmission and distribution numbers from Edison Electric Institute, *2012 Report*, table 9-1; generation investment was estimated from reporting forms of the EIA and Federal Energy Regulatory Commission, with averages applied for investment cost per kilowatt hour for applicable generating technologies

[close up space between lines]

Shortfalls in grid investments (transmission and distribution) are expected to account for almost 90% of the investment gap, equaling nearly $95B in additional dollars needed to modernize the grid.

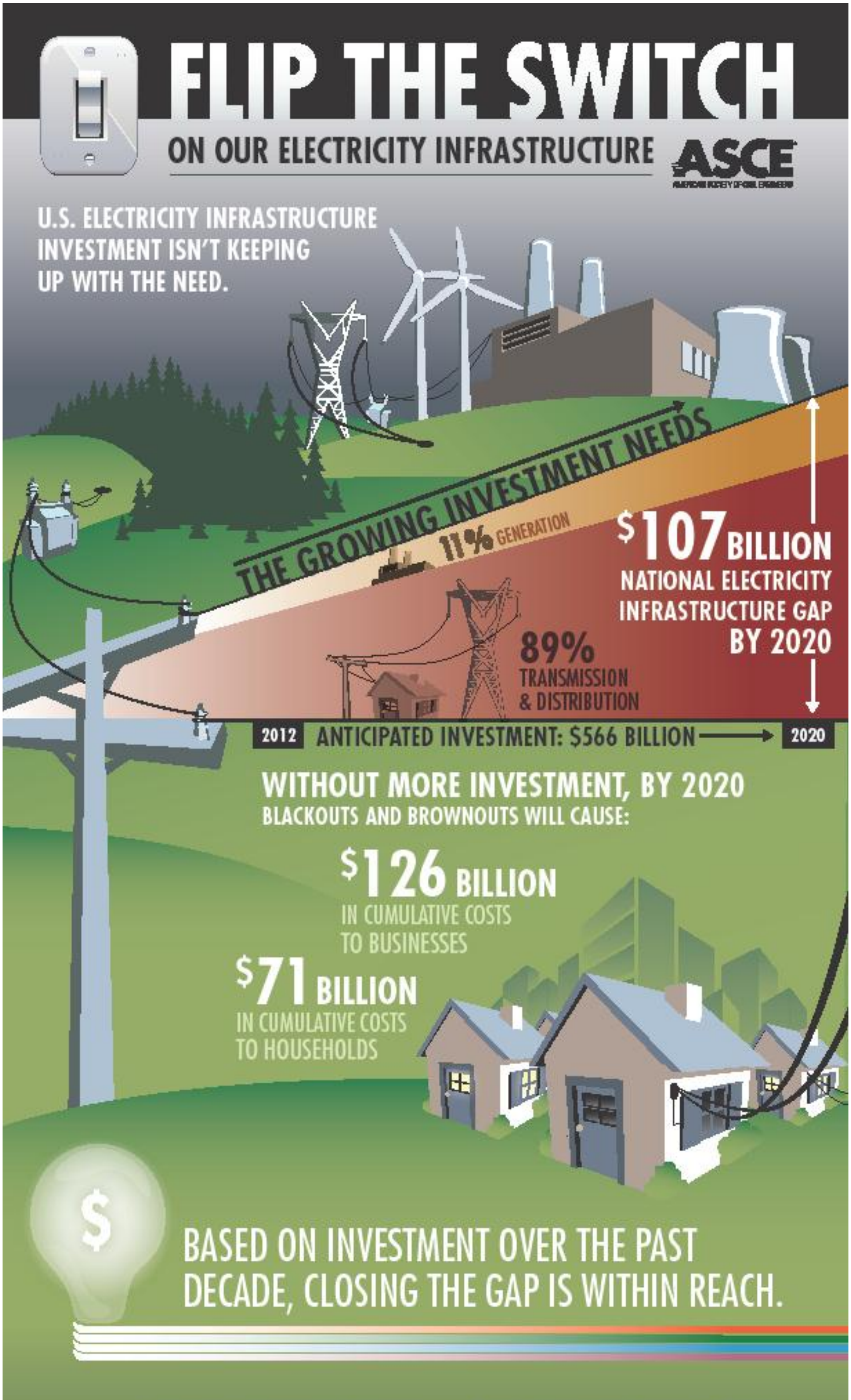
By 2020, the cumulative costs of service interruptions to households will be $71 billion, or $565 per household over the period. Businesses will lose approximately $126 billion.

Thus, the total cost to the U.S. economy will be $197 billion from now until 2020, and annual costs to the economy will average $20 billion by 2020. These costs are not felt equally across the United States, with larger cost increases in the South and West.

Unless investment is accelerated, the performance of the U.S. economy will suffer.

- Americans will lose jobs. The US economy will end up with an average of 529,000 fewer jobs than would otherwise occur by the year 2020. Impacts will fall heavily on the retail and consumer spending sectors with a 40% drop in employment in retail, restaurants, and bars as households spend more on electricity.
- Personal Income Will Fall: Personal income will fall by a total of $656 billion by 2020.
- Business productivity will go down. GDP is expected to fall by a total of $496 billion by 2020.
- U.S. exports will fall. The US will lose $10 billion in exports in 2020, which could grow to $40 billion by 2040. The hardest hit industrial sectors will be:
  - Aerospace
  - Electronic components
  - Air transport

If we invest an additional $11 billion per year from now until 2020, we can prevent these losses. This investment gap is not insurmountable.



