Session 718

Wind Turbine Safety: 200 Feet High in a Fire

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Wind turbines neither consume non-renewable energy nor produce pollution; however, there are dangerous and hazardous work environments during both construction and operation. This is a case study of a forensic investigation into the death of the wind turbine erection technician. Like all such investigations the focus is very narrow. The questions are: Was there negligence? By whom? What was the basis of the negligence?

The accident occurred during the construction phase when the original bolts, supplied by the manufacturer-general contractor, connecting two flanges in the power train were too long and needed to be replaced. The subcontractor's three-member erection crew, in the Nacelle, attempted to remedy the problem. During the process, workers used an acetylene torch: a fire started, two of the workers escaped, relatively unharmed. The third worker, the plaintiff, expired when he fell or jumped from the Nacelle.

The State of Minnesota's Occupational Safety and Health Administration reviewed the case and found two violations; 29 CFR 1926.352b and 29 CFR 1926.352d.

- ✓ 29 CFR 1926.352b: Positive means were not taken to confine the heat, sparks, slag and to protect the immovable fire hazards from them;
- ✓ 29 CFR 1926.352d: Suitable fire extinguishing equipment was not immediately available in the work area(s) where welding, cutting, or heating was being performed: procedures had not been implemented to cover "hot work" operations, including the immediate availability of fire extinguishing equipment.

The violations and fine of $25,000 was assessed to the erection subcontractor.

My investigation included, but was not limited to, the following:

1. Reviewed documents, including photographs; medical, fire, sheriff's reports, and interrogatories; supplied by Plaintiff's attorney.
2. Reviewed industry standards and codes relative to utility towers and fires including, but not limited to, Minnesota engineer and architect licensing, International Building Code, Minnesota State Building Code, Minnesota State Fire Code, OSHA and Minnesota OSHA.
3. Read & reviewed multiple trade industry documents relative to wind turbines including, but not limited to, design, operation, maintenance, construction, hazards, accidents, and fatalities.

4. Consulted with fire experts, Minnesota State Fire Marshall, Minnesota State Building Code Division, County Sheriff's & Zoning Department, Minnesota Public Utilities Commission, and Minnesota Board of Architecture, Engineering, Land Surveying, Landscape Architecture, Geoscience and Interior Design.

Seven safety issues, all relating to required regulations, impacted the safety of the workers at this wind turbine; they are:

1. Licensed Engineer's Certification.
2. Non-exempt structures.
3. Minnesota State Building Code.
4. Minnesota State Fire Code.
5. MN OSHA confined space entry.
6. MN OSHA fall & descent protection.
7. OSHA Multi-employer Policy.

Introduction to Wind Turbines

A wind turbine is a structure comprised of a foundation, tower, nacelle, and blades along with the associated machinery to convert wind to electrical energy. The towers are typically a tapered steel cylinder ranging in height from 25 meters to more than 100 meters.

Figure 1. A Wind Turbine Nomenclature shows the component parts of the Wind Turbine.

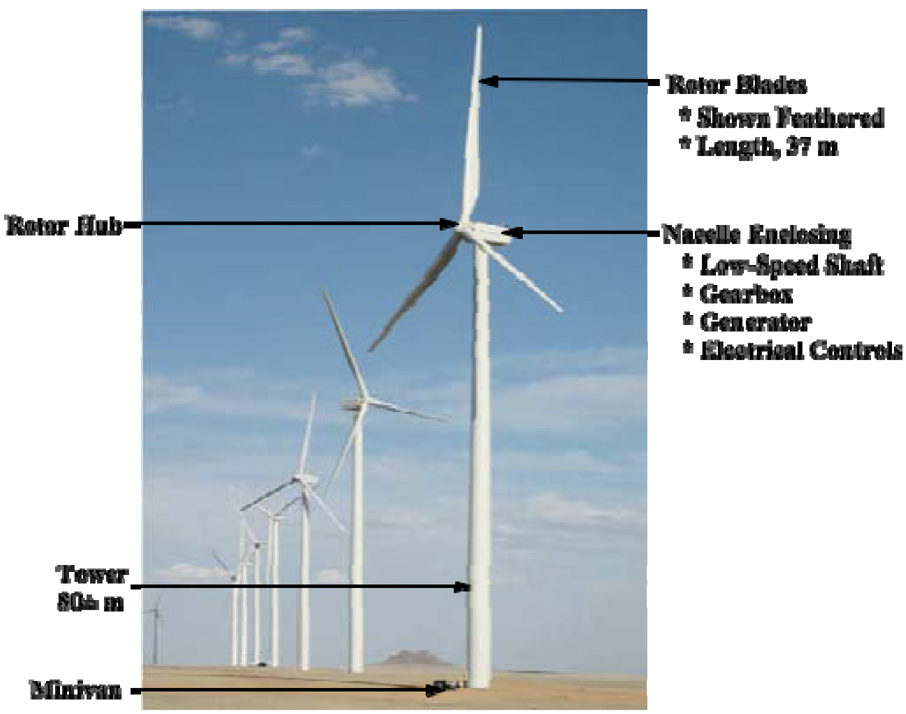

Figure 1. A Wind Turbine Nomenclature.
(Photo Courtesy of USDOE 2008)

Figure 2. *Wind Turbine vs. Building Height Compared* shows the height of a wind tower relative to a two-story house and a 20-story building. Note the location of the nacelle at the tower top.

