North American Regulatory Requirements for Small Wind Turbines

Brian Kramak, Director, Energy Services
www.Intertek.com/wind
4 March, 2010
Today’s Discussion

- Introduction to Intertek
- Small Wind Turbine Variations
- North American Standards and Requirements
- Example jurisdictional requirements
- Intertek’s service offerings
- Overview of our process
- Recommendations to manufacturers and authorities having jurisdiction
Our Heritage

1885
Caleb Brett founds a marine surveying business

1896
Thomas Edison establishes what’s later renamed as the Electrical Testing Laboratories (ETL)

today
Now recognised as the famous “ETL” mark – 55,000+ products from 7000+ manufacturers bear our mark

www.intertek.com
An Extensive Global Network

More than 1,000 laboratories and offices

Over 25,000 people

More than 100 countries

- FTSE 100 company in the Support Services sector
- Market capitalization at £2.3 billion
- Conducting over 2 million certification or performance tests annually
North American Accreditations

United States – Occupational Safety and Health Administration (OSHA)
  - Nationally Recognized Testing Laboratory (NRTL)
  - Scope of recognition includes 14 test sites and 500+ standards
  - A2LA, ISO 17025, NVLAP, IEC

Canada – Standards Council of Canada (SCC)
  - Accredited Testing Organization
  - Accredited Certification Organization

Authorities Having Jurisdiction (AHJ’s) -
  - Recognized by AHJ’s and local inspectors throughout North America as proof of product compliance
OSHA NRTL program

• NRTL – Nationally Recognized Testing Laboratory
• NRTL accreditation is the benchmark for excellence for product safety certification laboratories in the United States.
• Laboratories are accredited by the U.S. Occupational Safety and Health Administration, and then audited by OSHA for continued accreditation.
• An NRTL must be qualified both to test products and to certify products.
• Certification includes periodic factory audits to assure that manufacturers continue to produce products in accordance with the factory audit manual.

Small Wind Turbines

The Challenge...
Types of HAWT small wind turbines
Types of VAWT small wind turbines
Types of small wind turbines

- Must be classified as a ‘small’ wind turbine – swept area <= 200 m²
- Horizontal axis (HAWT), upwind, down wind
- Passive/active pitch and yaw controls
- Vertical Axis (VAWT)
- Variants and special designs (vertical axis design but mounted sideways, shrouded/ducted, non-traditional blade designs, etc)
- Synchronous – grid connected
- Grid connected via inverter
- Grid connected via battery and inverter
- Custom designed integrated inverter
- Off the shelf inverter by others
- Non-grid connected as sole AC source or battery charging only
- Building mounted, monopole, lattice tower, guyed and unguayed.
The Market

Small Wind Turbines

<table>
<thead>
<tr>
<th>2008 U.S. Sales</th>
<th>2008 Global Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.3 MW</td>
<td>38.7 MW</td>
</tr>
<tr>
<td>78% growth over 2007</td>
<td>53% growth over 2007</td>
</tr>
<tr>
<td>10,500 units</td>
<td>19,000 units</td>
</tr>
<tr>
<td>$77 million in sales</td>
<td>$156 million in sales</td>
</tr>
</tbody>
</table>

Expecting 30 fold growth in next 5 years

Current US installations ~ 80mw
Key points

- Given the many different design types and configurations, one test program and (and the associated design review and cost) does not fit all models for all manufacturers – and this is just in regards to the AWEA standard requirements.

- Because all technologies have different design considerations it will take patience and cooperation to determine how to best apply the selected standards to the different wind turbine design types. Intertek is already cooperating closely with SWCC on technical issues to ensure equal treatment between certification bodies.
Small Wind Turbines
The Solution...
Standards & Requirements

• AWEA 9.1
• IEC 61400-2, 61400-11, 61400-12-1, draft IEC 61400-22
• CAN/CSA C61400-2
• Electrical
  • NFPA 70 (NEC 2008) article 705.4
  • NFPA 79, EN 60204-1
  • UL Subjects 6140 & 6141
  • UL 1741, C22.2 No 107.1
  • UL 1004-1, -4, C22.2 No 100
• Example specific jurisdictional requirements
  • California
  • Oregon
  • Michigan
AWEA 9.1

• I thought SWCC was the only SWT certifier?
  • AWEA 9.1 clause 1.4.1 states that certification to this standard shall be done by an independent certifying agency such as the Small Wind Certification Council (SWCC) or a Nationally Recognized Testing Laboratory (NRTL). Self-certification is not allowed.