FLIP THE SWITCH
ON OUR ELECTRICITY INFRASTRUCTURE
ASCE
U.S. ELECTRICITY INFRASTRUCTURE INVESTMENT ISN'T KEEPING UP WITH THE NEED.
THE GROWING INVESTMENT NEEDS
11% GENERATION
$107 BILLION
NATIONAL ELECTRICITY INFRASTRUCTURE GAP BY 2020
89% TRANSMISSION & DISTRIBUTION
2012 ANTICIPATED INVESTMENT: $566 BILLION 2020
WITHOUT MORE INVESTMENT, BY 2020
BLACKOUTS AND BROWNOUTS WILL CAUSE:
$126 BILLION
IN CUMULATIVE COSTS TO BUSINESSES
$71 BILLION
IN CUMULATIVE COSTS TO HOUSEHOLDS
BASED ON INVESTMENT OVER THE PAST DECADE, CLOSING THE GAP IS WITHIN REACH.

Moving Forward to Modernize our Nation's Electric Grid

There are a number of solutions that can help ensure that the nation's interconnected electric grid remains reliable and efficient:

- Adopt a national energy policy that anticipates and adapts to future energy needs and promotes the development of sustainable energy sources, while increasing the efficiency of energy use, promoting conservation, and decreasing dependence on fossil fuels as sources are depleted. Such a policy must be adaptable and scalable to local and state policy.
- Provide mechanisms for timely approval of transmission lines to minimize the time from preliminary planning to operation.
- Design and construct additional transmission grid infrastructure to efficiently deliver power from remote geographic generation sources to developed regions that have the greatest demand requirements.
- Encourage the adoption of the same minimum design methods and storm loads for distribution poles as are used for transmission structures derived by ASCE standards.
- Continue research to improve and enhance the nation's transmission and generation infrastructure as well as the deployment of technologies such as smart grid, real-time forecasting for transmission capacity, and sustainable energy generation which provide a reasonable return on investment.

Conclusion

Electricity is the basis for a competitive U.S. economy and contributes to the success or failure of American businesses. Our quality of life also depends on access to affordable and reliable energy.

Looking ahead in the 21st century, our nation is increasingly adopting technologies that will automate our electric grid and help manage congestion points. In turn, this will require robust integration of transmission and distribution systems so that the network continues to be reliable. Investments in the grid, select pipeline systems, and new technologies have helped alleviate congestion problems in recent years, but capacity and an aging system will be issues in the long term.

To compete in the global economy, improve our quality of life and raise our standard of living, we must maintain and modernize America's infrastructure and the electric grid.

Appendix

Accredited
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Committee
C2-2012

National Electrical Safety Code®

Secretariat
Institute of Electrical and Electronics Engineers, Inc.

Approved 14 April 2011
Institute of Electrical and Electronics Engineers, Inc.

Approved 3 June 2011
American National Standards Institute

2012 Edition

Abstract: This Code covers basic provisions for safeguarding of persons from hazards arising from the installation, operation, or maintenance of (1) conductors and equipment in electric supply stations, and (2) overhead and underground electric supply and communication lines. It also includes work rules for the construction, maintenance, and operation of electric supply and communication lines and equipment. The Code is applicable to the systems and equipment operated by utilities, or similar systems and equipment, of an industrial establishment or complex under the control of qualified persons. This Code consists of the introduction, definitions, grounding rules, list of referenced and bibliographic documents, and Parts 1, 2, 3, and 4 of the 2012 Edition of the National Electrical Safety Code.

Keywords: communications industry safety; construction of communication lines; construction of electric supply lines; electrical safety; electric supply stations; electric utility stations; high-voltage safety; operation of communications systems; operation of electric supply systems; power station equipment; power station safety; public utility safety; safety work rules; underground communication line safety; underground electric line safety

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Section 25.
Loadings for Grades B and C

250. General loading requirements and maps

A. General

1. It is necessary to assume the wind and ice loads that may occur on a line. Three weather loadings are specified in Rules 250B, 250C, and 250D. Where all three rules apply, the required loading shall be the one that has the greatest effect.

2. Where construction or maintenance loads exceed those imposed by Rule 250A1, the assumed loadings shall be increased accordingly. When temporary loads, such as lifting of equipment, stringing operations, or a worker on a structure or its component, are to be imposed on a structure or component, the strength of the structure or component should be taken into account or other provisions should be made to limit the likelihood of adverse effects of structure or component failure.

   NOTE: Other provisions could include cranes that can support the equipment loads, guard poles and spotters with radios, and stringing equipment capable of promptly halting stringing operations.

3. It is recognized that loadings actually experienced in certain areas in each of the loading districts may be greater, or in some cases, may be less than those specified in these rules. In the absence of a detailed loading analysis, using the same respective statistical methodologies used to develop the maps in Rule 250C or 250D, no reduction in the loadings specified therein shall be made without the approval of the administrative authority.

4. The structural capacity provided by meeting the loading and strength requirements of Sections 25 and 26 provides sufficient capability to resist earthquake ground motions.

B. Combined ice and wind district loading

Four general degrees of district loading due to weather conditions are recognized and are designated as heavy, medium, light, and warm island loading. Figure 250-1 shows the districts where these loadings apply. Warm island loading applies to Hawaii and other island systems located in the range of 0 to 25 degrees latitude, north or south.

NOTE: The localities are classified in the different loading districts according to the relative simultaneous prevalence of the wind velocity and thickness of ice that accumulates on wires. Light loading is for places where little, if any, ice accumulates on wires. In the warm island loading zone, cold temperatures and ice accumulation on wires only occurs at high altitudes.

Table 250-1 shows the radial thickness of ice and the wind pressures to be used in calculating loads. Ice is assumed to weigh 913 kg/m^3 (57 lb/ft^3).