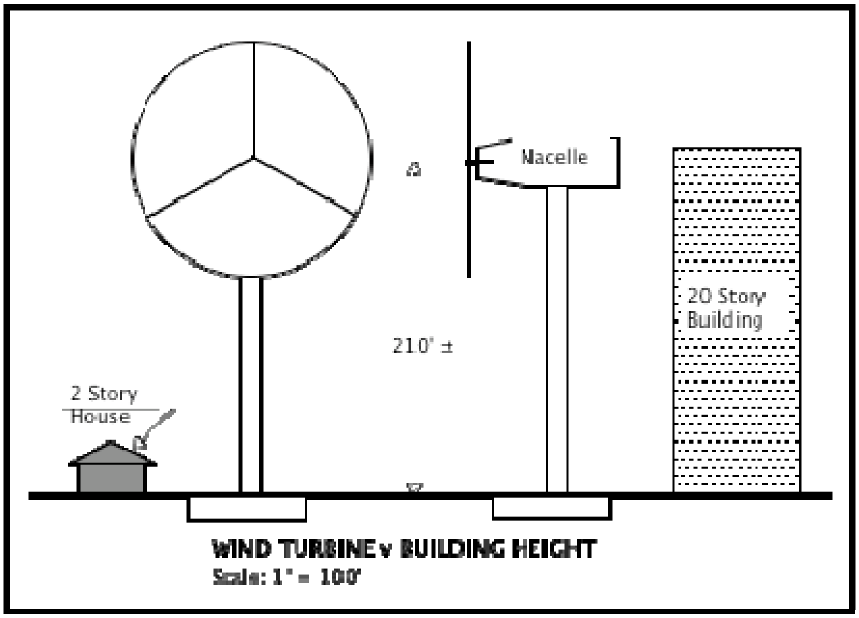

Figure 2. Wind Turbine vs. Building Height Compared.

Figure 3. The Inside of a Nacelle shows a view of the machinery inside a nacelle relative to the exterior housing. The steel tower contains the access ladder workers climb to reach the nacelle. There is a vertical access hatch into the nacelle. The nacelle houses the generating equipment in a relatively small, crowded space.

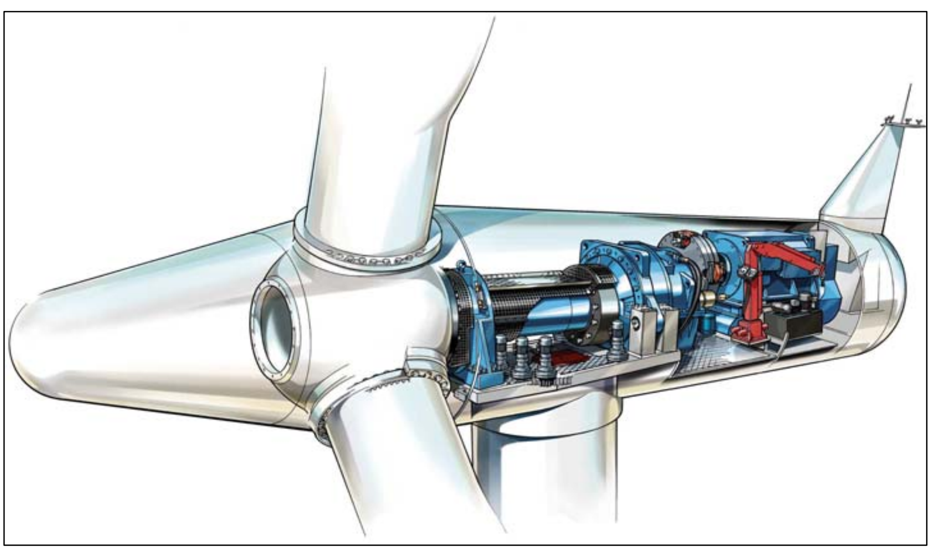

Figure 3. Generator Equipment Inside of a Nacelle.
(Courtesy of CEEO 2003; Graphics by BONUS Energy)

Safety Issue 1: Licensed Engineer's Certification

In the course of this investigation, the only licensing or certification found on record with a local organization and pertaining to the construction of this particular tower, was a zoning permit. The zoning permit ensures that the tower or wind farm is located in an area away from existing roads, buildings, and public areas.

The Minnesota Public Utilities Commission does not require wind turbine generators to have a permit if the energy produced is less than five megawatts. Generators with a capacity greater than 5MW do need a permit: issuing a permit requires a public hearing. A high percentage of wind towers built in Minnesota produce less than five megawatts. The results are wind farms built without public hearings or a permit.

