10/28/2019

Team 519: Composite Airframe Life Extension

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Targets and Metrics

Targets and metrics are used to validate functions and designate specific values to the design's criteria (McConomy, 2018). These targets and metrics address the part's functions and elaborate on more aspects of the design, relative to the customer's needs. Each critical and secondary function corresponds to a metric and target. There are also some other metrics that do not directly correspond with a function. The purpose of this section is to explain what the targets are and how those specific values were determined. For a detailed description of the validation methods, see the testing section.

Critical targets and metrics were selected based on the function priorities. Critical functions correspond to critical metrics. See the previous section for the rationale on the differentiation of critical and secondary functions. The critical targets and metrics are listed below, and a comprehensive catalogue can be found in appendix B.

Critical Targets and Metrics.

Table 3

Critical Targets and Metrics

Functions	Metrics	Targets
Withstand Loading	Tensile Strength	x MPa
	Shear Strength	x MPa
	Vibration Frequency/Intensity	Varies
Control Heat Transfer	Maximum Temperature	85˚C
	Minimum Temperature	–60˚C

Describe this table

Target 1: Bending Strength.

The target is to have the same yield strength in bending as aluminum. According to the bending equations, the aluminum beam has a bending strength of 2274 Nm along the y direction and 358 Nm along the x direction. Detailed calculations are found in the appendix.

Bending in both x and y directions is done with the same test. ASTM D790 covers Flexural properties of reinforced plastics and ASTM D2344 covers short-beam strength of polymer matrix composite materials. Both tests are 3-point-bend style tests with rectangular specimens. The machine used will be the MTS 858 Mechanical Test System located at HPMI.

Target 2a: Maximum Temperature.

From the customer requirements, the maximum temperature the part must withstand is 85˚C, which is in non-operating conditions. The part must maintain the required strength at this temperature. Elevated temperatures can cause a reduction in mechanical properties due to two distinct phenomena: glass transition and thermal degradation.

ASTM D5418 dynamic mechanical properties in flexure is used to determine thermal degradation of the composite, including glass transition and the modulus with respect to temperature.

TA Instruments q800 Dynamic Mechanic Analyzer which tests the mechanical properties with respect to time, temperature, and frequency. This test will determine the thermal degradation of the composite system under high temperature.

The MIL-STD requires the sample to be held at the maximum temperature for a period time, and for the mechanical properties to be evaluate at the end of that period while the specimen is still hot.

Specimens will be placed in an oven and cycled between room temperature and 85˚C over a period of 72 hours. Afterwards ASTM D790 will be done while the specimens are still at 85C.

Target 2b: Minimum Temperature

The minimum temperature the part must withstand is -60˚C, which is the absolute minimum temperature any external part will be exposed to under any conditions or altitude. The part must maintain appropriate strength at this temperature.

ASTM D5418 will be used to determine the material's performance at below freezing temperatures.

TA Instruments q800 Dynamic Mechanic Analyzer which tests the mechanical properties with respect to time, temperature, and frequency. This test will determine the mechanical properties of the composite system under low temperature.

Target 3: Tensile Strength.

While not the primary loading, the part will be loaded in tension to some degree. The actual stress in the part will depend mostly on the attachment methods employed. These can vary greatly, so the test done will be a standard tensile test.

ASTM D3039 tensile properties of polymer matrix composite materials will be done to determine the tensile modulus of the composite. The target is the tensile strength of the beam is equivalent to the aluminum beam, which is 152120 N.

The Shimadu tensile tester will be used, located at HPMI.

Target 5: Vibration.

The part will be subjected to continuous vibration during flight operations, with the intensity and frequency dependent upon the location in the aircraft. This test will need to be outsourced because the team does not have access to facilities that operate at the required frequencies.

There are three location groups with vibration profiles respective to each. These vibration profiles are shown below in the following order: Forward FS 100, Between FS 100 – 240, Aft of FS 240. (Fuselage Station (FS) indicates where along the aircraft the part is, along an axis running from nose to tail.)