C. Extreme wind loading

If no portion of a structure or its supported facilities exceeds 18 m (60 ft) above ground or water level, the provisions of this rule are not required, except as specified in Rule 261A1c, 261A2e, or 261A3d. Where a structure or its supported facilities exceeds 18 m (60 ft) above ground or water level the structure and its supported facilities shall be designed to withstand the extreme wind load associated with the Basic Wind Speed, as specified by Figure 250-2. The wind pressures calculated shall be applied to the entire structure and supported facilities without ice. The following formula shall be used to calculate wind load.

Load in newtons $= 0.613 \cdot (V_{m/s})^2 \cdot k_z \cdot G_{RF} \cdot I \cdot C_f \cdot A(m^2)$

Load in pounds $= 0.00256 \cdot (V_{mi/h})^2 \cdot k_z \cdot G_{RF} \cdot I \cdot C_f \cdot A(ft^2)$

where

0.613 0.00256	Velocity-pressure numerical coefficient reflects the mass density of air for the standard atmosphere, i.e., temperature of 15 °C (59 °F) and sea level pressure of 760 mm (29.92 in) of mercury. The numerical coefficient 0.613 metric (0.00256 customary) shall be used except where sufficient climatic data are available to justify the selection of a different value of this factor for a design application.
k_z	Velocity pressure exposure coefficient, as defined in Rule 250C1, Table 250-2
V	Basic wind speed, 3 s gust wind speed in m/s at 10 m (mi/h at 33 ft) aboveground, Figure 250-2
G_{RF}	Gust response factor, as defined in Rule 250C2
I	Importance factor, 1.0 for utility structures and their supported facilities
C_f	Force coefficient (shape factor). As defined in Rules 251A2 and 252B
A	Projected wind area, m^2 (ft^2)

The wind pressure parameters (k_z, V, and G_{RF}) are based on open terrain with scattered obstructions (Exposure Category C as defined in ASCE 7-05). Exposure Category C is the basis of the NESC extreme wind criteria. Topographical features such as ridges, hills, and escarpments may increase the wind loads on site-specific structures. A Topographic Factor, K_{zt}, from ASCE 7-05, may be used to account for these special cases.

NOTE: Special wind regions—Although the wind speed map is valid for most regions of the country, special wind regions indicated on the map are known to have wind speed anomalies. Winds blowing over mountain ranges or through gorges or river valleys in these special regions can develop speeds that are substantially higher than the values indicated on the map.

1. Velocity pressure exposure coefficient, k_z

   The velocity pressure exposure coefficient, k_z, is based on the height, h, to the center-of-pressure of the wind area for the following load applications:

   a. k_z for the structure is based on 0.67 of the total height, h, of the structure above ground line.

      NOTE: In Table 250-2, for h ≤ 75 m (250 ft), the structure k_z values are adjusted for the wind load to be determined at the center-of-pressure of the structure assumed to be at 0.67 h. The wind pressure is assumed uniformly distributed over the structure face normal to the wind.

   b. k_z for the wire is based on the height, h, of the wire at the structure.

      In special terrain conditions (i.e., mountainous terrain and canyon) where the height of the wire aboveground at mid-span may be substantially higher than at the structure, engineering judgment may be used in determining an appropriate value for the wire k_z.

   c. k_z for a specific height on a structure or component is based on the height, h, to the center-of-pressure of the wind area being considered.

      The formulas shown in Table 250-2 shall be used to determine all values of k_z.

      EXCEPTION: The selected values of k_z tabulated in Table 250-2 may be used instead of calculating the values.

2. Gust response factor, G_{RF}

   a. The structure gust response factor, G_{RF}, is determined using the total structure height, h. When calculating a wind load at a specific height on a structure, the structure gust response factor, G_{RF}, determined using the total structure height, h, shall be used.

   b. The wire gust response factor is determined using the height of the wire at the structure, h, and the design wind span, L. Wire attachment points that are 18 m (60 ft) or less above ground or water level must be considered if the total structure height is greater than 18 m (60 ft) above ground or water.

In special terrain conditions (i.e., mountainous terrain and canyon) where the height of the wire aboveground at mid-span may be substantially higher than at the attachment point, engineering judgment may be used in determining an appropriate value for the wire G_{RF}.

c. The gust response factor, G_{RF}, to be used on components, such as antennas, transformers, etc., shall be the structure gust response factor determined in Rule 250C2a.

Selected values of the structure and wire gust response factors are tabulated in Table 250-3. The structure and wire gust response factors may also be determined using the formulas in Table 250-3. For values of $h > 75$ m (250 ft) and $L > 600$ m (2000 ft), the G_{RF} shall be determined using the formulas in Table 250-3.

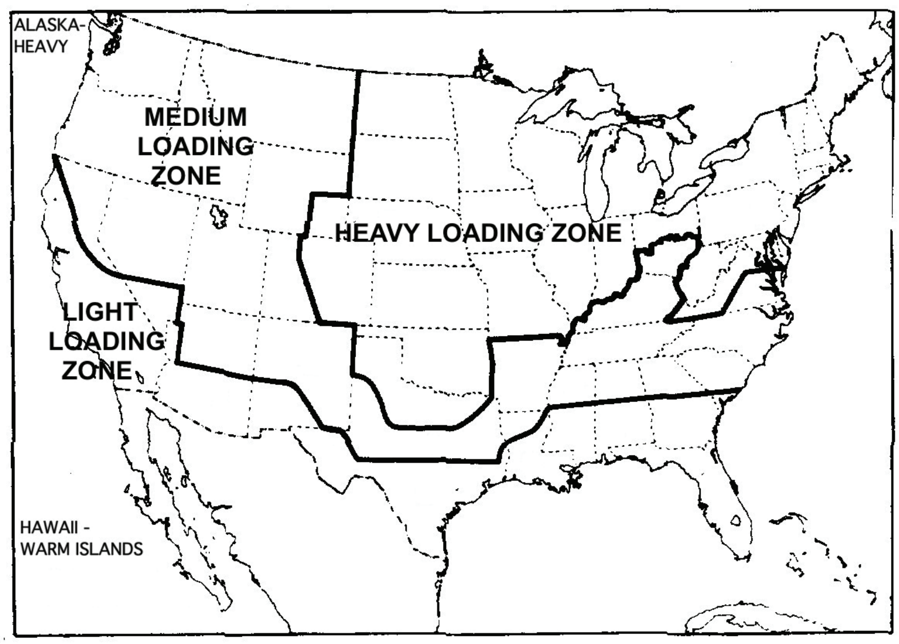
NOTE: Where structure heights are 50 m (165 ft) or less and spans are 600 m (2000 ft) or less, the combined product of k_z and G_{RF} may be conservatively taken as 1.15 if it is desired to simplify calculations.

