Section 8

AS TESTED CERTIFICATION AND DOCUMENTATION REQUIREMENTS

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TRIDYNAMIC SOLUTIONS

Recommendations

- Document
  - What was tested.
  - The test system.
  - The measurement and processing of data.
  - The device performance.
  - Prediction (design) versus performance.
- Demonstrate
  - As supplied is consistent with as tested.
  - As supplied is within a valid range of application relation to as tested.

Top Mass and Appurtenances

- Adding top mass tends to improve the performance of towers that respond with local windowing (composite lattice, composite pipe).
- For ductile towers (aluminum lattice and aluminum pipe) that do not have frangible joints along the height, adding top mass tends to worsen the performance of the towers in terms of force, energy, response and wing damage.
- Test results shall only be considered valid within a limited variation of the top mass.
- Towers shall be tested and certified for specific ranges of top mass or for specific appurtenance configurations including connections, cross arms, etc.

Adding Top Mass

Device Type	Top Mass (kg)	Maximum Energy (kN-m)	% Diff
Aluminum Lattice	0	16.7	
	10	29.5	77%
	20	53.4	220%
	30	67.6	305%
Composite Pipe	0	14.2	
	10	11.3	-20%
	20	10.4	-27%
	30	10.4	-27%

Adding Top Mass

- Recommendation:
  - Require testing at the boundaries of the range of the mass values.
    - For a tower tested with a specific top mass, it is only certified for that top mass.
    - For a tower tested at two different top masses, it is certified for any mass between the two.

Tower Height and Impact Point

- Assuming:
  - Enforced prohibition of "wrap-around" (exception allowed for segmentation).
  - Active windowing response.
- Tower height and impact point along height are not critical.
- Impact point relative to frangible joints discussed elsewhere but shall be carefully documented.

Tower Mass and Material Strength

- Variation in tower mass and tower strength:
  - Mechanical, structural and geometric characteristics of as tested towers shall be completely documented.
  - Material strengths shall be provided with test results (e.g., mill certification test reports for the as fabricated and tested tower).
  - The material strength of towers as supplied to the user shall be controlled through quality control methods to assure properties consistent with the as tested configuration. The common practice of substitution of stronger materials based on availability shall be avoided.

Tower Mass and Material Strength

- 10% increase in mass => 10.6% increase in energy
- 10% increase in strength => 7.3% increase in energy

Tower Material Strength

- Precedents:
  - FAA – ALS - D6155
    - Requires periodic material and drop hammer testing with upper and lower limits on strength and impact energy.
  - FAA approved fuse bolts
    - Restrict minimum and maximum strengths

Tower Mass and Material Strength

- Recommendation:
  - Mechanical, structural and geometric characteristics of as tested devices shall be completely documented.
  - Material strengths shall be provided with test results (mil certification test reports for the as fabricated and tested tower as an example).
  - As supplied towers shall have strength and mass per length properties within 10% of the as tested condition.
  - The material strength of towers as supplied to the user shall be controlled through quality control methods to assure properties consistent with the as tested configuration. The common practice of substitution of stronger materials based on availability shall be avoided.

Impact Test Documentation

- Impacted Device
  - Material, geometric, and mass characteristics as described above.
  - Specific details regarding support conditions including base plates, anchor bolts, fuse bolts, etc.
  - Specific details regarding any appurtenances and connections including geometry, strength and mass characteristics.
  - Evidence of ongoing quality control efforts ensuring consistent material, geometric and mass properties particularly as related to critical frangible connections and components.
  - The proximity of the impact point relative key geometric features of the device shall be documented. Examples include position relative to frangible joints, changes in cross-section, truss joints and appurtenances including bracing.

Impact Test Documentation

- Impacted Device
  - Detailed description of intended frangible failure mechanisms identifying connections or components that are critical to the frangible response of the device.
  - Design or analysis calculation set quantifying the predicted response.
  - Documentation of critical frangible connections or components in the form of force versus displacement, moment versus rotation, stress versus strain or resultant failure energy.
  - For windowing systems the mass and dimensions of as designed segments shall be documented and compared with test results.
  - Detailed comparison of the test response and failure mechanisms with the predicted response and the intended frangible behavior.

Impact Test Documentation

- Impacted Device
  - As supplied devices shall have critical frangible connections and components with strength and mass per length properties within 10% of as tested condition.
  - The material strength of devices (in particular critical frangible connections and components) as supplied to the user shall be controlled through quality control methods to assure properties consistent with the as tested configuration. The common practice of substitution of stronger materials based on availability shall be avoided.

Impact Test Documentation

- Impactor Assembly and Surrogate Wing
  - Establish a standard impactor system including a surrogate wing similar to a small aircraft.