Based on Minnesota Statutes, 326.02 Licensure Or Certification and 326.03 License Or Certificate Required, all buildings are subject to the Minnesota State Licensing statute and the rules of the Minnesota Board of Architecture, Engineering, Land Surveying, Landscape Architecture, Geoscience, and Interior Design regardless of their location within the state. The following two Minnesota Statutes are relevant:

> **326.02 Licensure or Certification.** In Subdivision 1. Licensure or certification mandatory. In order to safeguard life, health, and property, and to promote the public welfare, any person in either public or private capacity practicing, or offering to practice, architecture [or] professional engineering … in this state, either as an individual, a copartner, or as agent of another, shall be licensed or certified as hereinafter provided. It shall be unlawful for any person to practice, or to offer to practice, in this state, architecture [or] professional engineering, or to solicit or to contract to furnish work within the terms of sections 326.02 to 326.15, or to use in connection with the person's name, or to otherwise assume, use or advertise any title or description tending to convey the impression that the person is an architect [or] professional engineer (hereinafter called engineer), unless such person is qualified by licensure or certification under sections 326.02 to 326.15. …
>
> **326.03 License Or Certificate Required.** In Subdivision 1. Plans; documents. No person, except an architect [or] engineer, … licensed or certified as provided for in sections 326.02 to 326.15 shall practice architecture [or] professional engineering, … respectively, in the preparation of plans, specifications, reports, plats or other architectural [or] engineering… documents, or in the observation of architectural, engineering … projects. In preparation of such documents, reasonable care shall be given to compliance with applicable laws, ordinances, and building codes relating to design.

The above statutes state, a Licensed Professional Engineer must certify the design and building plans unless a specific class of building is exempt. In the investigation, no organization was found to be policing these licensing requirements. The essential reason for the licensed engineer's certification is to ensure that some recognized, competent person has reviewed life and safety issues, not only for the public that may move around and through the structures, but also for the persons responsible for constructing and operating it.

I contacted local licensing offices, including but not limited to, the Sheriff's Department, Zoning Department, and primary's county's office receptionist; Engineer and Architect's licensing board, and the Minnesota Public Utilities Commission, and I made inquiries about getting a copy of the wind turbine plans and specifications certified by a Minnesota Licensed Professional Engineer. This investigation discovered that no organization contacted had plans & specifications nor had any knowledge of an organization that did.

Buildings and structures including Wind Turbine Towers, no matter their location within Minnesota, are subject to the engineer and architects licensing statute. The engineer's plans and documents shall reasonably comply with the building codes relating to their design. This means they shall "safeguard life, health, and property, and promote the public welfare," i.e., conform to accepted engineering practice.

Safety Issue 2: Non-Exempt Structures

A Licensed Professional Engineer needs to certify the design and building plans of a proposed structure unless it is a specific class of buildings that are exempt. Wind towers fall under the classification of utility tower and are not exempt structures, per MN Statute 1800.5900.

Utility towers greater than 1-story are defined as Occupancy Group U and are not an exempt class. *Table 2. 1800.5900 Classes of Buildings by MN Statute* provides additional information about the Group U class and elements that must be met to have an "exempt" status. Clearly, utility towers and wind towers with a height greater than eight feet are not exempt.

1800.5900 CLASSES OF BUILDINGS: In accordance with Minnesota Statutes, sec. 326.02, subd. 5, and 326.03 subd. 2, the following classes of buildings are exempt subject to the limitations of the elements listed below.	
Classification	**Elements that must be met to be exempt***
Utility (as defined by the MSBC under occupancy group U except for fences higher than 8 feet, tanks and towers, and retaining walls with over 4 feet of vertical exposed face)	Not greater than 1-story with no basement and Not greater than 1000 GSF
*All terms used in this table shall be defined by the Minnesota State Building Code.	

Table 2. Classes of Buildings by MN Statute (Adapted from MSBC, 2000)

Upon review Minnesota Statutes, 326.03 License or Certificate Required, Subd. 2. Exceptions, wind utility towers are not exempt structures and when constructed in the State of Minnesota and they require certification by a competent Professional Engineer or Architect licensed by the

Minnesota Board of Architecture, Engineering, Land Surveying, Landscape Architecture, Geoscience, and Interior Design regardless of their location within the state.

Safety Issues 3 &4: Building and Fire Codes

The fire in the nacelle originally started when workers attempted to remove a bolt from the rotor plate mounted at the front of the tower. The original bolts sent from the manufacturer-general contractor and installed in the rotor plate were the wrong ones; they were too long. The correct bolts were installed when the manufacturer-general contractor supplied the proper length bolts. Worker One and Worker Two were in the nacelle to replace the bolts. One of the wrong bolts needed to be cut out with an acetylene torch since it could not be removed easily. The plaintiff was working in the rear section of the nacelle on an unrelated project.

During the cut, molten slag fell onto the nacelle's interior skin, igniting the foam insulation. When the foam caught fire, both Worker One and Worker Two attempted to stamp out the fire, but within seconds it spread out of control and began filling the nacelle with intense heat and thick smoke. A handheld fire extinguisher was brought to the site, but the surviving workers cannot recall if it was hauled to the top of the tower.

The fire spread so quickly that Worker One and Worker Two only had time to verbally alert the plaintiff to evacuate since they were unable to see the plaintiff. Worker One and Worker Two were able to reach exit hatch and get down the exit ladder, which is located in the center of nacelle: Plaintiff was not. The fire spread quickly to the plastic polyurethane housing and completely engulfed the nacelle until the polyurethane was expended exposing the structural skeleton and equipment.