D. Extreme ice with concurrent wind loading

If no portion of a structure or its supported facilities exceeds 18 m (60 ft) aboveground or water level, the provisions of this rule are not required. Where a structure or its supported facilities exceeds 18 m (60 ft) aboveground or water level, the structure and its supported facilities shall be designed to withstand the ice and wind load associated with the Uniform Ice Thickness and Concurrent Wind Speed, as specified by Figure 250-3. The wind pressures for the concurrent wind speed shall be as indicated in Table 250-4. The wind pressures calculated shall be applied to the entire structure and supported facilities without ice and to the iced wire diameter determined in accordance with Rule 251. No loading is specified in this rule for extreme ice with concurrent wind loading for warm islands located from 0 to 25 degrees latitude, north or south.

Ice is assumed to weigh 913 kg/m^3 (57 lb/ft^3).

1. For Grade B, the radial thickness of ice from Figure 250-3 shall be multiplied by a factor of 1.00.
2. For Grade C, the radial thickness of ice from Figure 250-3 shall be multiplied by a factor of 0.80.
3. The concurrent wind shall be applied to the projected area resulting from Rules 250D1 and 250D2 multiplied by a factor of 1.00.



The Warm Island Loading District includes American Samoa, Guam, Hawaii, Puerto Rico, Virgin Islands, and other islands located from 0 to 25 degrees latitude, north or south.

Figure 250-1—General loading map of United States with respect to loading of overhead lines