Impact Test Documentation

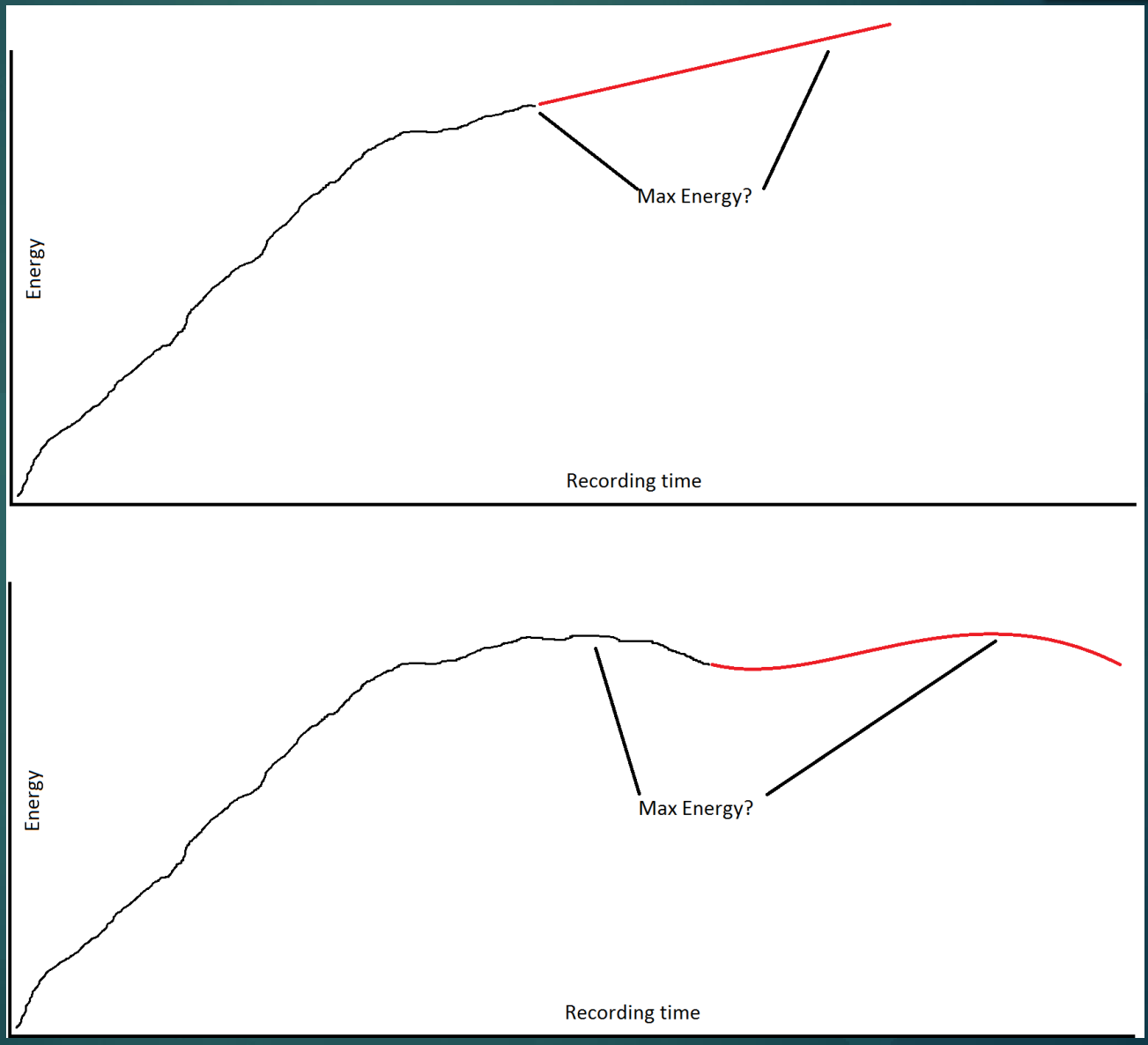
- Instrumentation and data processing shall include but not limited to:
  - Document instrumentation system data acquisitions systems, sensors, converters, amplifiers, etc.
  - Calibration records shall be provided.
  - Effective sampling rate for raw data shall be provided (min 10 kHz per current spec).
  - Force, acceleration, displacement, etc. shall be provided in raw form and plotted in test reports.
  - Digital versions of the raw data suitable for review and processing shall be made available upon request.

Impact Test Documentation

- Instrumentation and data processing shall include but not limited to:
  - Energy (or impulse) plots shall be included in the report.
  - Peak force, time of peak force and maximum energy (impulse) shall be summarized in tabular form.
  - Recording time shall extend past 250 ms.

Impact Test Documentation

Extend recording time to ensure complete data



Impact Test Documentation

- Energy Plots
  - An increase in the slope of the energy plot greater than 10 kN-m/s (at 140 kph) is considered excessive and may invalidate the test or result in failure of the device.
  - A cyclic (sinusoidal shaped) plot of energy with amplitude variation greater than 5% may indicate a dynamically sensitive impactor system and may invalidate the test.

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