• What does it cover?
  • Special US definitions and marking requirements
  • Performance, acoustic and duration testing similar to IEC, based on IEC standards methods – IEC 61400-2, -11, -12-1
  • Strength and safety analysis and testing similar to IEC

• What doesn’t it cover (as compared to Canadian and IEC stds)?
  • Blade test, detailed design evaluation, tower integration, electrical, manufacturing evaluation
1.5.2.1 AWEA Rated Power: The wind turbine’s power output at 11 m/s (24.6 mph) per the power curve from IEC 61400-12-1…

1.5.2.2 AWEA Rated Annual Energy: The calculated total energy that would be produced during a one-year period at an average wind speed of 5 m/s (11.2 mph)…

1.5.2.3 AWEA Rated Sound Level: The sound level that will not be exceeded 95% of the time, assuming an average wind speed of 5 m/s (11.2 mph)…
IEC 61400-2

- How does it fit in NA certification?
  - Reference document of AWEA 9.1 – contains requirements for conducting duration test
  - Can extend AWEA 9.1 evaluation to address additional jurisdictional requirements or concerns
  - Guide for methodology for electrical certification (section 10, later)
- Relationship to proposed dIEC 61400-22
  - Where IEC 61400-2 addresses SWT issues, -22 addresses certification methodology. Expected to be released in July 2010
- Overlap with other wind standards
  - Also basis for Canadian CAN/CSA C61400-2 and other nationalized versions of the SWT standard
**IEC 61400-2 Wind Turbine Class**

### Table 1 – Basic parameters for SWT classes

<table>
<thead>
<tr>
<th>SWT Class</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{ref}}$ (m/s)</td>
<td>50</td>
<td>42,5</td>
<td>37,5</td>
<td>30</td>
<td>Values to be specified</td>
</tr>
<tr>
<td>$V_{\text{ave}}$ (m/s)</td>
<td>10</td>
<td>8,5</td>
<td>7,5</td>
<td>6</td>
<td>by the designer</td>
</tr>
<tr>
<td>$l_{15}$ (-)</td>
<td>0,18</td>
<td>0,18</td>
<td>0,18</td>
<td>0,18</td>
<td></td>
</tr>
<tr>
<td>$a$ (-)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{ref}}$</td>
<td>112 mph</td>
<td>95 mph</td>
<td>84 mph</td>
<td>67 mph</td>
</tr>
<tr>
<td>$V_{\text{ave}}$</td>
<td>22 mph</td>
<td>19 mph</td>
<td>17 mph</td>
<td>13 mph</td>
</tr>
<tr>
<td>$1.8V_{\text{ave}}$</td>
<td>40 mph</td>
<td>34 mph</td>
<td>30 mph</td>
<td>24 mph</td>
</tr>
</tbody>
</table>
IEC 61400-2 Duration Test

- at least 6 months of operation;
- at least 2,500 h of power production in winds of any velocity;
- at least 250 h of power production in winds of $1.2 \times V_{ave}$ and above; and
- at least 25 h of power production in winds of $1.8 \times V_{ave}$ and above.

<table>
<thead>
<tr>
<th>Class</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vref</td>
<td>112 mph</td>
<td>95 mph</td>
<td>84 mph</td>
<td>67 mph</td>
</tr>
<tr>
<td>Vave</td>
<td>22 mph</td>
<td>19 mph</td>
<td>17 mph</td>
<td>13 mph</td>
</tr>
<tr>
<td>$1.8 \times V_{ave}$</td>
<td>40 mph</td>
<td>34 mph</td>
<td>30 mph</td>
<td>24 mph</td>
</tr>
</tbody>
</table>

www.intertek.com
IEC 61400-11 and IEC 61400-12-1

- IEC 61400-11
  - Acoustic Measurement
  - Provides method for AWEA 9.1
  - AWEA 9.1 reporting has special requirements for sample rate and format
- IEC 61400-12-1
  - Power performance test method IEC 61400-2 addresses SWT issues, -22 addresses certification methodology. Expected to be released in July 2010
- Overlap with other wind standards
  - Also basis for Canadian CAN/CSA C61400-2 and other nationalized versions of the SWT standard
CAN/CSA C61400-2

• Differences from IEC 61400-2
  • Cold weather -20c min design temp and special considerations
  • Requirement for low temp testing to verify safety sys works
  • Icing design analysis to S37
  • Evaluation to NBC – National Building Code of Canada, and compliance with CEC – Canadian Electrical Code

• Adoption by Provinces?
  • One province has adopted.