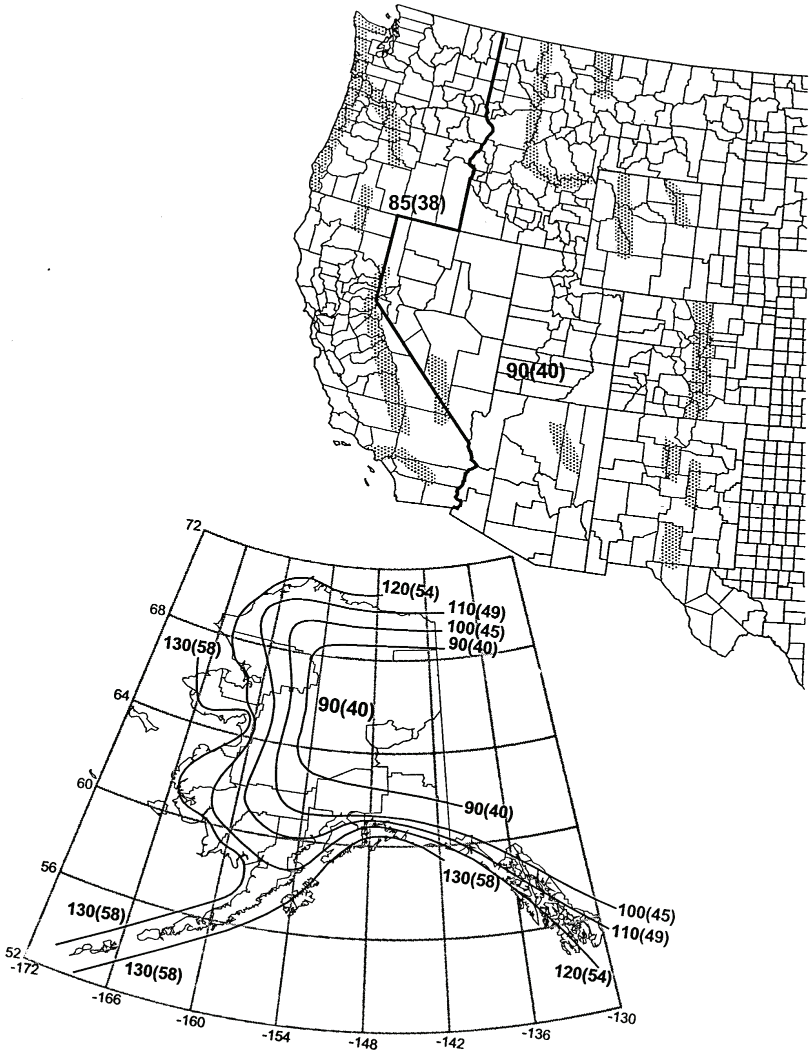


Figure 250-2(a)—Basic wind speeds

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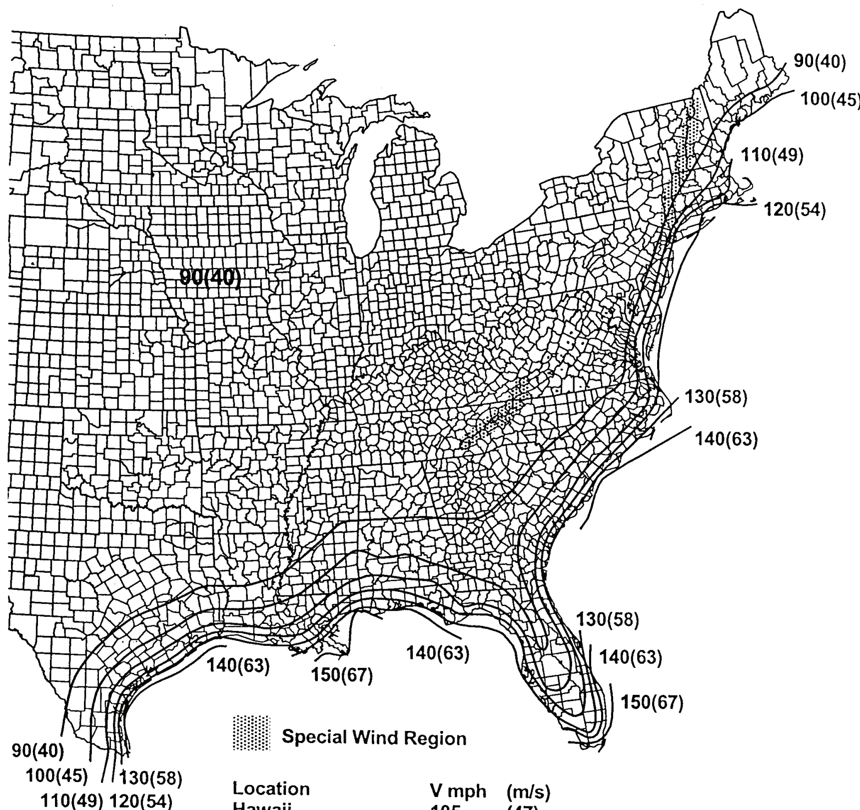

Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	145	(65)
Guam	170	(76)
Virgin Islands	145	(65)
American Samoa	125	(56)

Notes:
1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure C category.
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

Figure 250-2(b)—Basic wind speeds

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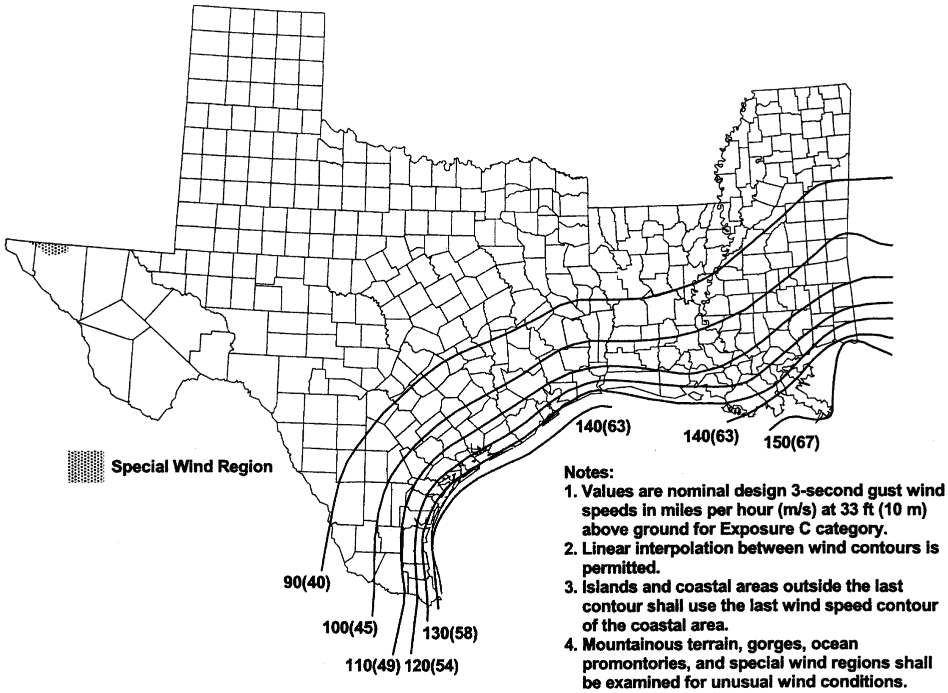

Figure 250-2(c)—Western Gulf of Mexico hurricane coastline

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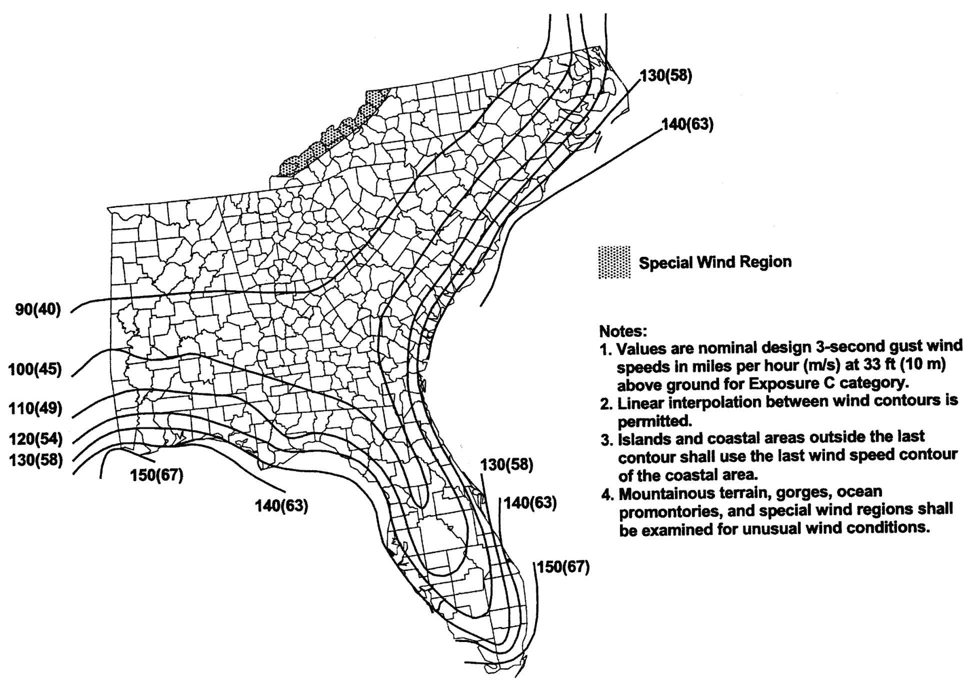