Figure 4. A Burnt Out Nacelle shows an example of how consuming and damaging a fire in a nacelle can be to the structure.

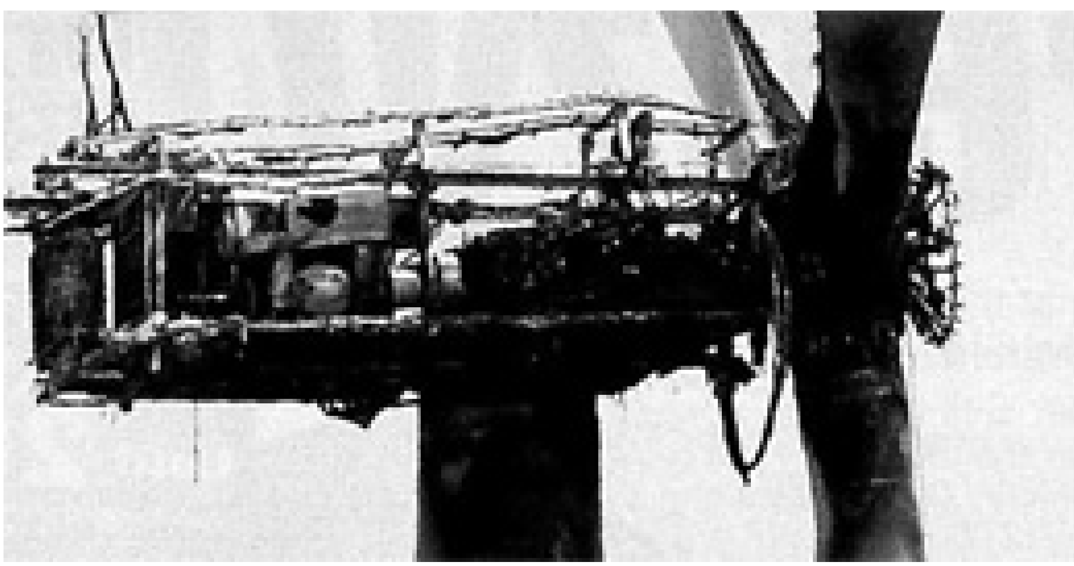

Figure 4. A Burnt Out Nacelle (Photo courtesy of Nankervis 2006)

Was there strict observance of the Minnesota State Building Codes and Fire Codes, which are designed to safeguard against all fire hazards, during the construction of this wind turbine?

As this paper reviews the codes pertinent to this situation, the following unique characteristics of the shroud housing a wind turbine nacelle become relevant (Phelan, 2008). The nacelle's walls or housing consist of polyurethane and plastic. This material has an auto-ignition temperature of 335 ºC to 378 ºC with ignition time of one to 12 seconds. The source of the fire, flame-cut slag, has a temperature of 2100 ºC with ignition time of less than 1 second.

Table 2. Polyurethane: A Foam Summary shows the summary characteristics of the polyurethane foam after inspection and identification after the inspection by the Fire Engineer's inspection.

Polyurethane: Foam Summary			
	Celsius	Fahrenheit	
Piloted	324-363	615-619	
Auto Ignition	335-378	635-712	
Heat Release & Smoke			
Incident Flux Rate	20	40	70
Peak Heat Release Rate	290	710	1221
Time to Ignition	12	1	1
Total Heat Release	9.4	13.2	13.3
Heat of Combustion	18.4	45.3	37.5
Peak Rae of Smoke Release	3.4	6.5	9.1
Total Smoke Release	138	301	297

Table 2. Polyurethane: Foam Summary (Data Adapted from Phelan, 2008)

What does this mean? In simple terms, the walls are volatile. The auto-ignition temperature of the housing is so low that the walls could ignite from such influences as, but not limited to a paper or wooden match held against it; hot oil leaking from an overheating gear box; welding splatter; an electric arc; lightning; or flame-cut slag. When polyurethane and plastic burn, they produce products of combustion within the nacelle: cyanide, carbon dioxide, carbon monoxide, hydrocarbon, & soot. The cyanide, carbon dioxide, and carbon monoxide create a <u>toxic environment within a confined space</u>. Add soot and the result is black smoke. Adding to the situation, oxygen is depleted as the fire burns increasing the toxicity in an already life threatening condition. Established statutes, codes and regulations protect against hazards such as this, if they are applied.

The intent of the codes is to safeguard against injury and fire hazards in built environments. The State of Minnesota adopted by reference the International Building Code and the International Fire Code. The International Building Code specifically refers to the International Fire Code:

> 101.4.6 Fire prevention. The provisions of the International Fire Code shall apply to matters affecting or relating to structures, processes and premises from the hazard of fire and explosion arising from the storage, handling or use of

> structures, materials or devices; from conditions hazardous to life, property or public welfare in the occupancy of structure or premises is unoccupied; and from the construction, extension, repair, alteration or removal of fire suppression and alarm systems or fire hazards in the structure or on the premises from occupancy or operation.