• C61400-12-1 and C61400-11 – identical to IEC Versions
• C61400-24 for lightning protection, almost the same as IEC
Wind Turbine testing

- Intertek can work with manufacturers to test at a site of their choosing today.
- We can offer complete wind turbine testing and certification for all of North America to the AWEA standard and Canadian standards.
- We can do just the minimum required testing to allow certification through SWCC.
- As an NRTL, we also test and certify the wind turbine electrical system and components for NEC compliance, as part of a complete package, or separately.

www.intertek.com
• Article 705.4
  • All equipment of distributed generation systems must be approved
  • Utility interactive (Grid tie) inverters must be listed to UL 1741

• Wind Turbines - How to comply? Answer is in NEC article 100 definition of ‘Approved’ and the requirements for electrical system and components from IEC 61400-2
• Article 100, Handbook Edition

• DEFINITION - Approved – Acceptable to the authority having jurisdiction – same as 2005 edition

• GUIDANCE - … Where an evaluation is conducted on site, industry standards such as NFPA 79 can be used…
10.1 General (excerpts)

• comply with the applicable portions of Clauses 4 to 15 of IEC 60204-1, the relevant National standards, and any local codes.

• Every electrical component shall be able to withstand all the design environmental conditions (see 6.4), as well as the mechanical, chemical and thermal stresses to which the component may be subjected to during operation.

• All turbine protection system circuits that could possibly be affected by lightning and other transient overvoltage conditions shall be protected according to IEC 61643-1. All surge protection devices used on SWTs shall be in compliance with the IEC 61643-1.
## EN/IEC 60204-1 vs NFPA 79

<table>
<thead>
<tr>
<th>EN/IEC 60204-1 2006</th>
<th>NFPA-79 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 General requirements</td>
<td>Chapter 4 General Operating Conditions</td>
</tr>
<tr>
<td>5 Incoming supply conductor terminations and devices for disconnecting and switching off</td>
<td>Chapter 5 Incoming Supply Circuit Conductor Terminations and Devices for Disconnecting and Removing Power</td>
</tr>
<tr>
<td>6 Protection against electric shock</td>
<td>Chapter 6 Protection from Electric Shock</td>
</tr>
<tr>
<td>7 Protection of equipment</td>
<td>Chapter 7 Protection of Equipment</td>
</tr>
<tr>
<td>8 Equipotential bonding</td>
<td>Chapter 8 Grounding</td>
</tr>
<tr>
<td>9 Control circuits and control functions</td>
<td>Chapter 9 Control Circuits and Control Functions</td>
</tr>
<tr>
<td>10 Operator interface and machine-mounted control devices</td>
<td>Chapter 10 Operator Interface and Control Devices</td>
</tr>
<tr>
<td>11 Controlgear: location, mounting, and enclosures</td>
<td>Chapter 11 Control Equipment: Location, Mounting, and Enclosures</td>
</tr>
<tr>
<td>12 Conductors and cables</td>
<td>Chapter 12 Conductors, Cables, and Flexible Cords</td>
</tr>
<tr>
<td>13 Wiring practices</td>
<td>Chapter 13 Wiring Practices</td>
</tr>
<tr>
<td>14 Electric motors and associated equipment</td>
<td>Chapter 14 Electric Motors and Associated Equipment</td>
</tr>
<tr>
<td>15 Accessories and lighting</td>
<td>Chapter 15 Accessories and Lighting</td>
</tr>
</tbody>
</table>
New UL subject standards 6140/41

- What are they?
  - Subject 6140 covers wind turbine electrical systems
  - Subject 6141 covers wind turbine power conversion equipment
  - Both standards released in May 2009 to correspond with AWEA tradeshow in Chicago, Illinois.
  - Neither standard contains test requirements.
  - These subject standards form the basis for three new standards, in development, to be released sometime in next couple years
    - UL 6141 – Large Wind turbine electrical systems
    - UL 6142 – Small Wind turbine electrical systems
    - UL 6171 – Wind Turbine Converters and Interconnection Systems Equipment
UL subject 6140