Figure 250-2(d)—Eastern Gulf of Mexico and southeastern U.S. hurricane coastline

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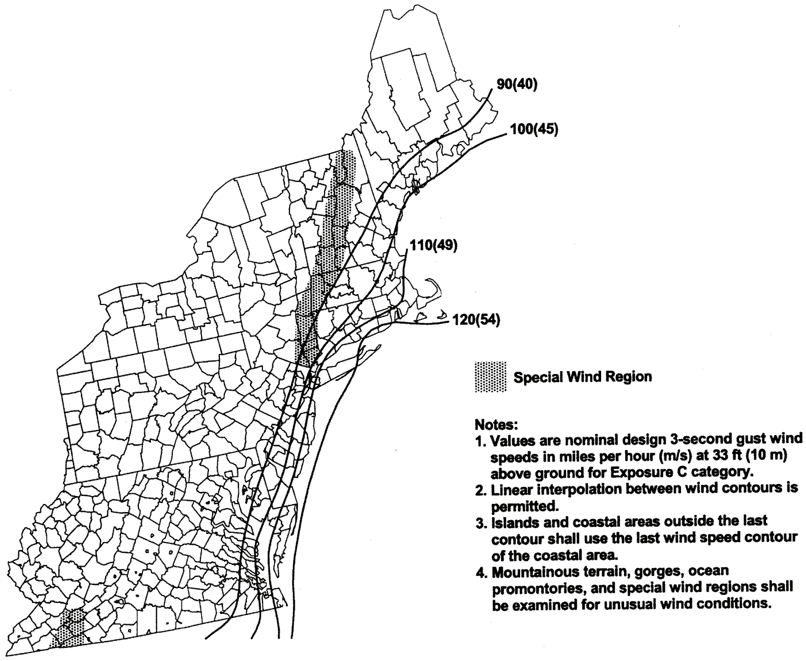

Figure 250-2(e)—Mid and northern Atlantic hurricane coastline

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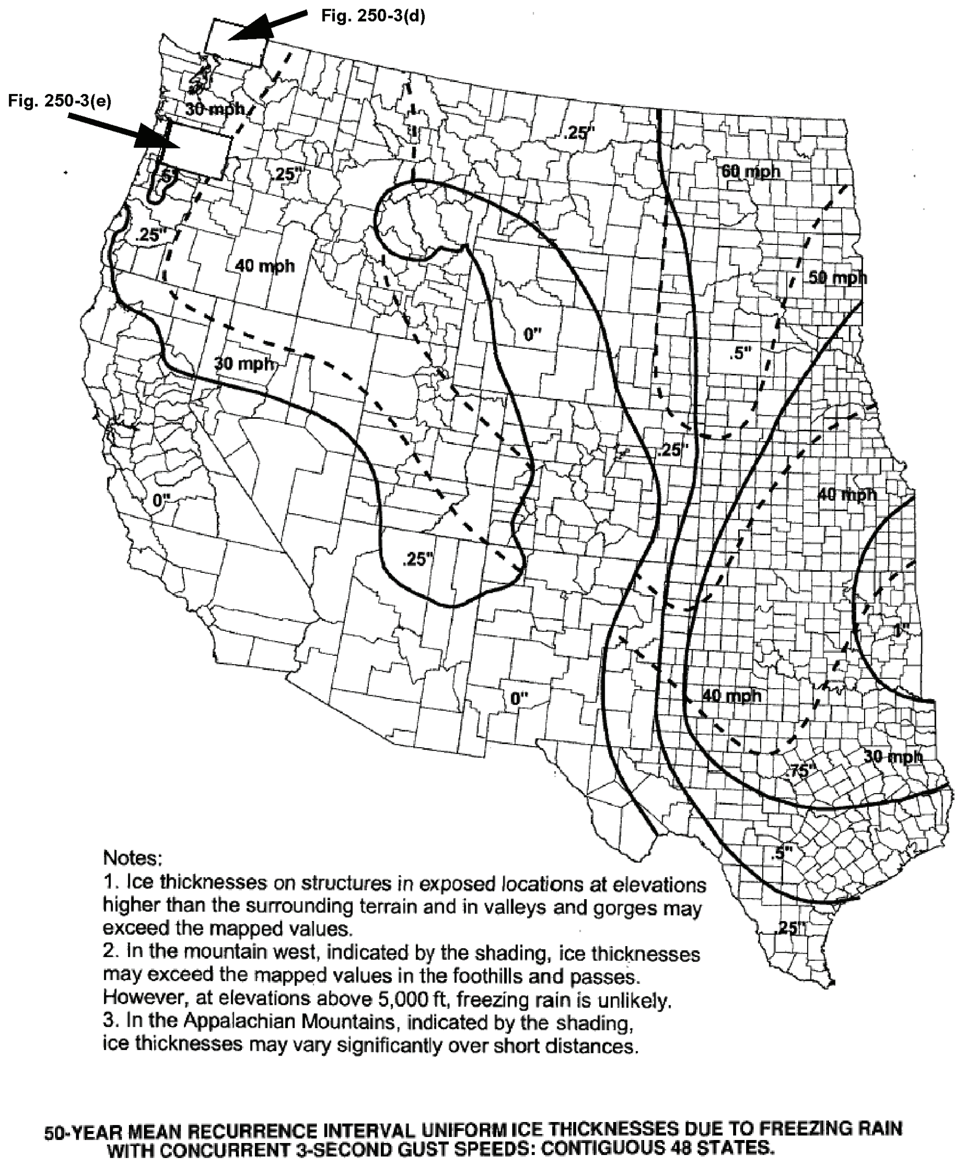