In addition, the IBC is specific in its purpose and Intent and the connection between Utility Towers and exempt structures. As a maker of structures, which specifically fall into the Utility & Miscellaneous Group U category, the Manufacturer/General Contractor must comply with the MSBC and MSFC safety regulations. The codes that apply are:

> 101.3 Intent. The purpose of this code is to establish the minimum requirements to safeguard the public health, safety and general welfare through structural strength, means of egress facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to life and property from fire and other hazards attributed to the built environment.
>
> Section 312, Utility & Miscellaneous Group U
>
> Section 312.1 General. Buildings and structures of an accessory character and miscellaneous structures not classified in any specific occupancy shall be constructed, equipped, and maintained to conform to the requirements of this code <u>commensurate with the fire and life hazard incidental to their occupancy</u>. <u>Group U shall include, but not be limited to, the following: … TOWERS.</u>
>
> Chapter 31, Special Construction
>
> 3102.1 Scope. Provisions of this chapter shall govern special building construction including … towers.
>
> Chapter 33
>
> 3301.1 Scope. Provisions of this chapter shall govern safety during construction
>
> 3309.2 Fire Hazards. The provisions of this code and of the *International Fire Code* shall be strictly observed to safeguard against all fire hazards attendant upon construction operations.
>
> <u>International Fire Code</u>, Section 101, General
>
> 101.2 Scope. This code establishes regulations affecting or relating to structures, processes and premises and safeguards from the hazard of fire and explosion arising from the storage, handling or use of structures, materials or devices; from conditions hazardous to life, property or public welfare in the occupancy of structures or premises from fire hazards in the structure or on the premise from occupancy or operation; and, matters related to the construction, extension, repair, alteration or removal of fire suppression and alarm systems
>
> 101.3 Intent. The purpose of this code is to establish the minimum requirements consistent with nationally recognized good practice for providing a reasonable level of life safety and property protection from the hazards of fire, explosion or dangerous conditions in new and existing buildings, structures and premises.

Accidents and deaths involving wind turbines have taken place worldwide, occurring during both the construction and operation of these machines. The *Caithness Windfarm Information Forum*

Report (Craig, 2006), often referred to as CWIF, has been tracking wind turbine accidents since the 1970s. "This compendium includes all documented cases of wind turbine accidents which could be found and confirmed through press reports or official information releases up to November 1st 2006."

Unfortunately, the report contains little data from the two biggest turbine operators in the world - Denmark and Holland. This is because the wind industry is reluctant to share or report accidents. The CWIF report believes that its data may be "the tip of the iceberg in terms of the numbers of accidents and their frequency." Regardless, the information collected provides an excellent "cross-section" of wind turbine accidents.

Table 3. A Summary of Wind Turbine Accidents reflects the number of accident to November 2006 classified by category.

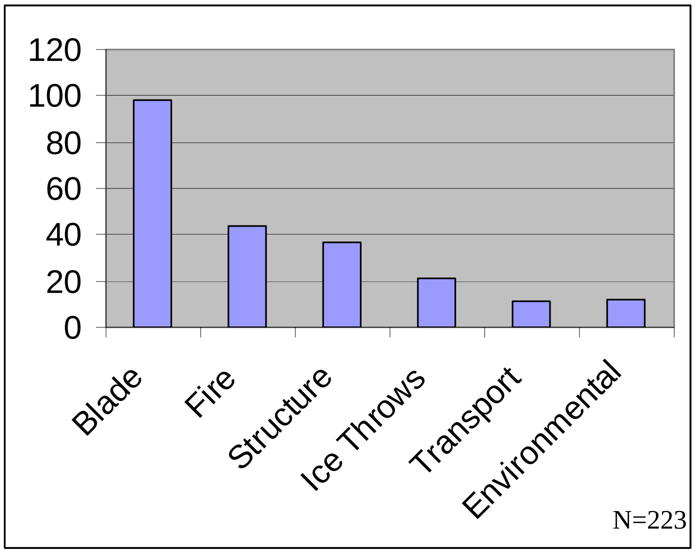

Table 3. A Summary of Wind Turbine Accidents.
(Adapted from data in Craig, 2006)

Data indicates fire is reported to be the second most common accident in Wind Towers (Craig, 2006), but it may be the most damaging and dangerous. This is due to the highly flammable material used in most nacelles; a fire consumes the nacelle quickly and completely. Since the fire takes place high in the air, far beyond the scope or reach of rural fire departments equipment, it is common to let such fires burn themselves out. Even this simple act can complicate the already-dangerous situation. In windy conditions, burning debris can blow over a wide area causing more damage by igniting any structures or dry vegetation it happens to fall onto.

In Deaths in Wind Energy Data Base, Paul Gripe (Gripe, 2006) talks about 32 fatalities worldwide associated with wind turbines. Half of them (16 incidents) occurred during construction. Of the 16 construction accidents, 12 occurred in the United States. Another six accidents occurred in the United States during the operation and maintenance of the equipment.

As *Table 4. A Summary of Wind Turbine Deaths* shows, over half (56%) of all accidents documented by Gripe take place in the United States and of those in the US 75% were in construction (where Federal OSHA does not cover confined space during construction).