Special Components of WTGS

3.1 Wiring
3.2 Cable drip loop
3.3 Bus bars
3.4 Switchgear
3.5 Transformers
3.6 Hub
3.7 Converter/Inverter
3.8 Lightning protection systems
3.9 Slip rings
3.10 Gearboxes
3.11 Hoists and winches
3.12 Fire alarms
3.13 Emergency stop
UL subject 6140

- Why is it important
  - Supplements requirements of NFPA 79.
  - Focuses on components

- While the standard provides good information on components of wind turbines, and some specific component related requirements, it doesn’t include much system level information specific to wind turbines. IEC 61400-2 section 10 is still the best wind turbine specific guide.
**UL subject 6141**

**CONSTRUCTION**
5 General ................................................................. .5
6 Liquid Cooling Systems ............................................. .5

**PERFORMANCE**
7 General ................................................................. .5
8 Stand Alone Operation ............................................... 6
9 Utility Grid Interaction ............................................... 6
9.1 General ............................................................... .6
9.2 Utility grid interaction performance ............................ .6
10 Abnormal Conditions ................................................. 7

**MARKINGS, RATINGS AND INSTRUCTIONS**
11 Markings and Ratings ............................................... 7
12 Instructions ............................................................ .8

- Not much in this standard – all requirements from external standards UL 1741 or UL 508C, except for markings
Why is it important

- Wind turbines (and other distributed generation services) range in size from under 1kw to over 2mw. Installations are for single units to groups of units, all with different protection schemes.
- States all have varying requirements for protection, depending on installation size. ‘Community Wind’ and singly installed demonstration units will fall on the borderline.
- Establishes basic guidelines for when UL 508C applies to power conversion equipment and when UL 1741 applies.
- Some designs will have different requirements – example synchronous generators without power conversion equipment.
Today -
• Wind turbine electrical systems CAN BE evaluated with existing US standards

Tomorrow (future) –
• NEC article 694 and new UL standards 6141 and 6142 will cover small wind turbine requirements
View of US/Canadian markets

- What is Intertek’s opinion on component certification for US/Canadian market?
  - Major electrical components most critical to prevent ‘last minute’ rejections by electrical authorities. Most mechanical components accepted during permitting (for now)
    - Generators – UL 1004-1, 1004-4 and CSA C22.2 No 100
    - Insulation systems – UL 1446 or IEEE 1776 (built into C22.2 No 100 for Canada)
    - Inverter – UL 1741, C22.2 No 107.1
    - Control Cabinets – UL 508A, CSA C22.2 No 14
North American Certification

- How can a small wind turbine manufacturer accomplish certification to address US and Canadian requirements for least cost/effort?
- Intertek has plan specific to NA that would minimize all risk of jurisdictional non-acceptance. Plan includes:
  - AWEA 9.1 testing and certification
  - Specific evaluation of electrical system components and systems to US and Canadian requirements
  - Complete evaluations of civil/structural/mechanical to Canadian requirements
  - Intertek follows IEC guidelines and draft standards for our NA certification plan
International Certification

- Intertek has a comprehensive plan to take advantage of overlap between standards
- Reduction in time and cost for certification
- IEC Type Certification
- BWEA/MCS Certification
Standard Development Involvement

- Intertek supports the Wind Industry in North America – both Canada and US – by participating in standards writing activity
  - Canada – participated in development of electrical sections of CAN/CSA C61400-1, participate in CEC panel determining requirements for wind turbines
  - US – secretary of structural committee, on STP code panels for UL 6141 and 6142
- International - TC88 for IEC wind turbine standards development
Specific State issues

- Intertek is aware of issues involving wind turbine electrical systems in several states

- Examples
  - California – wind turbine not allowed to be installed because of no ‘system’ level electrical certification
  - Michigan – same
  - Oregon – same

- Electrical AHJ’s are looking at article 100 and 705 and are pressing for more details on the electrical system and components.
Why Intertek as Your Partner

- Global reach
- Years of experience behind our technical approach
- Tackling demanding requirements with bespoke services
- In-house diversity to tackle convergence of technology
- Rapid response capability
More information about our Wind activities at

www.intertek.com/wind

Brian Kramak  
Director, Energy Services  
Intertek  
607-758-6482 office  
607-345-8266 mobile  
3933 US Route 11 Cortland, NY 13045-9715  
intertek.brian.kramak skype

LinkedIn  
brian.kramak@intertek.com  
http://twitter.com/etlmark