Figure 250-3(a)—Uniform ice thickness with concurrent wind

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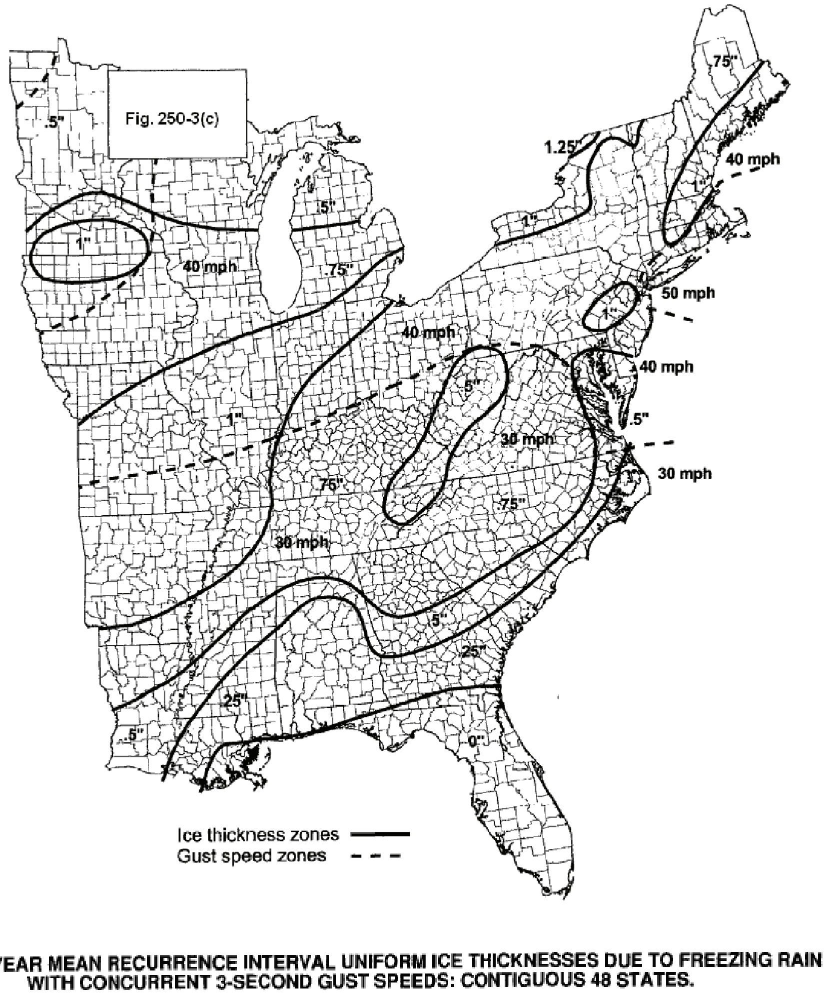

Figure 250-3(b)—Uniform ice thickness with concurrent wind

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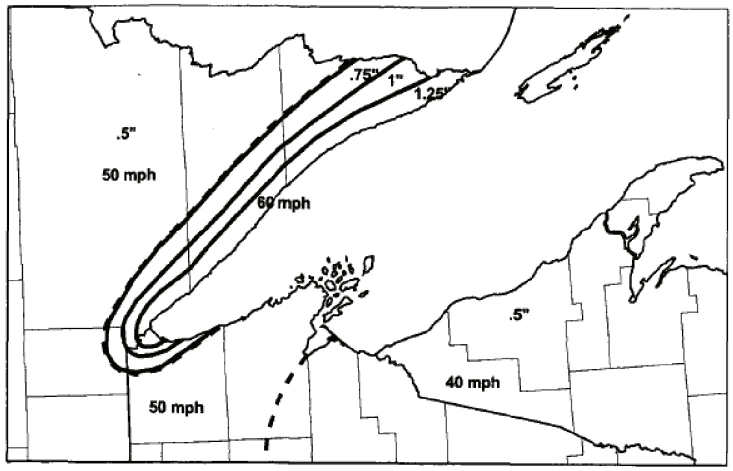

LAKE SUPERIOR DETAIL

Figure 250-3(c)—Uniform ice thickness with concurrent wind

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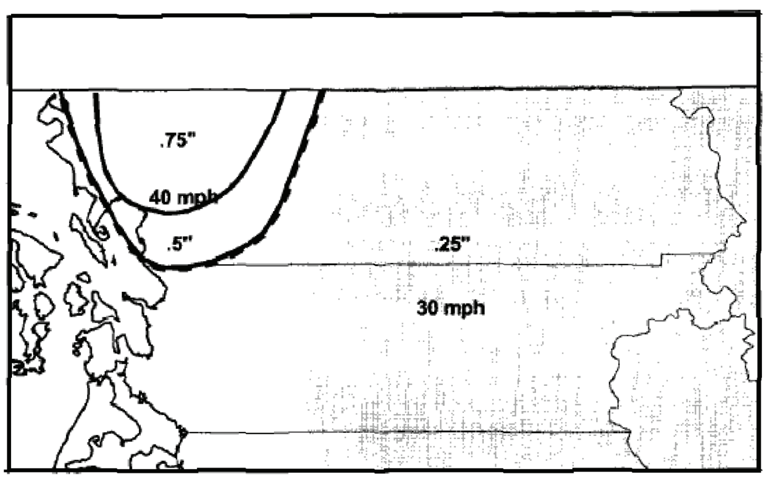