Type of Accident	#	%		#	% Total	% Construction		
Construction	16	50	USA	18	56%	USA	12	75%
Operation & Maintenance	15	47	Other	14	44%	Other	4	25%
Public	1	3	Total	32	100%	Total	16	100%

Table 4. A Summary of Wind Turbine Deaths.
(Information adapted from Gripe, 2006)

So many documented injuries and deaths should be enough to convince the industry that fire prevention would result in a safer workplace. Rather than using volatile polyurethane the industry could shift to the available fire-retardant polyurethane at little or no added cost.

The Manufacturer-general contractor knew, or should have known, they were required to follow established International Building Codes and International Fire Codes. They knew, or should have known of the polyurethane's volatile fire hazard; they had a duty to warn and protect the workers inside the nacelle and they failed to do so. This contributed to the plaintiff's death.

Safety Issue 5: MN OSHA Confined Space Entry

It should be noted that Federal OSHA does not contain any regulations that address confined spaces in construction. The MN OSHA confined-space regulations in construction are specific and unique to Minnesota.

Based on The State of Minnesota OSHA regulations, Chapter 5207, Standards for Construction, Statute 5707.0300 Confined Space, a wind turbine nacelle meets the definition of a confined space. It has already been discussed in the previous section that a fire within a nacelle produces a dangerous, toxic, oxygen-reducing environment, which is one of the key elements of a confined space. The MN OSHA regulations define a confine space as follows (MN OSHA):

5207.0301 Definitions.

Subp. 2. Confined space. "Confined space" is defined as a space that is large enough and so configured that an employee can bodily enter and perform assigned work and has limited or restricted means for entry or exit and that could result in one or more of the following characteristics:

a. Contains or has a potential to contain a dangerous air contamination, an oxygen deficiency, or an oxygen enrichment;
b. Contains a material that has the potential for engulfing or asphyxiating any entrant; or
c. Contains any other recognized serious safety or health hazard.

Subp. 3. Confined space entry. "Confined space entry" means any action resulting in any part of the worker's face breaking the plane of any opening of the confined space, and includes any ensuing work activities inside the confined space.

Subp. 4. Dangerous air contamination. "Dangerous air contamination" is an atmosphere presenting a threat of death, acute injury, illness, or disablement due to the presence of flammable, explosive, toxic, or otherwise injurious or incapacitating substances.

b. Dangerous air contamination due to a combustible particulate is defined as a concentration greater than ten percent of the minimum explosive concentration of the particulate.
c. Dangerous air contamination due to a toxic, corrosive, or asphyxiant substance… . Dangerous air contamination that presents an acute illness hazard represents an atmospheric concentration immediately dangerous to life and health (IDLH) …"Immediate severe health effect" means that an acute clinical sign of a serious, exposure-related reaction is manifested within 72 hours after exposure.

Subp. 5. Engulfment. "Engulfment" means the surrounding and effective capture of a person by finely divided particulate matter or a liquid.

Subp. 6. Oxygen deficiency. "Oxygen deficiency" is defined as an atmosphere containing oxygen at a concentration of less than 19.5 percent by volume.

The Manufacturer-general contractor knew, or should have known, the nacelle was a permit-required confined space; had a duty to inform their subcontractor and require conformance with confined space rules and procedures, which includes training the workers in exit-emergency procedures and required stand-by watchers.

These regulations are designed to protect workers in confined spaces as their exposure to deadly environments is greater than average. From the regulation's scope, it is clear that most confined spaces are located either within the ground or close the level of grade. Can safety applications that work well on the ground be applied to confined spaces suspended ±200 feet in the air? The scope of the MN OSHA regulations relating to working in confined spaces is summarized below (MN OSHA):

MN OSHA 5207.0300 Confined Spaces.

Subpart 1. Scope. Parts 5207.0300 to 5207.0304 prescribe minimum standards for preventing worker exposure to dangerous air contamination, oxygen deficiency, or oxygen enrichment as defined under part 5207.0301, within such spaces as silos, tanks, vats, vessels, boilers, compartments, ducts, sewers, pipelines, vaults, bins, tubs, pits, and other similar spaces.

Operating procedures and training for those working in confined spaces are regulated and call for written and understandable procedures such as (MN OSHA):

- ✓ Entry permit system
- ✓ Descriptions of possible hazards that may be encountered by the workers
- ✓ Identify special work practices such as when atmospheric testing is required
- ✓ Follow regulated procedures required for confined spaces
- ✓ Personal Protection Equipment (PPE) required

The entry permit must be in writing and provide the following information:

- ✓ When entry to the confined space is to take place

- ✓ Who will be entering the confined space and who is in charge
- ✓ When the permit was issued and when it expires
- ✓ Identifies hazards present prior to and after entering the confined space
- ✓ Requirements for when, how, and who will complete atmospheric testing
- ✓ Identifies PPE required including rescue equipment
- ✓ Special work procedures required prior to entry or while inside the confined space

In additional, the following statute relates to special pre-entry procedures that workers need to follow (MN OSHA):

MN OSHA 5207.0303 Preentry Procedures.

Subpart 1. Application. The applicable provisions of this part shall be implemented before entry into a confined space is permitted.

Subp. 8. Ignition sources. No sources of ignition may be introduced into the space until implementation of appropriate provisions of this part has ensured that dangerous air contamination due to flammable or explosive substances does not exist.