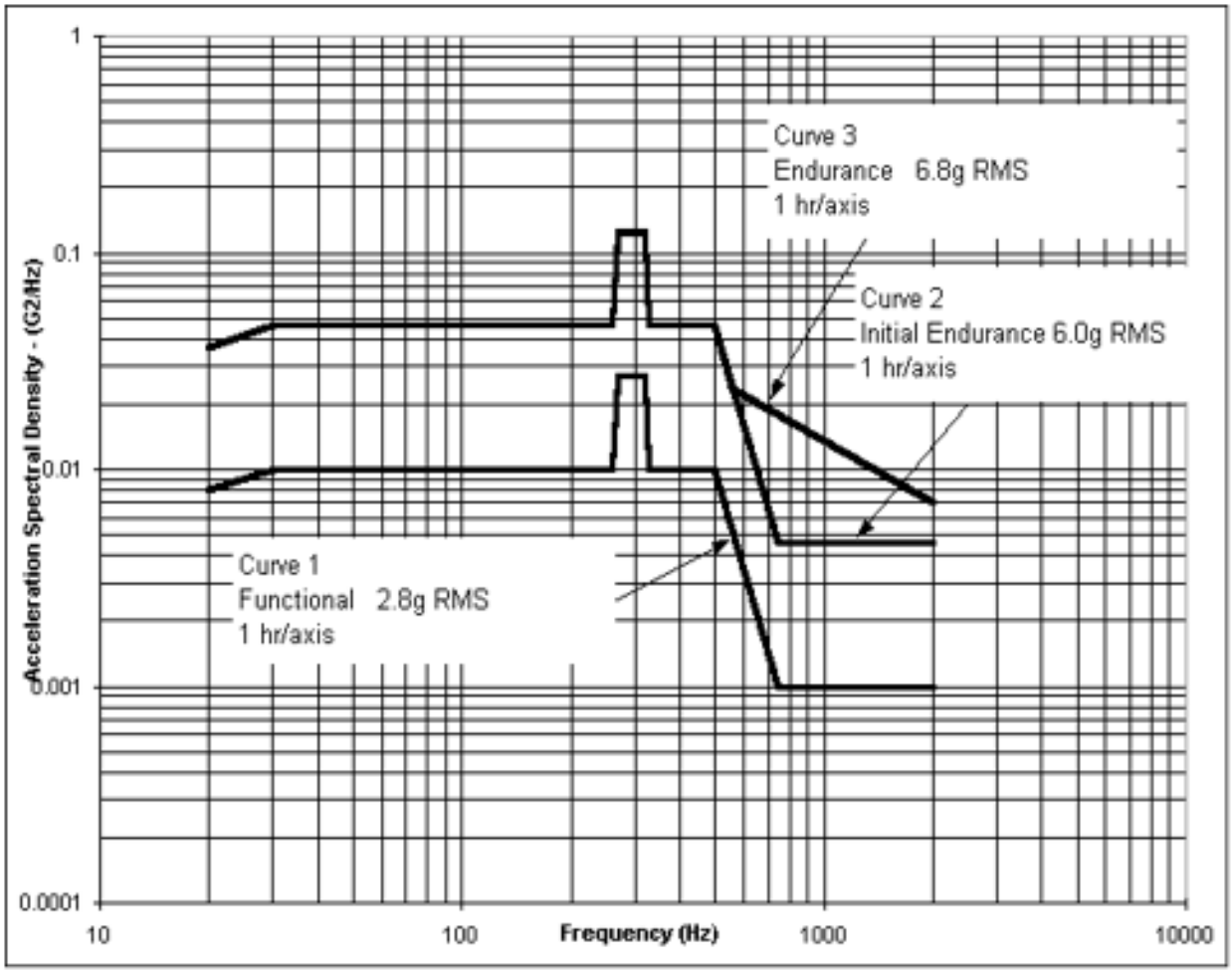

Figure 3: Vibration profile Forward of FS 100.