FRASER VALLEY, WASHINGTON DETAIL

Figure 250-3(d)—Uniform ice thickness with concurrent wind

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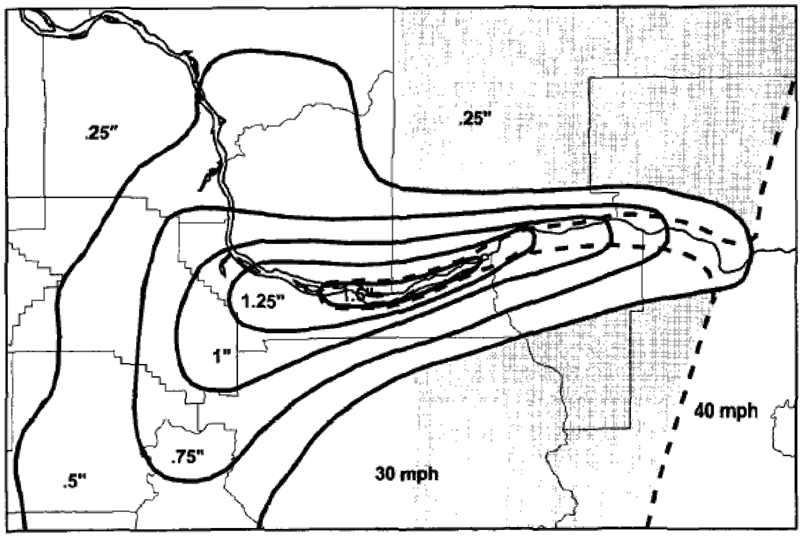

COLUMBIA RIVER GORGE, WASHINGTON DETAIL

Figure 250-3(e)—Uniform ice thickness with concurrent wind

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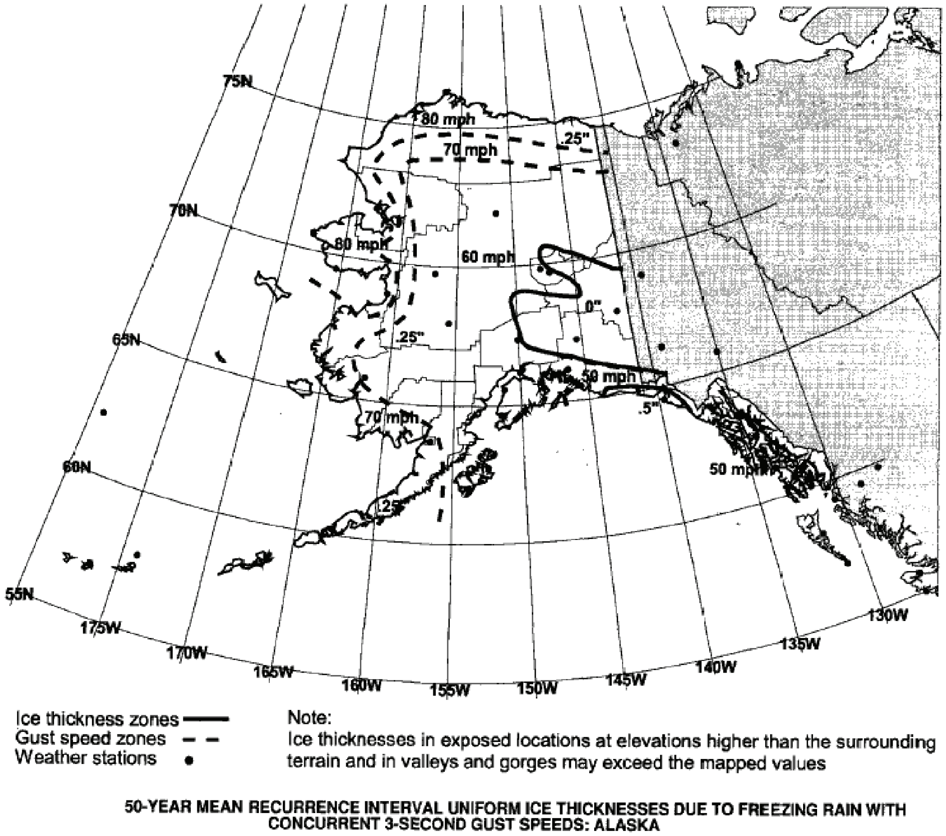

Figure 250-3(f)—Uniform ice thickness with concurrent wind

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Table 250-1—Ice, wind pressures, and temperatures

	Loading districts (for use with Rule 250B)					Extreme wind loading (for use with Rule 250C)	Extreme ice loading with concurrent wind (for use with Rule 250D)
	Heavy see Figure 250-1	Med-ium see Figure 250-1	Light see Figure 250-1	Warm islands located at 0 to 25 degrees latitude ①			
				Altitudes sea level to 2743 m (9000 ft)	Altitudes above 2743 m (9000 ft)		
Radial thickness of ice							
(mm)	12.5	6.5	0	0	6.5	0	See Figure 250-3
(in)	0.50	0.25	0	0	0.25	0	See Figure 250-3
Horizontal wind pressure							
(Pa)	190	190	430	430	190	See Figure 250-2	See Figure 250-3
(lb/ft^2)	4	4	9	9	4	See Figure 250-2	See Figure 250-3
Temperature							
(°C)	–20	–10	–1	+10	–10	+15	–10
(°F)	0	+15	+30	+50	+15	+60	+15

①Islands located at 0 to 25 degrees latitude include American Samoa (14°S), Guam (13°N), Hawaii (22°N), Puerto Rico (18°N), and Virgin Islands (18°N).