Subp. 9. Oxygen consuming equipment. Whenever oxygen-consuming equipment is to be used, measures shall be taken to ensure adequate combustion air and exhaust gas venting.

Subp. 11. Smoking. Smoking shall not be allowed in confined spaces or within 20 feet of a confined space opening.

MN OHSA has determined that confined spaces of any type are extremely dangerous. In addition to completing the confined space requirements just mentioned, another safety practices that must be in place <u>before</u> any worker may enter a confined space is as follows (MN OSHA 5207.0304).

- ✓ A “stand-by” person must be standing by outside the confined space; ready to provide emergency assistance.
- ✓ A form of communication between the worker(s) within the confined space and the “stand-by” person outside must be established, i.e., visual, voice, or signal.
- ✓ Where practical, a safety belt or harness must be used with the free end of the line secured outside the entry opening.
- ✓ In the event of an emergency, the “stand-by” person must alert emergency services before he or she enters the confined space.

These regulations require all confined space workers to be <u>trained prior to the initial entrance</u> of the confined space and <u>then annually</u>.

In this case, there was neither an entry permit created nor any written information relating to entering the nacelle provided to the three workers before they climbed the ladder. Pre-entry procedures for ignition sources and oxygen consuming equipment were not completed; nor did they have a stand-by person outside the nacelle.

The Manufacturer-general contractor knew, or should have known, the nacelle was a permit-required confined space; had a duty to inform their subcontractor and require conformance with confined space rules and procedures, which included training the workers in exit/emergency procedures, and stand-by watchers.

Safety Issue 6: Safe Descent

Observation: Although there are fall protection requirements, there was no effective safe descent equipment evident.

Standard: No regulation required for safe descent by OSHA & MN OSHA.

Discussion: Fire-safe tie off needed to be inherent in the nacelle manufacture, i.e., needed a connection to the nacelle's structural skeleton. Fire-safe descent readily available: example, using steel-core cable as an Emergency Escape Device.

Conclusion: The manufacturer-general contractor knew, or should have known, that both fire-safe tie off and descent equipment required. manufacturer-general contractor failed to require the protection and contributed to Plaintiff's fall and death.

Paul Gripe has tracked and reviewed fatal accidents that occur in the wind power industry. There are 37 documented deaths. He states: "falling from the tower is the single most apparent occupational hazard of working with wind energy" (Gripe, 2003). Besides the height issue, workers also have other hazards to content with such as, but not limited to, working in confined spaces, rotating machinery, and falling objects.

Safety Issue 7: OSHA Multi-employer Worksite

Manufacturer-general contractor knew, or should have known of the volatile character of the nacelle housing, failed to inform the subcontractors and became responsible as the creating, controlling, exposing and correcting employer.

MN OSHA provides a multi-employer Worksite Policy, which is as follows:

A. Multi-employer Worksites. On multi-employer worksites (in all industry sectors), more than one employer may be citable for a hazardous condition that violates an OSHA standard. A two-step process must be followed in determining whether more than one employer is to be cited.

Step One: The first step is to determine whether the employer is a creating, exposing, correcting, or controlling employer.

Step Two: If the employer falls into one of these categories, it has obligations with respect to OSHA requirements. Step Two is to determine if the employer's actions were sufficient to meet those obligations.

B. The Creating Employer (Manufacturer-general contractor)

Step 1: Definition: The employer that caused a hazardous condition that violates an OSHA standard.

Step 2: Actions Taken: Employers must not create volatile conditions. An employer that does so is citable even if the only employees exposed are those of other employers at the site.

C. The Exposing Employer (Manufacturer-general contractor)

Step 1: Definition: An employer whose own employees are exposed to the hazard.

Step 2: Actions taken: If the exposing employer created the violation, it is citable for the violation as a creating employer.

D. The Correcting Employer (Manufacturer-general contractor)

Step 1: Definition: An employer who is engaged in a common undertaking, on the same worksite, as the exposing employer and is responsible for correcting a hazard.

Step 2: Actions taken: The correcting employer must exercise reasonable care in preventing and discovering violations and meet its obligations of correcting the hazard.

E. The Controlling Employer (Manufacturer-general contractor)

Step 1: Definition: An employer who has general supervisory authority over the worksite, including the power to correct safety and health violations itself or require others to correct them.

Step 2: Actions Taken: A controlling employer must exercise reasonable care to prevent and detect violations on the site. The extent of the measures that a controlling employer must implement to satisfy this duty of reasonable care is less than what is required of an employer with respect to protecting its own employees. This means that the controlling employer is not normally required to inspect for hazards as frequently or to have the same level of knowledge of the applicable standards or of trade expertise as the employer it has hired.

Factors Relating to Reasonable Care Standard. Factors that affect how frequently and closely a controlling employer must inspect to meet its standard of reasonable care include:

a. The scale of the project;

b. The nature and pace of the work, including the frequency with which the number or types of hazards change as the work progresses;

c. How much the controlling employer knows both about the safety history and safety practices of the employer it controls and about that employer's level of expertise.

d. More frequent inspections are normally needed if the controlling employer knows that the other employer has a history of non-compliance. Greater inspection frequency may also be needed, especially at the beginning of the project, if the controlling employer had never before worked with this other employer and does not know its compliance history.

e. Less frequent inspections may be appropriate where the controlling employer sees strong indications that the other employer has implemented effective safety and health efforts. The most important indicator of an effective safety and health effort by the other employer is a consistently high level of compliance. Other indicators include the use of an effective, graduated system of enforcement for non-compliance with safety and health requirements coupled with regular jobsite safety meetings and safety training.