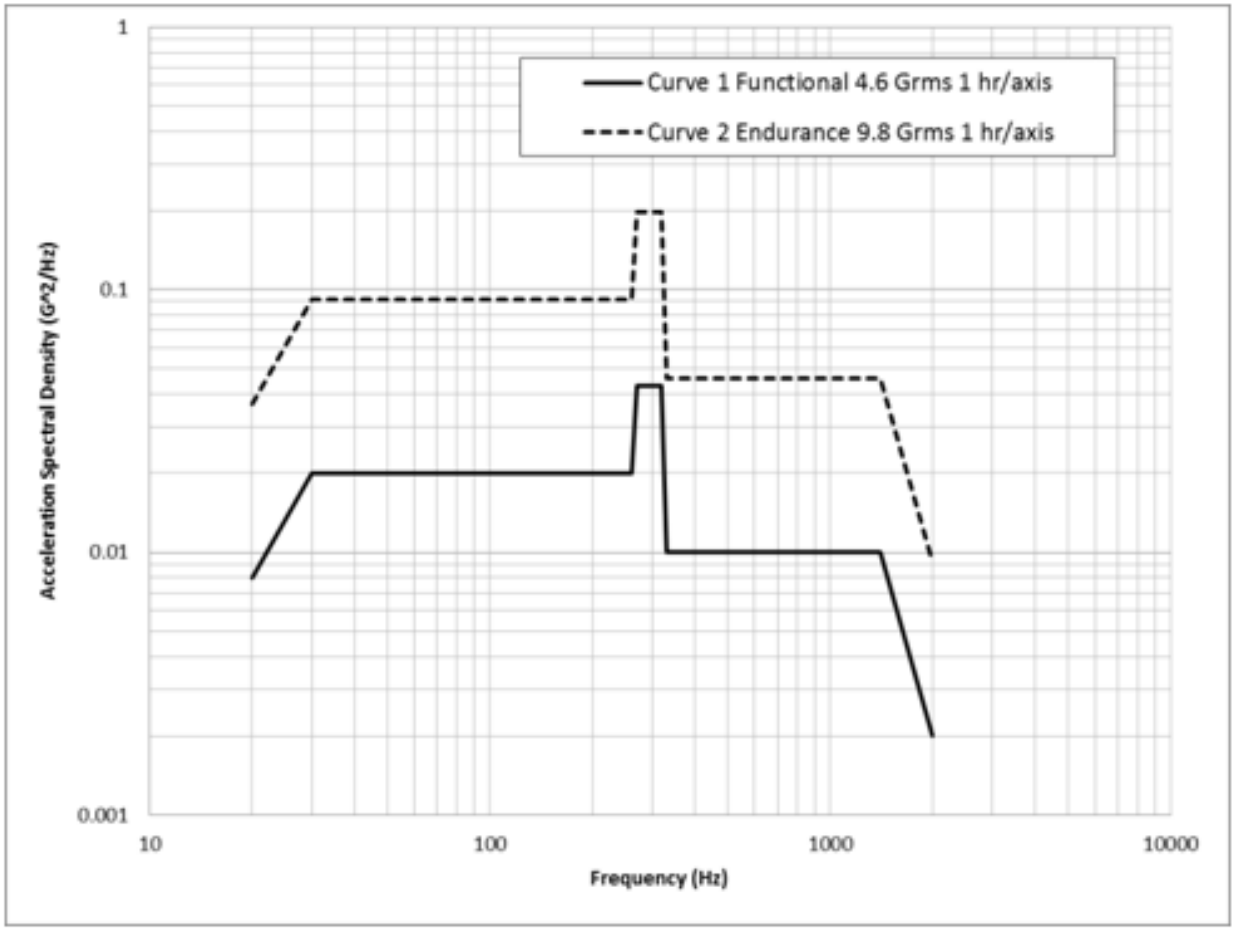

Figure 4: Vibration profile between FS 100 and FS 240

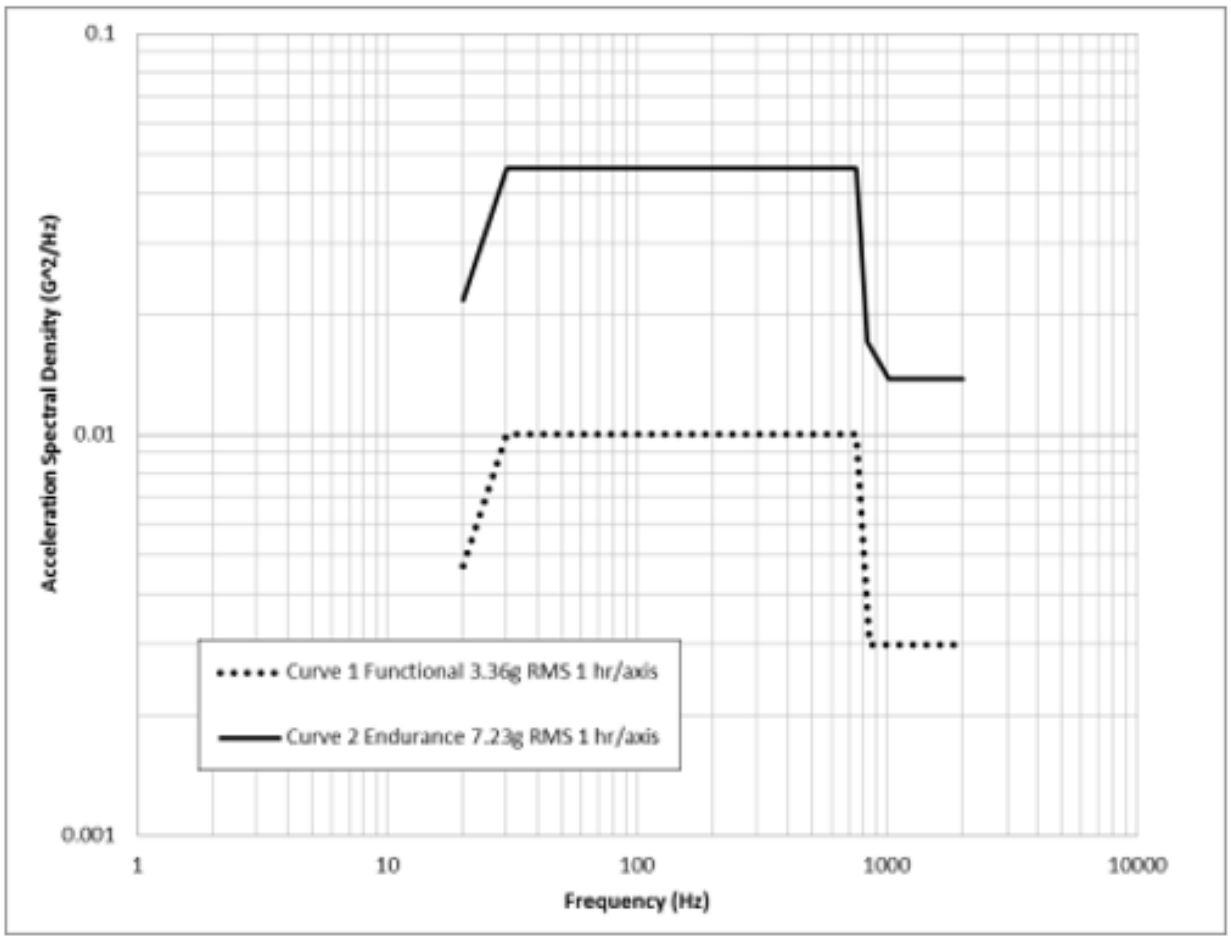

Figure 5: Vibration profile aft of FS 240.

Target 6 Humidity

There are several methods to test swelling degradation in a polymer. Since the MIL-STD test is to immerse the specimen in water, we will put it in a chamber at 85C and test how much water has accumulated within the material or do ASTM D709.

A Hot-Wet machine will be used, located at HPMI.

Target 7: Torsion

The minimum temperature the part must withstand is -60˚C, which is the absolute minimum temperature any external part will be exposed to under any conditions or altitude. The part must maintain appropriate strength at this temperature. The test to validate this target is the Cold/Wet test, during which a specimen is immersed in cold water, then taken out and analyzed by the TA Instruments q800 Dynamic Mechanic Analyzer which tests the mechanical properties with respect to time, temperature, and frequency. This test will determine the thermal degradation of the composite system under low temperature. While this test cannot accommodate a temperature below 0˚C, it is likely the best method available to the team. Accurate predictions can be made by extrapolating the change in mechanical properties at various known temperatures within the limited temperature range the team can test at (0˚C to 100˚C).

This concludes the critical target discussion. A complete targets catalogue can be found in Appendix B.