Evaluating Reasonable Care. In evaluating whether a controlling employer has exercised reasonable care in preventing and discovering violations, consider questions such as whether the controlling employer:

a. Conducted periodic inspections of appropriate frequency;

b. Implemented an effective system for promptly correcting hazards;

c. Enforces the other employer's compliance with safety and health requirements with an effective, graduated system of enforcement and follow-up inspections.

Types of Controlling Employer

a. Control Established by Contract. In this case, the Employer Has a Specific Contract Right to Control Safety: To be a controlling employer, the employer must itself be able to prevent or correct a violation or to require another employer to prevent or correct the violation. One source of this ability is explicit contract authority. This can take the form of a specific contract right to require another employer to adhere to safety and health requirements and to correct violations the controlling employer discovers.

b. Control Established by a Combination of Other Contract Rights: Where there is no explicit contract provision granting the right to control safety, or where the contract says the employer does not have such a right, an employer may still be a controlling employer. The ability of an employer to control safety in this circumstance can result from a combination of contractual rights that, together, give it broad responsibility at the site involving almost all aspects of the job. Its responsibility is broad enough so that its contractual authority necessarily involves safety. The authority to resolve disputes between subcontractors, set schedules and determine construction sequencing are particularly significant because they are likely to affect safety.

c. Architects and Engineers: Architects, engineers, and other entities are controlling employers only if the breadth of their involvement in a construction project is sufficient to bring them within the parameters discussed above.

d. Control Without Explicit Contractual Authority . Even where an employer has no explicit contract rights with respect to safety, an employer can still be a controlling employer if, in actual practice, it exercises broad control over subcontractors at the site

F. Multiple Roles

A creating, correcting or controlling employer will often also be an exposing employer. Consider whether the employer is an exposing employer before evaluating its status with respect to these other roles.

Exposing, creating and controlling employers can also be correcting employers if they are authorized to correct the hazard.

Conclusions

Forensic Conclusion: In my opinion, manufacturer’s use of flammable polyurethane in the nacelle walls is an inherently hazardous condition that violated Minnesota State Building and Fire Codes. The confined space required anyone working within the nacelle to conform to Minnesota OSHA regulations for permit-required confined space. The manufacturer-general contractor was the hazard’s creating contractor and had a duty to inform and supervise the workers within the nacelle. The manufacturer-general contractor's failure to inform and supervise their Subcontractor was the cause of Plaintiff's fall and death.

In addition, the manufacturer-general contractor and its Safety Director, familiar with the manufacture of the nacelle and its components knew, or should have known, of the danger. The result is an unsafe confined space. The hazardous condition was the direct cause of the fall and plaintiff's death.

The intent and purpose of codes, standards and warnings are to prevent personal injuries and fatalities of this type.

<u>Comments:</u> In most, if not all, personal injury investigations the conclusion has specific charges that should be met: (1) what constituted negligence, (2) what was the standard, (3) who had the duty to perform, (5) what specific action constituted negligence, (6) did the opposing party know, or should have known, of the issue, and (7) what is the intent and purpose of codes, standards and warnings.

<u>Conclusive Remarks</u>: As my investigation proceeded it became evident that there was little oversight from the Minnesota State Fire Marshall, Minnesota State Building Code Division, Minnesota OSHA, Minnesota Public Utilities Commission, and Minnesota Board of Architecture & Engineering.

Permit-required Confined Space regulations are specifically applicable because of the high probability of an oxygen deficient or toxic atmosphere in the nacelle; however, the protections specified in the OSHA regulations are impractical. Because of the massive amount of mechanical equipment crowded into a relatively small space and the vertical exit route within the nacelle and down into the tower, typical OSHA techniques just won't work. This is not an empty tank at ground level where the removal of an overcome, inert body can be accomplished using a tag line. Also, first responders are not readily available 80 meters high and there is minimal space for them to work at the confined space entry to be effective.

In a nacelle fire where the fuel source is polyurethane the rescue time interval is irrelevant. The fire is going to consume the nacelle faster than the time needed to reach and extract a technician who is seriously injured or overcome by fumes. A solution could be found in fire prevention: a fire consultant suggested a nacelle manufactured out of fire retardant plastic or polyurethane (Phelan 2008). Properly used, this could convert the flammable, toxic component to a far safer element without the confined-space designation. Nor is it cost prohibitive.

This is an infant industry in a cycle where the learning curve will "allow engineers to develop technology improvements" in safety as well as the mechanical components, i.e., rotor, blades, active controls, towers and drive train (US DOE 2008). I agree that improvements in technology and more attention to worker training will certainly decrease accidents in the industry. Keep in mind that wind power is a growing industry. The US Department of Energy estimates the number of towers will increase thirty-fold by 2020 (US DOE 2008). Without changes to the choice of construction material, this increase in turbine projects is almost certainly going to increase the number of wind turbine-related deaths.

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